YAG Laser Injury of Intraocular Lenses

S. GREGORY SMITH, JACK HOLLADAY and RANDALL KNOLL

Wilmington, Delaware, USA

OBJECTIVE: To assess the effect of severe YAG laser injury of an intraocular lens on vision. STUDY DESIGN: Intraocular lenses had resolution and transmission tested prior to YAG laser injury. They were then injured with either 50 hits of 5 mJ or 50 hits of 1.25 mJ. Resolution and transmission were then reassessed to see what effect these degrees of injury had on these two aspects of IOL function. SETTING: Experimental laboratory. MAIN OUTCOME MEASURES: Resolution of an intraocular lens transmission of light of an intraocular lens. RESULTS: Severe YAG laser injury had minimal effect on resolution of intraocular lens. Severe injury did decrease the transmission of an intraocular lens by 14%. CONCLUSIONS: Decreased Snellen visual acuity in an intraocular lens with severe YAG laser injury is not due to the injury of the intraocular lens and other causes should be evaluated. Decreases in contrast sensitivity can be expected with severe injury.

Keywords: YAG laser injury; Intraocular lens

INTRODUCTION

Intraocular lens pitting with the YAG laser has been reported to occur between 15% and 30% of cases by Stark and co-authors [1] (2110 eyes), 81% of cases (53 eyes) by Flohr and co-authors [2], 51% of the cases by Nirankari & Richards [3] (52 eyes) and 33% of cases (526 eyes) by Keates and co-authors [4]. Recently, Bath and co-authors [5] have reported one case in which a patient complained of glare and had decreased vision. They felt this was due to pitting of an intraocular lens and this intraocular lens was removed. We have also had occasion to evaluate a patient with similar YAG laser injury (Fig. 1). However, in this patient the contrast sensitivity and glare testing performed appeared similar in both eyes and the visual acuity was 20/25 in each eye. The intraocular lens was not removed in this case. We designed a study to determine experimentally what effect YAG laser injury had on the resolution and transmission of light by intraocular lens.

MATERIALS AND METHODS

The following materials were used in the study:

(1) ten optics of injection molded PMMA Rohm and Haas VS 100;

(2) four optics of lathe cut PMMA Perspex CQ;

(3) ten optical discs of lathe cut PMMA Perspex CQ.

Prior to treatment the resolution in water of the PMMA material was measured. This was done on an optical bench using the ANSI grid and a 6 mm pupil. Transmission of the optical discs was also measured prior to treatment.

The materials were placed in a special holding device to be mounted on the YAG laser. This device consisted of a fluid-filled anterior chamber and posterior chamber and a holding device on which the

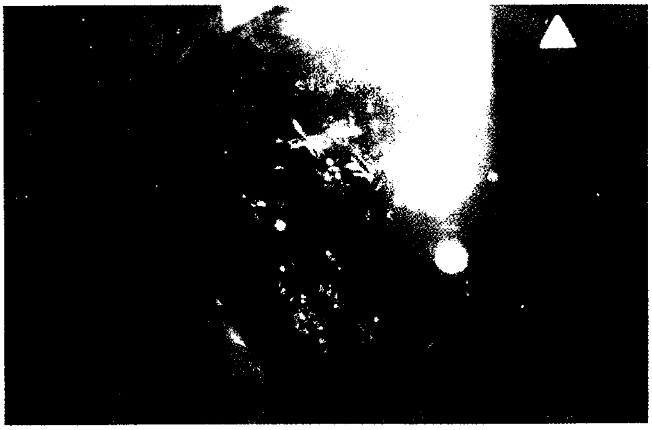

Fig. 1 Clinical appearance of eye which had undergone YAG laser capsulotomy with numerous hits within the intraocular lens

---

Correspondence to: Dr S. Gregory Smith, M.D., 1700 Shallcross Ave., Suite 2, Wilmington, DE 19806.

0955–3681/92/030157+04 $08.00/0 © 1992 Baillière Tindall

optic or disc was held. The materials were then subjected to the following:

(1) three injection-molded PMMA optics, one Perspex CQ optic and three optical discs of Perspex CQ were subjected to 50 hits placed in five rows of ten, at 5.0 mH of injury (1) focused within the material;

(2) three injection-molded PMMA optics, one Perspex CQ optic, and three optical discs of Perspex CQ were subjected to 50 hits of 1.25 mJ of injury placed in the same pattern and location.

(3) Three injection-molded PMMA optics, one Perspex CQ optic, three optical discs of Perspex CQ were subjected to 50 bursts of mJ of energy placed in five rows focused *c.* 2 mm behind the optic or the disc. This was controlled by obtaining a focus on the material and moving the implant forward 2 mm by the micrometer on the device.

4. Finally, one PMMA injection-molded VA 100 optic, one Perspex CQ lathe-cut optic and one Perspex CQ lathe-cut PMMA optical disc were placed in the device and then removed.

The resolution in water for the PMMA optics at a 3 mm aperture and the light transmission at a 6 mm aperture of optical discs was then remeasured by the same technician. The 3 mm setting was chosen to more closely mimic the clinical situation.

MEASUREMENT OF INJURY SIZE

Photographs of representative lenses were taken at various magnifications. The techniques of illumination of the IOLs and the magnification were noted. Scanning electron microscopy of two IOLs was also performed.

The size of the laser injury area was measured in millimetres for 1.25 mJ and 5 mJ injury at 50× and 100× with backlighting, and with scanning electron microscopy. For one IOL the same spots were measured using surface lighting and back lighting. Assumptions made during all these measurements were that the injury sites consisted of a circular area and possibly an associated crack. This crack was assumed to be rectangular and all the injury would be depicted as a black or dark grey area in the photographs. The area of the circular injury was calculated as π × radius of the injury size. The area of the associated cracks was also calculated. These values were divided by the magnification to determine the injury size. The injury sizes were averaged for 5 mJ, and 1.25 mJ for 50× magnification, 100× magnification and scanning electron microscopy.

The decrease in transmission was calculated for each measured injury size using the following formula:

The decrease in transmission =

$$\frac{\pi\ (\text{radius of injury size}) \times \text{no. hits}}{\pi\ (\text{radius of pupils})}$$

The effective injury size was also calculated for 5 mJ and 1.25 mJ of injury using the same equation and solving for the radius of injury size.

RESULTS

The resolutions in water are shown on Table 1. A change of one element on the ANSI grid (column 3) yielded approximately 30 line pairs.

The transmission is shown in Table 2.

Measurement of injury size at 1.25 mJ of 33 spots at 50 yielded an average size of 40 microns (Fig. 2) (Table 3). The measurements were taken for 5 mJ of injury (Figs 3, 4).

Table 4 compares the measurement technique (using back lighting for light microscopy) for spot size with the predicted + actual transmission change and effective injury size.

Table 1 Resolutions in water

		Pre-RX resolution	*Post-RX resolution*	*Change in element*	*Average change*
5 mJ	PMMA (IM)	74	104.7	+1	
50 Hits	PMMA (IM)	103	74.5	−1	
	PMMA (IM)	73.4	74	0	
	PMMA (LC)	74	74	0	
1.25 mJ	PMMA (IM)	73.4	104.3	41	
50 Hits	PMMA (IM)	103.9	105.7	0	0
	PMMA (IM)	73.5	74	0	
	PMMA (IM)	73	74.5	0	−0.25
5 mJ	PMMA (IM)	103.2	74.4	−1	
Shoot through	PMMA (IM)	103.2	104	0	
	PMMA (IM)	73.4	74	0	
	PMMA (LC)	74	74	0	−0.25
Place in device	PMMA (IM)	73.6	102.6	+1	
	PMMA (IM)	103.2	103.4	0	+0.5

IM, insertion molded; LC, lathe cut.

Table 2 Transmission

	% Transmission pre-RX	*% Transmission post-RX*	*Change in element*	*Average change*
5 mJ				
50 Hits LC	95	83	−12%	
LC	98	78	−20%	
LC	98	88	−10%	−14%
1.25 LC	97	92	−5%	
50 Hits LC	96	94	−2%	
LC	97	95	−2%	−2.7%
5 mJ LC	96	94	−2%	
Shoot through LC	92	93	+1%	
LC	96	96	0%	−0.3%
Control LC	72	80	+8%	+8%

Table 3 Measurement of injury size

Injury	*No. spots*	*Magnification*	*Average size*	*Total average*
1.25 mJ	33	50	40 microns	40
1.25 mJ	6	100	40	
5 mJ	8	100	254	
5 mJ	16	50	383	
5 mJ	28	50	109	224
5 mJ	1	1000	40	
5 mJ	4	200	120	
5 mJ	7	151	50	72

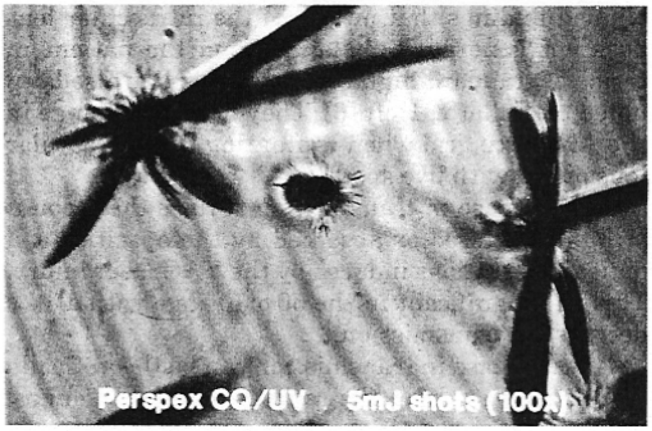

Fig. 3 5 mJ hit on 5 mJ injury site on Perspex CA

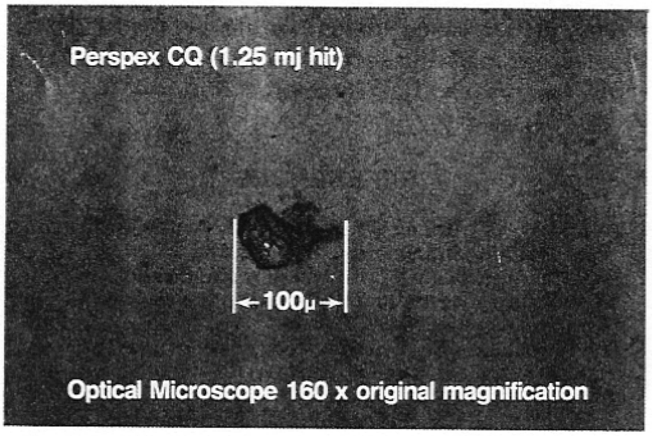

Fig. 2 1.25 mJ hit in Perspex CQ

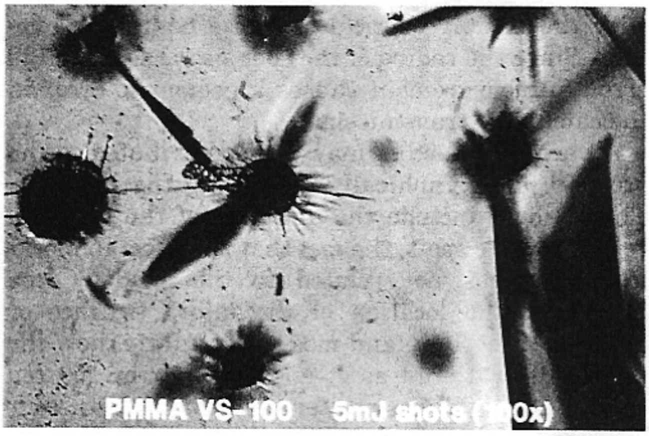

Fig. 4 5 mJ injury sites on PMMA VS-100

Table 4 Measurement technique for spot size

Energy used	*Microscopy*	*Measured spot size*	*Predicted decrease transmission*	*Actual transmission*	*Calculated effective size*
1.25 mJ	Light	40 microns	0.8%	2.7%	70
5.0 mJ	Light	224 microns	28%	14%	168
5.0 mJ	Light	72 microns	2.9%	14%	168

Table 4 was derived using a 14% decrease in transmission, a 3 mm pupil and 50 hits at 5 mJ.

DISCUSSION

Following 50 hits at either 5 or 1.25 mJ, focused within the intraocular lens, the PMMA optics of the injection-molded PMMA, or lathe-cut PMMA, showed no significant decrease in resolution when measured on the ANSI targets. There was, however, a decrease in transmission for both optic types at 50 hits of 5 mJ within the intraocular lens, but not at 50 hits of 1.25 mJ. These data help to explain the clinical findings that pitting of the intraocular lens does not generate complaints from the patient in terms of standard high contrast. This has also been noted by Fallor & Hoft [6]. They noted no change in the Air Force grid when evaluating five intraocular lens pitted with five spots.

The decrease in transmission reveals the amount of light scattered or absorbed by the opacities and optical aberrations induced by the YAG laser injury. This was significant in the 50 mJ range with a 14% decrease in transmission.

This decrease in transmission can be theoretically calculated by taking the ratio of the area of injury divided by the area of the 6 mm aperture. Light can pass through. The measured spot size for the 1.25 mJ was similar to the effective optical spot size of 70 microns. The 5 mJ spot size was overestimated by the light microscopy and underestimated by SEM with the effective optical spot size being 168 microns. Since the radius of the spot size is squared the error in measurement causes a geometric error in the calculated transmission.

A variety of factors may have contributed to the error in photographically measuring the spot size. These would include the direction of the lighting, relative to the spots, the fact that the effect in blocking light was not related to the shadow area measured, the location of the injury (surface or interior of the IOL) and most importantly, how the light was scattered as it encountered the injured area. If the light was scattered in a narrow angle it would still fall within the area being measured and be recorded as transmitted light. If it was scattered in a wide angle it would be deflected away from the area being measured and not be recorded.

The clinical effect of the decrease in transmission would be to reduce the contrast of the object viewed. The Pelli-Robson charts used to measure contrast sensitivity are in 0.15 log unit contrast steps (*c.* 25%), therefore a 14% decrease (for severe injury and a 3 mm pupil) does not appear to be clinically noticeable.

CONCLUSION

In conclusion, severe YAG laser injury may cause a decrease in contrast of the retinal image due to forward light but not resolution scatter. Known factors contributing to any decrease in contrast include the patient's pupil size, the energy used in creating the injury areas and the number of the YAG laser hits. Different IOL materials such as hydrogel and silicone would be expected to give a different injury area for the same energy. For a patient with severe YAG laser injury and decreased vision other etiologies such as CME, macular degeneration etc. should be investigated as no decrease in resolution of the IOL would be expected.

The effect of these injuries on glare is not known and a standardized technique for measuring this had not been established. In summary, a large amount of YAG laser injury would not be expected to cause a decrease in visual acuity but there may be some change in contrast sensitivity. For a given patient the amount of decrease in transmission can be estimated using the number of hits and/or cross-sectional area from two power settings. Should the clinician encounter a patient with decreased visual acuity and an IOL with YAG laser injury other causes of decreased vision should be investigated, e.g. cystoid macular oedema, uncorrected refractive error, etc. prior to IOL removal.

REFERENCES

1 WJ Stark, D Worthen, JT Holladay, G Murray. Neodymium: YAG lasers. *Ophthalmology*, 1985; **92**: 209–212.

2 MJ Flohr, AL Robin, JS Kelly. Early complications following Q switched neodymium: YAG laser posterior capsulotomy. *Ophthalmology*, 1985; **92**: 360–363.

3 VS Nirankari, RD Richards. Complications associated with the use of the neodymium: YAG laser. *Ophthalmology*, 1985; **92**: 1371–1375.

4 RH Keates, RF Steinert, CA Puliafito, SK Maxwell. Long term followup of Nd: Yag laser posterior capsulotomy. *Am. Intraocular Implant Soc. J.*, 1984; **10**: 164–168.

5 PE Bath, KJ Hoffer, Y Dan. Glare disability secondary to Yag laser intraocular lens damage. *J. Cataract Refract. Surg.*, 1987; **13**: 309–313.

6 MK Fallor, RH Hoft. Intraocular lens damage associated with posterior capsulotomy: A comparison of intraocular lens designs and four different Nd:Yag laser instruments. *Am. Intraocular Implant Soc. J.*, 1985; **11**: 564–567.