The influence of size and shape of Neodymium-doped:Yttrium Aluminium Garnet (Nd:YAG) laser capsulotomy on visual acuity and refraction

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Abstract

Background: Posterior capsule opacification is the most common complication of cataract surgery and results from the proliferation and migration of residual lenticular epithelial cells. Opacification may be diminished by atraumatic surgery; complete cleaning of cortex residues, polishing of both anterior and posterior capsules, clinical, pathological and experimental studies have shown that use of hydrodissection, the continuous curvilinear capsulorhexis or the use of specific intraocular lens (IOL) designs. The overall incidence of posterior capsule opacification (PCO) approaches 50% at 5 years following cataract surgery and disproportionately affects younger patients due to higher cell proliferation rates. Capsular-fixated, one-piece all-polymethylmethacrylate PC-IOLs with a C-shaped loop configuration and a posterior convexity of the optic are effective in reducing PCO.

Objectives:To evaluate the influence of size and shape of neodymium: yttrium aluminum- Garnet (Nd:YAG) laser capsulotomy on visual acuity and refraction.

Patients and method(s): A prospective study was performed in department of ophthalmology at Qena university hospital between September 2016 and September 2017. Informed consent was obtained from each patient before the study. A South Valley University institutional ethics committee approval was obtained.

In this study 60 pseudophakic eyes of 58 patients of age range (30-70years) were included. All of the patients had undergone non complicated cataract surgery (phacoemulsification (48eyes) or extracapsular cataract extraction (12 eyes)).

Result(s): All patients had significant vision loss and hazy fundus appearance due to posterior capsular opacification. There was significant improvement in VA in the four groups, with statistically significant improvement effect of cruciate shape capsulotomy with size >3.5mm on BCVA.

Conclusion: The cruciate 0shape with size more than 3.5 mm capsulotomy openings show better improvement in BCVA than the other groups. Spherical equivalent show slight improvement in all groups which was insignificant.

Keywords: Neodymium-doped, Yttrium Aluminium Garnet, laser capsulotomy

Introduction:

Posterior capsule opacification is the most common complication of cataract surgery and results from the proliferation and migration of residual lenticular epithelial cells. Opacification may be diminished by atraumatic surgery; complete cleaning of cortex residues, polishing of both anterior and posterior capsules, clinical, pathological and experimental studies have shown that use of hydrodissection, the continuous curvilinear capsulorhexis or the use of specific intraocular lens (IOL) designs **(Apple et al., 2000)**.

The overall incidence of posterior capsule opacification (PCO) approaches 50% at 5 years following cataract surgery and disproportionately affects younger patients due to higher cell proliferation rates. Capsular-fixated, one-piece all-polymethylmethacrylate PC-IOLs with a C-shaped loop configuration and a posterior convexity of the optic are effective in reducing PCO **(Mackool et al.,1991).** Polymethylmethacrylate loops that retain "memory" create a symmetric, radial stretch on the posterior capsule after in-the-bag placement, leading to a more complete contact between the posterior surface of the IOL optic and the taut capsule. This may help form a barrier against central migration of epithelial cells into the visual axis. PCO decreases visual acuity and contrast sensitivity leading to disability as a result of glare. The neodymium: yttrium-aluminum-garnet (Nd:YAG) laser is a solid-state laser with a wavelength of 1064 nm that can disrupt ocular tissues by achieving optical breakdown with a short, high-power pulse. Optical breakdown results in ionization, or plasma formation, in the ocular tissue. This plasma formation then causes acoustic and shock waves that disrupt tissue **(Apple et al., 1992)**.

The development of the Nd:YAG laser as an ophthalmic instrument and its application in discussion of the posterior capsule coincided with the conversion from intracapsular to extracapsular surgical techniques in cataract surgery. Before the introduction of the Nd:YAG laser, only surgical cutting or polishing of the posterior capsule could manage opacification of the posterior capsule following extracapsular cataract extraction. Nd:YAG laser posterior capsulotomy introduced a technique for closed-eye, effective, and relatively safe opening of the opacified posterior capsule, and laser capsulotomy rapidly became the standard of care **(Baratz et al., 2001)**.

Aim of the work:

To evaluate the influence of size and shape of neodymium:yttrium aluminum- Garnet (Nd:YAG) laser capsulotomy on visual acuity and refraction.

Patients and Methods:

Design: A prospective clinical study.

This prospective study was performed in department of ophthalmology at Qena university hospital between September 2016 and September 2017. Informed consent was obtained from each patient before the study. A south valley university institutional ethics committee approval was obtained. In this study 60 pseudophakic eyes of 58 patients of age range (30-70years) were included. All of the patients had undergone non complicated cataract surgery (phacoemulsification (48eyes) or extracapsular cataract extraction (12 eyes)). All patients had significant vision loss and hazy fundus appearance due to posterior capsular opacification.

Exclusion criteria:

Included previous iridotomy, iris bombe, optic capture, lens dislocation & subluxation, diabetic & hypertensive retinopathy. Every patient were clinically assessed by:

Full history taking: Name, age, sex, duration of blurring of vision, history of the operation of cataract (extracapsuler extraction or phacoemulsification).

Clinical examination of the eye:

Ocular examination with slit lamp biomicroscopy, post-cycloplegic refraction estimation, UCVA, BCVA, IOP measurements and fundoscopy were performed before and three month after Nd: YAG laser capsulotomy. All patients were followed three month after Nd: YAG laser capsulotomy.

The eyes were divided into 4 groups according to size and shape of capsulotomy:

Group 1: Eyes with cruciate shape with opening less than or equal to 3.5mm (15 eyes).

Group 2: Eyes with cruciate shape with opening greater than 3.5 mm (15eyes).

Group 3: Eyes with circular shape with opening less than or equal to 3.5mm (15 eyes).

Group 4: Eyes with circular shape with opening greater than 3.5 mm (15eyes).

The posterior capsulotomies were performed in a single session with an Nd: YAG laser, with capsulotomy contact lenses (Double aspheric capsulotomy lens, Volk, USA). In cruciate shape capsulotomy, laser beam focused on 12 o'clock posterior capsule and capsulotomy done to 6 o'clock then from 3 o'clock to 9 o'clock. In circular maneuver capsulotomy were started peripherally from 3'clock posterior capsule and continue circularly, any residual opacities in the center of the opening treated by laser beam. The spot energy level, total spot count, and total energy use of each patient were recorded. After Nd:YAG laser, topical steroid and Alpha 2 agonist eye drops were prescribed one week to control inflammation & IOP elevation respectively.

Results:

We evaluated a total of 58 patients with 60 eyes diagnosed PCO during the study period. Of the 58 patients, 26 females and 32 males. The mean age of the included patients in the 4 groups was (58.87 ± 9.49 year, 59.53 ± 9.13 year, 56.47 ± 11.42 year &58.60 ± 8.52 year respectively, p=0.933) (range 30-70 years). The mean interval between surgery and Nd:YAG laser capsulotomy in the 4 groups was (2.76 ± 1.34 year, 2.09 ± 1.53 year, 3.04 ± 2.21 year, 2.86 ± 2.77 year respectively, p=0.357) (0.6 - 7.0 years).

Eyes were divided into four groups according to the shape and size of capsulotomy. Groups comprised patients with cruciate shape capsulotomies with openings of less than and equal to 3.5 mm (Group 1) or greater (Group 2) and patients with circular shape capsulotomies with openings of less than and equal to 3.5 mm (Group 3) or greater (Group 4). Pre-procedural and post-procedural mean values of UCVA were (0.09±0.94 – 0.55±0.25logMAR), (0.58±0.70 - 0.57±0.22logMAR), (0.05±1.04 - 0.62±0.21logMAR), (0.34±0.84 - 0.50±0.25logMAR) in the 4 groups respectively & they were not statistically significant (Table 1).

Table (1): UCVA logMAR

UCVA logMAR	Before (n= 15)	After (n= 15)	P-value[1]
Group I:			0.387
Mean ± SD	0.09 ± 0.94	0.55 ± 0.25	
Range	-1.3 - 1.0	0.3 - 1.0	
Group II:			0.106
Mean ± SD	0.58 ± 0.70	0.57 ± 0.22	
Range	-1.1 - 1.0	0.2 - 0.8	
Group III:			0.510
Mean ± SD	0.05 ± 1.04	0.62 ± 0.21	
Range	-1.8 - 1.0	0.2 - 1.0	
Group IV:			0.659
Mean ± SD	0.34 ± 0.84	0.50 ± 0.25	
Range	-1.3 - 1.0	0.2 - 1.0	
P-value[2]	0.138	0.533	

As shown in table 2, Pre-procedural and post-procedural mean values of BCVA were (0.08±0.80 – 0.29±0.16 log MAR), (0.63±0.54-0.35±0.19logMAR), (0.40±0.80 – 0.29±0.16logMAR), (0.41±0.74 - 0.31±0.19logMAR) respectively & they were statistically significant in group 2 (p=0.010) .

Table (2): BCVA logMAR

BCVA logMAR	Before (n= 15)	After (n= 15)	P-value[1]
Group I:			0.875
Mean ± SD	0.08 ± 0.80	0.29 ± 0.16	
Range	-1.3 - 1.0	0.0 - 0.6	
Group II:			0.010*
Mean ± SD	0.63 ± 0.54	0.35 ± 0.19	
Range	-1.1 - 1.0	0.0 - 0.6	
Group III:			0.076
Mean ± SD	0.40 ± 0.80	0.29 ± 0.16	
Range	-1.8 - 1.0	0.0 - 0.5	
Group IV:			0.108
Mean ± SD	0.41 ± 0.74	0.31 ± 0.19	
Range	-1.3 - 1.0	0.0 - 0.6	
P-value[2]	0.090	0.896	

Pre-procedural and post-procedural mean spherical equivalent (SE) values were (0.80±1.91 - 0.15±1.42D), (-1.15±2.17 - 0.28±1.03D), (-0.17 ±1.69- 0.32±2.55D), (-0.77±1.85— 0.67±1.06Diopter) respectively & they were not statistically significant. Pre-procedural and post-procedural mean values of IOP were (19.95±4.67 – 19.49±4.63),(17.96±5.30 – 19.85±5.57), (20.03±4.30-20.40±3.32), (20.80±3.38—23.96±3.39) respectively & they were statistically significant in group 4 (p=0.009) & statistically significant post procedural in all groups (p=0.028).

The mean number and energy of laser firings values were (18.93±7.73), (22.00±8.19), (17.00±8.44), (20.47±9.20) & (2.21±0.40mj), (2.29±037mj), (2.49±0.59mj), (2.12±0.57mj) respectively & they were significantly higher in Group 2 & group 3 respectively (p=0.216 ,p=0.274), with non - statistically significant changes (Table 3). No statistical significance in number of patients reporting floating bodies (33 patients, p=0.297).

Table (3): No. of pulses

No. of pulses	Group I (n= 15)	Group II (n= 15)	Group III (n= 15)	Group IV (n= 15)	P-value
Mean ± SD	18.93 ± 7.73	22.00 ± 8.19	17.00 ± 8.44	20.47 ± 9.20	0.216
Range	8.0 - 30.0	10.0 - 30.0	8.0 - 30.0	5.0 - 30.0	

Discussion

In this study, our aim was evaluation of influence of size & shape of Nd:YAG laser capsulotomy on visual acuity & refraction. There were overall improvement in VA in all groups post procedural. With respect pre & post procedural UCVA outcome there was improvement, values were (p=0.138- p=0.533) which were non statistically significant. Pre & post procedural BCVA outcome was markedly improved (p=0.090- p=o.896) respectively & they showed statistically significant effect on BCVA in group 2 (cruciate capsulotomy >3.5mm in size) p = 0.010. Smaller capsulotomy openings limit visual acuity by diffraction & result in light passing through the unopened region of the capsule being scattered causing glare & decreasing contrast sensitivity **(Holladay et al., 1985)**. Capsulotomy opening should therefore be equal to or larger than the size of the pupil in scotopic conditions **(Patton et al., 2004)**. Capsulotomy openings should be large enough to ensure good visualization of the peripheral fundus particularly in patients with retinal diseases **(Patton et al., 2004). Ruiz-Casas et al.** showed a significant increase in the BCVA up to the third month control after Nd: YAG laser **(Ruiz-Casas et al., 2013).**

Dhillon et al. in the patients studied there was a substantial average improvement in contrast sensitivity, near visual acuity, distance visual acuity and glare disability **(Dhillon et al., 2002).** However, even taking into account the different amounts of PCO in different patients, there was no correlation within the parameters measured of capsulotomy size, eccentricity and shape with eventual improvement in visual function. A small capsulotomy, even if slightly eccentric, should give an improvement in vision that is not significantly different from that obtained with a larger, exactly centrally placed aperture. The aperture does not need to be round in shape. These findings seem to hold true for capsulotomies with diameters greater than 1.25 mm and eccentricity up to 1 mm **(Dhillon et al., 2002).**

In this study there were slight improvement effect in SE refraction (p=0.126) pre-procedural & (p=0.374) post procedural with no statistically significant difference found in SE refraction before and after Nd:YAG laser capsulotomy between all groups of the study. Refractive changes are not affected by size & shape of capsulotomy **(Yilmaz et al., 2006)** found the change in SE refraction to be 0.38 ±0.52 D in the small capsulotomy group and 0.22±0.36 D in the large capsulotomy group and no statistically significant differences were noted in SE refraction change (p=0.47)between the two groups ,and the size of posterior capsulotomy did not significantly affect refraction and the improvement in VA **(Yilmaz et al., 2006)**.

In the current study, IOP showed marked elevation after Nd:YAG laser (p= 0.249 pre procedural & p= 0.028 post procedural) in the all 4 groups which were statistically significant changes, moreover; group 4 (circular shape capsulotomy with size more than 3.5mm) showed higher rise in IOP than the other 3 groups which was statistically significant changes pre & post procedura l (20.80±3.38-23.96±3.39, p=0.009). IOP increased in all patients postoperatively, regardless the size of capsulotomy **(Yilmaz et al., 2006)**. The frequency of increased IOP after Nd:YAG laser capsulotomy is highly variable, ranging from 0.8% to 82% in different studies **(Yilmaz et al., 2006)**.

Floaters were reported from some patients (33 patients, 55%) which were insignificant. Floaters are more frequently reported & the amount of energy used is higher, in circular shape capsulotomies (**Charles, 2001).** In our study we did not observe any complications related to Nd:YAG laser capsulotomy like cystoid macular edema, vitrous prolapse & retinal detachment or posterior IOL dislocation.

Our findings suggest that there was significant improvement in VA in the four groups, with statistically significant improvement effect of cruciate shape capsulotomy with size >3.5mm on BCVA.

Conclusion:

We concluded that the cruciate shape with size more than 3.5 mm capsulotomy openings show better improvement in BCVA than the other groups. Spherical equivalent show slight improvement in all groups which was insignificant.

Limitations:

The limitation of this study was the lack of further correlations between the techniques type, capsulotomy size and IOL types (one piece, three-piece, et cetera), shortness of follow up period and performance by different surgeons. Moreover, the effects of Nd:YAG capsulotomy on the ocular biometric parameters might be further evaluated. Additional studies to investigate the association of these factors with increased number of patients are required to substantiate our results.

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