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Original Article

OBJECTIVE REFRACTION CHANGES AFTER USING ND: YAG LASER IN TREATMENT OF POSTERIOR CAPSULAR OPACIFICATION IN PSEUDOPHAKIC EYES

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Abstract
Background: *Posterior capsule opacification (PCO) is a common complication of cataract surgery caused by the proliferation of residual lens epithelial cells. Nd: YAG laser capsulotomy is the standard treatment, but prior studies on refractive changes after capsulotomy are inconsistent.* ***Aim:*** *To evaluate refractive changes after Nd: YAG laser capsulotomy for PCO in pseudophakic patients.* ***Methods:*** *This prospective interventional case series included 69 eyes of 61 adult patients undergoing capsulotomy for PCO at two centers in Egypt from August 2022 to November 2023. Complete ophthalmic examination and automated refraction were performed before and after treatment. The mean spherical equivalent (SE) and cylindrical refractive errors were compared pre- and post-capsulotomy.* ***Results:*** *The mean SE refractive error showed a statistically significant myopic shift, changing from +0.42D pre-capsulotomy to -0.10D at 1-month post-capsulotomy (p<0.0004). The mean cylindrical error also demonstrated a significant myopic shift, from -1.93D pre-capsulotomy to -2.50D at 1 month (p<0.006). Best corrected visual acuity (BCVA) significantly improved from 0.30 logMAR pre-capsulotomy to 0.70 logMAR post-capsulotomy (p<0.001).* ***Conclusion****: Significant myopic refractive shifts and improved visual acuity were observed after Nd: YAG capsulotomy for PCO. The myopic shift differed from studies showing no change or a hyperopic shift post-capsulotomy. Further studies are needed to clarify the refractive effects of this common treatment*

Keywords: *Nd: YAG laser capsulotomy, posterior capsule opacification, cataract surgery, refractive error, pseudophakia.*

1. Introduction
The human lens is a transparent, biconvex structure located in the anterior segment of the eye that plays a key role in focusing light onto the retina for clear vision. The three main components of the lens are the lens fibers, lens capsule, and lens epithelium [1]. The lens capsule is a basement membrane enveloping the entire lens, while the interior consists primarily of tightly packed, elongated lens fibers extending from the posterior to anterior poles in concentric layers like an onion. The lens epithelial cells form a single cuboidal layer on the anterior capsule which controls ho-

meostatic functions and gives rise to new lens fibers [2]. With aging, the crystalline lens commonly develops opacification known as a cataract, causing visual impairment. Cataract extraction followed by intraocular lens (IOL) implantation is one of the most commonly performed and successful surgical procedures worldwide [3]. During cataract surgery, the cloudy natural crystalline lens is removed and replaced with an artificial IOL implanted inside the capsular bag to restore vision. While IOLs provide excellent visual rehabilitation in most patients, up to 40% develop clouds on the posterior capsule behind the IOL within 5 years after surgery, causing blurred vision again [4]. This post-operative complication is called posterior capsule opacification (PCO) and arises from the proliferation and migration of residual lens epithelial cells left after cataract extraction. PCO is the most frequent long-term complication necessitating additional treatment following otherwise successful cataract surgery and IOL implantation [5]. PCO occurs due to the proliferation, migration, and metaplasia of lens epithelial cells (LECs) remaining in the capsular bag after cataract rem-oval. These LECs can undergo epithelial-to-mesenchymal transition, differentiating into myofibroblasts that produce extracellular matrix proteins leading to collagen deposition and wrinkling on the posterior capsule [6]. The visual symptoms of PCO result from light scattering by the opacified posterior capsule obstructing the visual axis. PCO typically develops 2-5 years after surgery and has an incidence around 20%-40% within the first 5 postoperative years [7]. The standard treatment for clinically significant PCO is neodymium-doped yttrium aluminum garnet (ND:YAG) laser capsulotomy. During this noninvasive outpatient procedure, the laser is used to create a small opening in the opacified posterior capsule behind the IOL optic. This opening clears the visual axis and rapidly restores vision in the majority of patients. While generally safe and effective, potential complications of laser capsulotomy include IOL damage, intraocular pressure spikes, cystoid macular edema, and retinal detachment [8]. Prior studies evaluating refractive changes after ND: YAG capsulotomy for PCO have reported inconsistent results. Some show statistically insignificant hyperopic shifts while others demonstrate small myopic shifts or no significant change. The factors contributing to variable refractive outcomes remain unclear [9]. This study aims to analyze the impact of ND: YAG capsulotomy on objective refraction parameters in pseudophakic patients with PCO. Using precise measurement techniques, we will evaluate the magnitude and direction of refractive changes induced by laser capsulotomy and examine variables affecting these outcomes.

2. Patients and Methods

This prospective interventional case series enrolled 69 eyes of 61 adult patients undergoing Nd:YAG laser capsulectomy for posterior capsule opacification (PCO) at the Ophthalmology Department of Sohag University and Asyut Police Hospital in Egypt from August 2022 to November 2023.

2.1. *The inclusion criteria*

The inclusion criteria were age 20-75 years, ≥6 months since uncomplicated cataract surgery, visually significant central PCO, and clear ocular media. Exclusion criteria were other ocular diseases, high IOP, corneal opacities, dense PCO precluding refraction, and history of ocular surgery other than cataract extraction. Complete ophthalmological examination was performed before and 1 week and 1 month after capsulotomy. Uncorrected (UCVA) and best-corrected visual acuity

(BCVA) were measured using a Snellen chart and converted to LogMAR values. Slit lamp biomicroscopy, IOP measurement, and dilated fundus examination were completed. Objective refraction was measured by automated refractometer before and after laser treat-ment. Nd:YAG capsulotomy was performed in a single session by the same surgeon using a standardized laser technique and parameters. The cruciate pattern was used starting peripherally with a setting of 1-3 mJ to minimize complications, fig. (1).

Figure 1: Nd:YAG laser

2.2. *Ethical Consideration*

This prospective interventional study was conducted in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Review Board at Sohag Faculty of Medicine. Written informed consent was obtained from all participants after discussing the study purpose, procedures, risks and benefits of participation. Participants were informed of their right to withdraw from the study at any time without explanation. Guarantees were provided that all collected information would remain confidential and anonymous. Identifiers were removed during analysis and subjects were assigned unique numeric codes to maintain privacy.

2.3. *Statistical Analysis*

Statistical analysis was performed using SPSS version 23.0 (IBM Corp, Armonk, NY) for Windows. Categorical data were expressed as frequency and percentage. Continuous data were summarized as mean, standard deviation (SD), and range. Paired t-tests were used to compare pre- and post-treatment spherical equivalent and cylindrical refractive error. Wilcoxon signed-rank tests compared refractive data not normally distributed. A P value <0.05 was considered statistically sign-ificant.

3. Results

A total of 69 eyes of 61 patients undergoing Nd:YAG laser capsulotomy for PCO were included. The mean age was 59 ± 9 years, with a range of 55-65 years as shown in Table (1). There were 21 male patients (30.4%) and 48 female patients (69.6%) as displayed in Table (1). The right eye was treated in 32 cases

(46.4%) and the left eye in 37 cases (53.6%) as detailed in Table 2. The mean time from cataract surgery to capsulotomy was 20 ± 10 months per Table (2). Cataract surgery was phaco-emulsification in 64 eyes (92.8%) and extracapsular cataract extraction in 5 eyes (7.2%) as displayed in Table 2.

Table 1: Socio-demographic characteristics of the studied population, n=69

Item		No	%
Gender	***Male***	21	30.4%
	Female	48	69.6%
Age (years)	***Mean ± SD***	59 ± 9	
	(range)	62(55:65)	

Table 2: Clinical and surgical characteristics of the studied population

Parameter		Count	%
Side	***Left***	37	53.6%
	Right	32	46.4%
Date of cataract surgery before YAG months)	***Mean ± SD***	20 ± 10	
Type of cat surgery	***ECCE***	5	7.2%
	Phacoemulsification	64	92.8%

3.1. *Refractive changes*

The mean spherical equivalent refractive error shifted from +0.42 ± 2.19D pre-capsulotomy to +0.01 ± 1.73D at 1 week and -0.10 ± 1.63D at 1-month post capsulotomy, indicating a statistically significant myopic shift (p<0.0004) as shown in tab$_{s.}$ (3 & 4). The mean cylindrical refractive error changed from -1.93 ± 1.92D pre-capsulotomy to -2.62 ± 8.99D at 1 week and -2.50 ± 9.00D at 1-month pos tcapsulotomy, also demonstrating a statistically significant myopic shift (p<0.006) per tab$_{s}$. 3-4. The mean cylindrical axis was 93 ± 46° pre-capsulotomy, 93 ± 46° at 1 week, and 95 ± 46° at 1-month post-capsulotomy, showing no significant change (p=0.1) as detailed in tables 3-4. In the phacoemulsification group (n=64), there were significant myopic shifts in both spherical equivalent (p<0.001) and cylindrical error (p<0.003) but no change in cylindrical axis (p=0.2) as shown in tab. (5). In the ECCE group (n=5), there was a significant myopic sphere shift (p= 0.009) but no significant cylinder or axis changes per table 5. Comparing phacoemulsification versus ECCE, the sphere shift was significantly greater in the phaco group at 1 week and 1 month (p= 0.01) as depicted in Table 5. There was no significant difference in cylinder or axis changes between groups per tab. 5. There was no correlation between gender and refractive changes after capsulotomy as detailed in tab. (6).

Table 3: Refractive changes prior to Nd:YAG laser posterior capsulotomy and 1 week ,1 month after the procedure

Refraction		Mean	SD	Median	IQR	
					Percentile 25	***Percentile 75***
Sphere	***Before procedure***	0.42	2.19	.25	-.75	1.00
	1 week after procedure	0.01	1.73	.00	-1	.50
	1 month after procedure	-0.1	1.63	.00	-1	.50
P value	**<0.0004**					
Cylinder	***Before procedure***	-1.93	1.92	-2	-3	-1
	1 week after procedure	-2.62	8.997	-1.5	-2.5	-1
	1 month after procedure	-2.5	9.00	-1.25	-2.25	-.75

P value	**<0.006**					
Axis	***Before procedure***	93	46	95	70	120
	1 week after procedure	93	46	90	70	120
	1 month after procedure	95	46	91	73	120
P value	**0.1**					

Table 4: Multiple comparisons of refractive changes at different time intervals

		Mean	SD	SE	
Pair 1	**Spherical refraction before procedure**	.4203	2.19479	.26422	0.002
	Spherical refraction 1 week after the procedure	.0109	1.72803	.20803	
Pair 2	**Spherical refraction before procedure**	.4203	2.19479	.26422	<0.002
	Spherical refraction 1 month after the procedure	-.097	1.62710	.19588	
Pair 3	**Spherical refraction 1 week procedure**	.0109	1.72803	.20803	0.03
	Spherical refraction 1 month after the procedure	-.097	1.62710	.19588	
Pair 4	**Cylinder refraction before procedure**	-1.931	1.91975	.23111	0.5
	Cylinder refraction 1 week after the procedure	-2.62	8.997192	1.083135	
Pair 5	**Cylinder refraction before procedure**	-1.93	1.91975	.23111	0.5
	Cylinder refraction 1 month after the procedure	-2.49	9.00315	1.08385	
Pair 6	**Cylinder refraction 1 week procedure**	-2.62	8.997192	1.083135	0.9
	Cylinder refraction 1 month after the procedure	-2.49	9.00315	1.08385	
Pair 7	**Axis refraction before procedure**	92.10	45.828	5.599	0.9
	Axis refraction 1 week after the procedure	92.55	45.801	5.595	
Pair 8	**Axis refraction before procedure**	92.96	46.023	5.581	0.5
	Axis refraction 1 month after the procedure	94.91	45.665	5.538	
Pair 9	**Axis refraction 1 week procedure**	92.55	45.801	5.595	0.07
	Axis refraction 1 month after the procedure	94.09	45.500	5.559	

Table 5: Comparison between ECCE & phacoemulsification as regard refractive changes before and after the procedure.

		ECCE	**Phacoemulsification**	**P value**
		Mean ± SD ***Median (IQR)***		
Sphere	***Before procedure***	3.45 ± 1.95 3.25 (2: 4.75)	0.18 ± 2.04 0.25 (-0.75: .88)	0.001
	1 week after procedure	1.85 ± 1.73 1.5 (.50: 2.50)	-.13 ± 1.66 0 (-1: 0.5)	0.01
	1 month after procedure	1.65 ± 1.65 1 (.5: 2.25)	-0.23 ± 1.56 -.13 (-1:.38)	0.01
P1 value		0.009	<0.001	
Cylinder	***Before procedure***	-5 ± 0.85 -5.25 (-5.5: -4.25)	-1.69 ± 1.77 -1.75 (-2.75: -1)	<0.001
	1 week after procedure	-4.650 ± 0.962 -5 (-5.5: -3.750)	-2.46 ± 9.33 -1.5 (-2.25: -.750)	0.6
	1 month after procedure	-4.45 ± 1.2 -4.75 (-5: -3.50)	-2.35 ± 9.33 -1.25 (-2: -.75)	0.6
P1 value		0.1	<0.003	
Axis	***Before procedure***	111 ± 18 110 (105: 110)	92 ± 47 95 (67 :120)	0.3
	1 week after procedure	101 ± 24 90 (90: 105)	92 ± 47 90 (65 ± 120)	0.6
	1 month after procedure	103 ± 23 92 (90: 110)	94 ± 47 90 (70: 120)	0.6
P1 value		0.1	0.2	

Table 6: Comparison between males & females as regard refractive changes before and after the procedure

		Males N=21	Females N= 48	P value
		Mean ± SD *Median (IQR)*		
Sphere	*Before procedure*	.65 ± 2.39 .75 (-.5: 1.75)	.32 ± 2.12 .13 (-.75: .75)	0.5
	1 week after procedure	.06 ± 1.98 .25 (-.25: .75)	-.01 ± 1.63 0 (-1: .38)	0.8
	1 month after procedure	-.24 ±1.82 0 (-.5: .75)	-.04 ± 1.55 -.13 (-1: .25)	0.6
P1 value		0.005	<0.004	
Cylinder	*Before procedure*	-1.33 ±2.32 -1.75 (-2: -1)	-2.19- ± 1.67 -2.25 (-3: -1.25)	0.08
	1 week after procedure	-1.119 ±1.95 -1.25 (-2.25: -.5)	-3.28 ±10.679 -1.63 (-2.6: -1)	0.3
	1 month after procedure	-4.49 ±16.26 -1.25 (-2.25: -.5)	-1.63 ± 1.49 -1.5 (-2.38: -.75)	0.2
P1 value		0.1	<0.004	
Axis	*Before procedure*	83 ±50 80 (55: 100)	97 ± 43 98 (82: 120)	0.2
	1 week after procedure	96 ±43 90 (76: 125)	91 ± 47 93 (65 ± 118)	0.6
	1 month after procedure	98 ± 44 90 (80: 120)	93 ± 47 95 (63: 120)	0.6
P1 value		0.1	0.1	

3.2. *Visual acuity*

Mean BCVA improved significantly from 0.30 ± 0.20 logMAR pre-capsulotomy to 0.70 ± 0.20 logMAR post-capsulotomy (p<0.001) as shown in tab. (7). In the ph-acoemulsification subgroup, mean BCVA increased from 0.36 ± 0.14 to 0.67 ± 0.16 (p<0.001) per tab. (8). In the ECCE subgroup, it improved from 0.16 ± 0.05 to 0.40 ± 0.05 (p=0.002) as depicted in tab. 8. The visual acuity improvement was significantly greater in the phaco versus ECCE group (p=0.003) as detailed in tab. 8. No significant difference in BCVA change was found between gen-ders per tab. (9).

Table 7: BCVA before and after the procedure

	Mean	SD	Median	Percentile 25	Percentile 75
BCVA before procedure	**.3**	**.2**	**.4**	**.2**	**.5**
BCVA after procedure	**.7**	**.2**	**.7**	**.5**	**.8**
P value	<0.001				

Table: BCVA before and after the procedure between ECCE & phacoemulsification groups

Parameter	ECCE		Phacoemulsification		p-value
	Mean ± SD	*Median (IQR)*	*Mean ± SD*	*Median (IQR)*	
Pre-procedure BCVA	0.16 + .05	.2 (.1: .2)	.36 +.14	.4 (.3: .5)	0.003
Post-procedure BCVA	.4 + .05	.4 (.4: .5)	.67 + .16	.7 (.6: .8)	0.003
P1 value	0.002		<0.007		

Table 9: BCVA before and after the procedure between males & females

parameter	Males		Females		p-value
	Mean ± SD	*Median (IQR)*	*Mean ± SD*	*Median (IQR)*	
Pre-procedure BCVA	0.3+ .2	.3(.2: .4)	.4 +.1	.4 (.3: .5)	0.2
Post-procedure BCVA	.6+ .1	.6(.5: .7)	.7 + .2	.7 (.6: .8)	0.08

4. Discussion

PCO remains a significant long-term complication following cataract surgery [5]. Our study and others have found reported incidence rates of over 20% at two years and nearly 30% at five years [1]. Nd: YAG laser capsulotomy is the standard nonsurgical treatment for restoring vision lost due to PCO by creating an opening in the posterior capsule [6,7]. However, the procedure can cause potential complications in 10-20% of cases such as slightly increased IOP in the early postoperative period, rare but serious issues like IOL damage, dislocation or decomposition [10,11], and occasional cases of intraocular inflammation, cystoid macular edema, retinal tear or detachment. Careful patient counseling regarding risks is therefore warranted. We investigated the refractive outcomes of Nd: YAG capsulotomy in 69 eyes and found statistically significant myopic shifts in both refractive sphere and cylinder. While other research supports these findings of a myopic refractive change [12], some disparities exist. Ramachandra and Kur-iakose [13] reported a hyperopic shift, and Khambhiphant et al [14] found no significant change. There was also no consistent agreement on refractive cylinder axis changes - our study showed no significant shift whereas Vrijman et al. [9] found minimal changes. Some studies even reported no refractive alterations at all following capsulotomy [15]. The reason for these discrepancies in refractive sphere and cylinder findings between studies is unclear but could be related to differences in sample populations, surgeon experience and technique, capsulotomy parameters, biometry equipment and methodology, or timing of postoperative refraction assessment. For instance, using a larger laser spot size or higher energy level may cause a more posterior IOL shift and induce greater hyperopic change [15]. A key advantage of Nd:YAG laser capsulotomy, demonstrated across numerous studies including ours, is the significant improvement in BCVA that reliably occurs following the restoration of optical clarity behind the IOL [13,14,16,17]. Gains in visual acuity were consistently reported, alleviating visual decline from non-clearing PCO. Some studies found over 70% of patients gained 3 or more lines of vision on the Snellen eye chart [13,14,16,17]. While capsulotomy effectively resolves PCO in the great majority, careful refraction both pre- and postoperatively allows for optimizing refractive correction, as myopic shifts were a common tendency [13], Information should be provided on the variable refractive outcomes possible to set patient expectations. Future efforts evaluating the influence of surgical factors may help better predict refractive alterations [8].

5. Conclusion

our study found significant myopic shift in refractive sphere and cylinder following Nd:YAG laser capsulotomy, while best corrected visual acuity significantly improved. No hyperopic shift resulted, contradicting concerns about IOL displacement backward. The myopic shift differed from most prior studies showing no refractive change after treatment or reporting a hyperopic shift. Possible explanations include the laser affecting refractive structures like the lens zonules or ciliary body to induce a myopic shift. Capsulotomy may also allow for changes in pseudophakic accommodation by reducing capsular elasticity that drags the IOL slightly towards the anterior capsule. However, the study was limited by its small sample size from a single center, which may not accurately represent the broader population. Additionally, the short-term follow up may not capture longterm refractive effects. Larger, multi-center studies with randomized designs and long-term follow up are needed to confirm the mechanisms underlying refractive changes after Nd:YAG capsulotomy.

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