Original Article

Light exposure from microscope versus intracameral illumination during cataract surgery

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Purpose: To evaluate light exposure from microscope versus intracameral illuminations to patient's and surgeon's retina during cataract surgery. **Methods:** Thirty consecutive patients who had cataract surgery using microscope and intracameral illuminations. At the point of the ocular of an operating microscope, optical illuminance and irradiance from the microscope illumination (60, 40, 20% intensity) and the intracameral illumination (60% intensity) were measured using a light meter and a spectrometer at a pause after lens capsule polishing in cataract surgery. **Results:** Average illuminance (lux) was 1.46, 0.66, 0.27, and 0.1 from 60%, 40%, 20% intensity microscope illuminations and 60% intracameral illumination. Average total spectral irradiance (μW/cm2) was 1.25, 0.65, 0.26, and 0.03 from 60%, 40%, 20% intensity microscope illuminations and 60% intracameral illumination. **Conclusion:** Microscope ocular illuminance and irradiance during cataract surgery were higher in the microscope illumination than in the intracameral illumination. It suggests that light exposure reaching patient's and surgeon's retina during cataract surgery is lower in the intracameral illumination than in the microscope illumination.

Key words: Cataract surgery, illuminance, intracameral illumination, irradiance, light exposure, phototoxicity

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A red reflex, produced by reflection of coaxial light from the macula back to the observer, is one of the most important features of an ophthalmic microscope for cataract surgery. However, it has long been known that the red reflex in cataract surgery can induce retinal phototoxicity.[1]

It is important to find ways to reduce retinal phototoxicity during cataract surgery.[2] For preventing the toxicity, cataract surgeons try to minimize the level of microscope illumination, tilt the microscope beam away from the fovea or shorten the surgical time. In view of maximizing operational safety, which calls for sufficient red reflex during cataract surgery, nonetheless, these modifications cannot be considered routine.[3,4]

An advanced cataract surgery technique using the intracameral illumination has been introduced with an enhanced 3D effect and an improved depth perception of lens.[5-9] Increasing clinical experience with the intracameral illumination has provided us with a better understanding of certain features of this new technology. With concern about the retinal phototoxicity from the microscope coaxial light, this technique using the oblique light focused onto the lens offers the advantage of reduced direct illumination of the macula.[10] There have been no studies to date that show the measurement of illuminance and irradiance reaching patient's or surgeon's retina during cataract surgery. Therefore, we performed a prospective comparative indirect observation to assess light exposure to patient's and surgeon's retina between microscope versus intracameral illuminations during phacoemulsification cataract surgery [Fig. 1].

Methods

Gachon University IRB (GAIRB2016-65) approved this study before its initiation. Subjects participated with full, informed consent and the study adhered to the tenets of the Declaration of Helsinki. This investigation took place from April 2017 to June 2017 at the Department of Ophthalmology, Gachon University Gil Hospital, Incheon, South Korea. A review of medical records was performed in which demographic data, medical history, ocular history, best-corrected visual acuity (BCVA), slit-lamp examination including lens LOCS

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III (Lens Opacities Classification System, Version III) scoring, dilated fundus examination, and fundus photography were collected and reviewed.

Inclusion criteria were patient age greater than 40 years and surgical indication of senile cataracts. Exclusion criteria were patients with complicated cataracts (e.g., small pupil, mature lens, prior trauma, or zonular weakness), previous intraocular surgery, or surgical time longer than 25 min. All procedures were performed by one physician (D.H.N.) with an operating microscope coaxial illumination (M844 C40, Leica Microsystems, Wetzlar, Germany) (microscope illumination) or a 23-gauge endoillumination (Xenon BrightStar, DORC, Ziudland, Netherlands) (intracameral illumination). The surgical technique described in our previous studies 5--8 was used in all cataract surgeries including the advanced lens capsule polishing. To optimize visualization at all stages of the cataract surgery, we changed and customized illumination according to the varying requirements of different surgical procedures and eyes.

Illuminance and spectral irradiance of each wavelength were measured using a light meter (TES1332A, Electrical Electronic Corp., Taiwan) and a spectrometer (FLAME-S, Ocean Optics, Inc., USA). The measurements were performed at the point of the ocular (eyepiece) of an operating microscope [Fig. 2]. The illuminance and spectral irradiance from the microscope illumination (60, 40, 20% intensity) and the intracameral illumination (60% intensity) were measured at a pause after lens capsule polishing in cataract surgery with operating room lights off [Fig. 3]. Total spectral irradiance ($\mu W/cm^2$) was calculated as the average integration value for each waveform from 30 eyes. The total surgical time including the illuminance and irradiance measurement time was compared.

All statistical analyses were performed using SPSS software (version 12.0, SPSS, Inc.). ANOVA test were conducted for univariate analysis to demonstrate significance of differences between microscope illumination and intracameral illumination. *P* values of 0.05 or less were considered statistically significant.

Results

Thirty consecutive patients participated in the study. No patient experienced intraoperative complication such as posterior capsule rupture or zonular dialysis. The patient demographics are described in Table 1.

The total surgical time was 20.37 ± 1.33 min in microscope illumination group and 20.43 ± 1.45 min in intracameral illumination group (P = 0.624). Average illuminance (lux) was 1.46, 0.66, 0.27, and 0.10 from 60%, 40%, 20% intensity microscope illuminations and 60% intracameral illumination. The illuminance of 60% intracameral illumination was

Table 1: Patient demographics

Parameter	Patients
Eyes (*n*)	30
Age (y)	
Mean±SD	67.6±10.6
Range	53-86
Sex (*n*)	
Male	13
Female	17

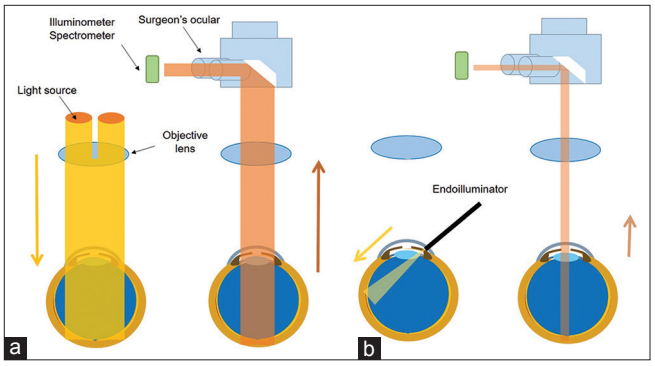

Figure 1: (a) Microscope illumination versus (b) Intracameral illumination. A red reflex is produced by reflection of bright coaxial light from the macula back to the observer (the ocular of an operating microscope) (a). Illumination, while, a side light of intracameral illumination is shining into not macula but peripheral retina. Therefore, the light reflection from the macula back to the observer is decreased (b)

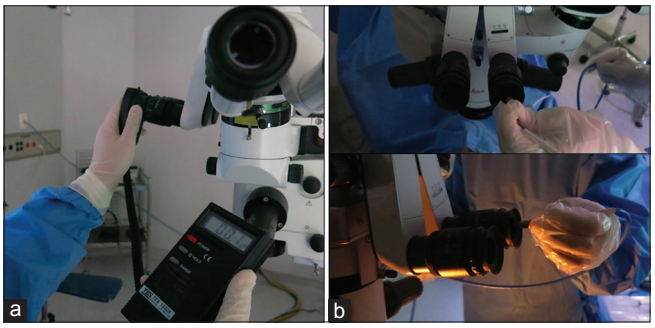

Figure 2: At the point of the ocular (eyepiece) of an operating microscope, illuminance and spectral irradiance of each wavelength were measured using a light meter (a) and a spectrometer (b)

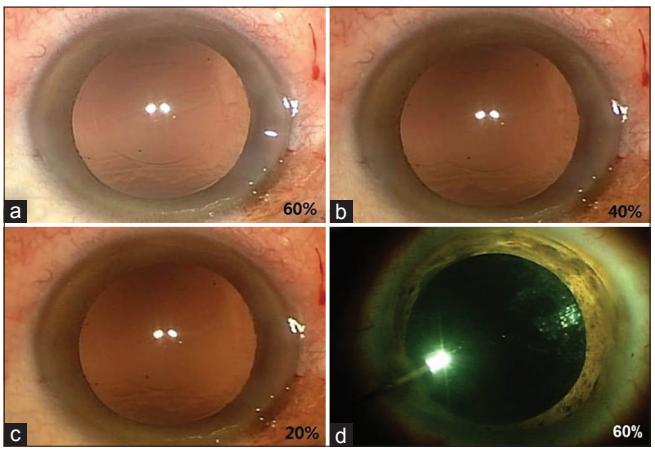

Figure 3: At a pause after lens capsule polishing with operating room lights off, we measured under microscope illumination 60% intensity, which is good illumination (a), 40%, which is fair illumination (b), 20%, which is poor illumination (c), and endoilluminator 60% intensity, which is good illumination (d)

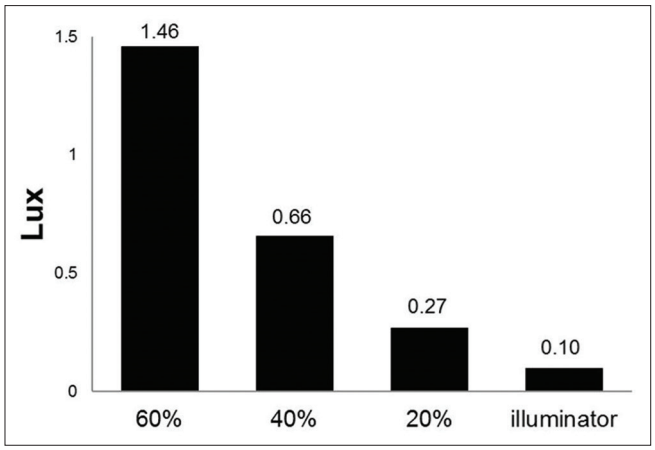

Figure 4: Average illuminance (lux) was 1.46, 0.66, 0.27, and 0.10 from 60%, 40%, 20% intensity microscope illuminations and 60% intracameral illumination. The illuminance was significantly different between the illuminations ($P < 0.001$, ANOVA test)

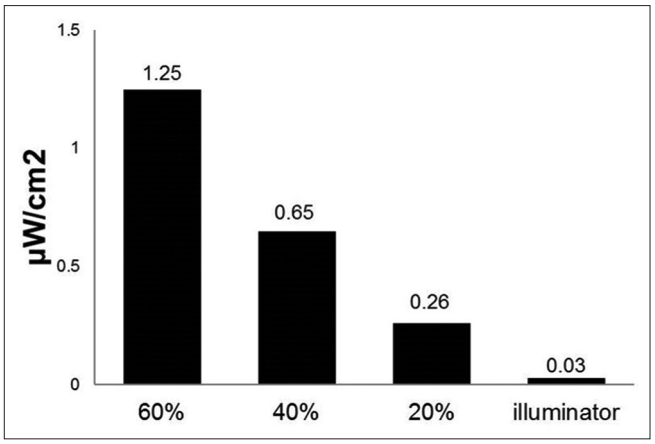

Figure 5: Total spectral irradiance (µW/cm2) was calculated as the average integration value for each waveform from 30 eyes. B. Average total spectral irradiance (µW/cm2) was 1.25, 0.65, 0.26, and 0.03 from 60%, 40%, 20% intensity microscope illuminations and 60% intracameral illumination. The total spectral irradiance was significantly different between the illuminations ($P < 0.001$, ANOVA test)

decreased to 6.8%, 15.1%, and 37.0% of levels of 60%, 40%, and 20% intensity microscope illuminations, respectively ($P < 0.001$, ANOVA test) [Fig. 4].

Average total spectral irradiance (µW/cm^2) was 1.25, 0.65, 0.26, and 0.03 from 60%, 40%, 20% intensity microscope illuminations and 60% intracameral illumination. The total spectral irradiance of 60% intracameral illumination was decreased to 2.4%, 4.6%, and 11.5% of levels of 60%, 40%, and 20% intensity microscope illuminations, respectively ($P < 0.001$, ANOVA test) [Fig. 5].

Discussion

Although intraoperative iatrogenic retinal phototoxicity is rare, it results in permanent visual dysfunction. In 1995, public health advisory from the US Food and Drug Administration was reported about Retinal Photic Injuries From Operating Microscopes During Cataract Surgery.[11] The operating microscope manufacturers have since incorporated ultraviolet and infrared filters to minimize the possibility of light damage. However, intraoperative microscope light-induced photochemical damage can be caused by radiation between 400 and 550 nm, still opening the possibility of photochemical insult to the retina.[12] Furthermore, the manufacturers do not provide a recommended illumination intensity level, leaving the surgeon free to set the intraoperative illumination intensity level according to individual preference. Therefore, it is very important for cataract surgeons to balance efficiency during cataract surgery, which calls for sufficient intraoperative illumination/visualization, and achieving good postoperative visual outcomes, which calls for the suppression of retinal phototoxicity. Raising the intensity of light to improve visibility leads to a sacrifice in safety. This study showed that the advanced cataract surgery technique using the intracameral illumination could be a viable option to achieve both operational efficiency and safety. The novel illumination not only improves observational conditions but also decreases the light exposure reaching retina during cataract surgery.

In terms of efficiency, the intracameral illumination enhances the details of the lens structures, mainly posterior capsule. In addition, it creates an enhanced 3D effect and improves depth perception of lens. The advantages could decrease the risk of intraoperative complications, especially in junior cataract surgeons.[5-9,13]

This is the first time intraoperative observation has been used to measure the light exposure during cataract surgery. Strengths of this study are its prospective nature and an intraindividual comparative design between microscope versus intracameral illuminations. This study suggests that light exposure reaching patient's and surgeon's retina during cataract surgery is much lower in the intracameral illumination than in the microscope illumination. It is consistent with previous study.[10] However, this study did not predict the absolute intensity of light that the retina could become exposed to during cataract surgery in real life. This is because our study did not measure the intensity of the light on the macula but at the point of the ocular of an operating microscope.[14] Therefore, it is difficult to compare the light values obtained from this observation to the toxic values reported in the literature.[11]

Conclusion

In conclusion, this study highlights the utility of the intracameral illumination to minimize intraoperative light exposure reaching patient's and surgeon's retina. The advanced cataract surgery with reduced light exposure enabled excellent intraoperative visualization of lens structures. Considering reduction of potential phototoxicity, control of light intensity is an important factor. In view of patient or surgeon retinal phototoxicity, the intracameral illumination may be safer than the microscope illumination. To confirm the efficacy and safety of this emerging technology, however, it is necessary to perform a prospective study comparing the clinical outcomes of the novel cataract surgery with intracameral illumination versus those of the standard cataract surgery with microscope illumination.

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Conflicts of interest

There are no conflicts of interest.

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