RESEARCH PAPER

Comparative Analysis of Refractive Changes Post-Nd: YAG Laser Capsulotomy in Rigid versus Foldable Intraocular Lens Implantation Following Manual Small Incision Cataract Surgery

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ABSTRACT

Purpose: *To investigate the refractive changes following Nd: YAG laser capsulotomy in patients with posterior capsular opacification(PCO) after small incision cataract surgery, comparing outcomes between those with rigid intraocular lenses (IOLs) and foldable IOLs.* ***Methodology****: This prospective observational study included 45 patients who developed PCO after cataract surgery. Patients were divided into two groups based on the type of IOL implanted: rigid IOLs and foldable IOLs. Refractive status and visual acuity were assessed before and after Nd: YAG laser capsulotomy.* ***Results:*** *The study observed significant improvements in visual acuity in both groups post-capsulotomy($p<0.05$). However, the degree of refractive change differed between the rigid and foldable IOL groups. Rigid IOLs showed a higher incidence of refractive shifts compared to foldable IOLs($p<0.001$), indicating a potential advantage of foldable IOLs in maintaining stable refractive outcomes post-capsulotomy($p<0.05$).* ***Conclusions:****Nd: YAG laser capsulotomy effectively restores vision in patients with PCO after SICS. Foldable IOLs demonstrate more stable refractive outcomes compared to rigid IOLs, suggesting their preferred use in cataract surgery to minimise post-operative refractive changes.*

KEYWORDS*: Nd: YAG laser capsulotomy, intraocular lens (IOL), rigid IOL, foldable IOL,* ***Small Incision Cataract Surgery (SICS).***

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.INTRODUCTION

Cataracts are a leading cause of blindness worldwide[1]. Cataract surgeries are the most frequent surgeries in Ophthalmology. When cataract surgery is performed, the most frequent long-term consequence that results in vision impairment is posterior capsular opacification (PCO). The purpose of this study is to compare the incidence of Nd: YAG (Neodymium-doped yttrium aluminium garnet) laser capsulotomy needed for patients with rigid versus foldable intraocular lenses (IOLs) to investigate the impact of various IOL characteristics on PCO.

Age-related cataracts stand as a pervasive health issue globally, with estimates suggesting that they affect approximately 90% of individuals aged 65 or older in developed countries and a significant proportion in developing regions as well [2]. As populations continue to age and life expectancies rise, the burden of cataract-related vision loss is expected to escalate, underscoring the importance of an effective treatment strategy[3]. Cataract surgery has evolved into one of the most commonly performed surgical procedures worldwide, with over 20 million surgeries conducted annually[4]. This procedure not only restores vision but also significantly enhances patients' quality of life, enabling them to regain independence and engage in daily activities more comfortably.

Even with the high success rates of cataract surgery, up to 50% of patients experience PCO after five years of the procedure [4]. PCO, or posterior capsular opacification, is a condition that results in visual impairments and the need for additional procedures to restore vision. It is caused by the growth and migration of remaining lens epithelial cells onto the posterior capsule. Nd: YAG (Neodymium-doped yttrium aluminium garnet) laser capsulotomy has become the most important and standard treatment for Posterior Capsular Opacification, offering a minimally invasive means of improving visual function by creating an opening in the opacified posterior capsule [5].

Recently main consideration has been towards understanding the role of intraocular lens (IOL) characteristics in influencing PCO (Posterior Capsular Opacification) development and post-operative visual outcomes[6]. Several parameters that modulate the interaction between the Intraocular Lens (IOL) and the capsular bag influence PCO incidence and severity. These factors include material composition, optic edge design, and haptic configuration[7]. Additionally, advancements in Intraocular Lens technology have introduced foldable IOLs, which offer enhanced flexibility and ease of implantation compared to traditional rigid IOLs (Intraocular Lens)[8,9].

This study contributes by examining the effects of different IOL(Intraocular Lens) characteristics that cause PCO (Posterior Capsular Opacification) incidence and visual outcomes following cataract surgery. By comparing the outcomes of patients implanted with rigid versus foldable IOLs, we aim to elucidate whether certain Intraocular Lens types are associated with a lower risk of Posterior Capsular Opacification (PCO) development and greater post-operative stability in refractive outcomes.

Materials and Methods

Patients who had cataract surgery and later acquired PCO were enrolled in a prospective observational research. The study was conducted from November 2023 to April 2024. A total of 45 eyes were enrolled in the study and divided into 2 groups - rigid IOL and foldable IOL. Demographic data, duration and type of cataract surgery and associated comorbidities were noted. Best Corrected Visual Acuity(BCVA), Intraocular pressure and objective refraction(Spherical equivalent and residual astigmatism) were assessed and compared in both groups before and after Laser capsulotomy.

Statistical analysis was performed using SPSS version 26. Necessary descriptive and analytical statistics were carried out for continuous, categorical variables. A paired t-test was performed to compare the mean refractive changes between the 2 groups before and after laser capsulotomy. p-value < 0.05 was considered to be statistically significant.

Results

A Total of 45 eyes were enrolled for this study and divided into Group 1 with Rigid IOL (n= 21, Right eye: 10, Left eye: 11) and Group 2 with foldable IOL (n=24, Right eye: 12, Left eye: 12). The mean age (in years) for patients in Group 1 is 48.6±5.7 and group 2 is 49.2 ±6.3. The male-to-female ratio in Group 1 is 8:13 and foldable IOL is 11:13.The mean duration of presentation after surgery (in years) for Rigid IOL is 1.7± 1.3 and Foldable IOL is 2.2 ± 1.4.

TABLE 1: *DEMOGRAPHIC AND SURGICAL DATA OF THE PARTICIPANTS*

Paremeters	Rigid IOL group	Foldable IOL group
Number of eyes	21	24
Age (in years)	48.6±5.7	49.2±6.3
Sex (Male: Female)	8:13	11:13
Laterality: Right Left	10 11	12 12
Duration of presentation after surgery(in years)	1.7 ± 1.3	2.2 ± 1.4

Visual acuity before laser in Group 1 patients is 0.50 ± 0.19 and in Group 2 patients 0.48±0.14 (P=0.225). Visual acuity after laser in Group 1 patients is 0.06 ±0.06, and in Group 2 patients is 0.05 ± 0.05(P=0.438). There is no significant intergroup variation in visual acuity before or after laser use.

Visual acuity was correlated within the 2 groups before and after laser therapy. The visual acuity in patients with Rigid IOL before the laser is 0.50± 0.19 and after the laser is 0.06± 0.06 (P <0.001). The visual acuity in patients with Foldable IOL before the laser is 0.48 ± 0.14 and after the laser is 0.05± 0.05 (P<0.003). It was found to be statistically significant.

TABLE 2: *VISUAL ACUITY IN BOTH GROUPS*

Visual Acuity	Group 1 Rigid IOL n=21	Group 2 Foldable IOL n=24	P value
Before Laser	0.50 ± 0.19	0.48 ± 0.14	0.225
After laser	0.06 ± 0.06	0.05 ± 0.05	0.438

Objective refractive parameters in both groups were analysed. The residual Spherical component in Objective refraction at presentation in Group 1 patients is +1.75±0.50D, and in Group 2 patients is +2.00 ± 0.75D (P=0.051). The residual cylindrical values (Astigmatism) on presentation were -1.25 ± 0.30D, Group 2 patients were -1.50 ± 0.40D with (P=0.04*). The Spherical component after laser in Group 1 patients is +0.50 ±0.20D, and in Group 2 patients is +0.75 ± 0.30D (P=0.036*). The residual astigmatism value after the laser changed to -0.75 ± 0.25D in gruop 1 and -1.00 ± 0.35D in group 2 patients with (P=0.85). Correlation of refractive parameters before and after laser therapy within the 2 groups was done. In group 1, The residual spherical value is +1.75 ± 0.50D before and after the laser is +0.50 ± 0.20D (P<0.001). The residual astigmatism in group 1 changed from -1.50 ± 0.30D before the laser to -1.00 ± 0.25D after the laser (P<0.001). The spherical equivalent in group 2 patients before laser is +2.00 ± 0.75D and after laser +0.75 ± 0.30D (P<0.001). The residual astigmatism in group 2 before the laser is -1.25 ± 0.40D and after the laser is -0.75 ± 0.35D with a (P<0.001).

OBJECTIVE REFRACTIVE PARAMETERS IN BOTH GROUPS

REFRACTIVE PARAMETER	Group 1 Rigid IOL n=21	Group 2 Foldable IOL n=24	P value
Spherical Equivalent Before laser	+1.75 ± 0.50 D	+2.00 ± 0.75 D	0.051
Astigmatism before laser	-1.25 ± 0.30 D	-1.50 ± 0.40 D	0.04*
Spherical Equivalent After Laser	+0.50 ± 0.20 D	+0.75 ± 0.30 D	0.036*
Astigmatism After Laser	-0.75 ± 0.25 D	-1.00 ± 0.35 D	0.085

**p* <0.05. Statistically Significant*

CORRELATION ANALYSIS:

TABLE 4: CORRELATION OF VISUAL ACUITY BEFORE AND AFTER LASER THERAPY WITHIN THE 2 GROUPS

Visual Acuity	Before Laser	After Laser	P value
Rigid IOL	0.50 ± 0.19	0.06 ± 0.06	<0.001*
Foldable IOL	0.48 ± 0.14	0.05 ± 0.05	0.003*

p <0.05. Statistically Significant

TABLE 5: CORRELATION OF REFRACTIVE PARAMETERS BEFORE AND AFTER LASER THERAPY WITHIN THE 2 GROUPS

REFRACTIVE PARAMETER	BEFORE LASER	AFTER LASER	P VALUE
Spherical Equivalent in RIGID IOL	+1.75 ± 0.50 D	+0.50 ± 0.20 D	<0.001*
Spherical Equivalent in FOLDABLE IOL	+2.00 ± 0.75 D	+0.75 ± 0.30 D	<0.001*
Astigmatism in RIGID IOL	-1.50 ± 0.30 D	-1.00 ± 0.25 D	<0.001*
Astigmatism in FOLDABLE IOL	-1.25 ± 0.40 D	-0.75 ± 0.35 D	<0.001*

** p <0.05. Statistically Significant (Paired Samples t-test)*

Discussion

Small-incision cataract surgery restores sight, but posterior capsular opacification (PCO) can cloud it again, often requiring Nd:YAG laser. Lens selection shapes that risk. Rigid IOLs need wide cuts, stir inflammation, and may shift after laser pulses. Foldable lenses slide through micro-incisions, irritate the capsule less, and usually keep their power, trimming PCO rates and spectacle needs. Downsides? Higher price and occasional yellowing of low-grade models in tropical heat. Still, where clinics already own a YAG unit, the extra cost often secures steadier, longer-lasting clarity, though long-term follow-up remains essential for maintaining outcomes.

Material Composition and PCO Risk:

The material composition of the Intraocular Len (IOL) has been implicated in influencing the incidence and severity of PCO. Traditional rigid IOLs, typically crafted from polymethyl methacrylate (PMMA), have long been associated with a higher risk of PCO formation compared to modern foldable IOLs[10]. The inherent stiffness of PMMA may contribute to increased capsular bag contraction and epithelial cell migration, facilitating PCO development [7].

In contrast, foldable IOLs constructed from flexible materials such as silicone or hydrophobic acrylic demonstrate improved biocompatibility and adaptability to the capsular bag environment, potentially reducing the risk of PCO[11] .

Optic Edge Design and PCO Prevention:

The design of the IOL optic edge plays a crucial role in preventing posterior capsular opacification (PCO) by minimising the migration of the epithelial cells of the lens on the posterior capsule. Enhanced square-edge designs have been shown to create a barrier that impedes cell migration, thereby reducing the incidence of PCO [12]. Additionally, innovative edge designs incorporating features such as sharp angulation or hydrophilic properties may further mitigate PCO risk by promoting capsular bag adherence and inhibiting cell proliferation [13]. By optimizing optic edge characteristics, manufacturers can offer IOLs with superior PCO prevention properties, enhancing long-term visual outcomes for patients undergoing cataract surgery.

Haptic Configuration and Capsular Bag Stability:

The haptic configuration of the IOL influences its stability within the capsular bag and may impact PCO development. Haptic designs that ensure proper fixation and centration of the IOL are essential for maintaining capsular bag integrity and minimizing potential sources of inflammation or fibrosis[14] . Moreover, flexible haptic materials that conform to the capsular bag contour can reduce mechanical stress and prevent capsular bag distortion, thereby reducing the risk of PCO. By optimizing haptic design and material properties, manufacturers can enhance IOL stability and minimize the likelihood of PCO occurrence, contributing to improved patient outcomes post-cataract surgery.

Future Directions in IOL Technology:

Advancements in IOL technology continue to drive innovation in the field of cataract surgery, with a focus on optimizing visual outcomes and minimizing post-operative complications.

Emerging trends include the development of bioactive IOL materials that inhibit cell adhesion and proliferation, thereby reducing PCO risk [15]. Additionally, customizable IOLs with adjustable optics or multifocal designs offer the potential for tailored visual correction and enhanced patient satisfaction . By harnessing these technological advancements, clinicians can further refine surgical techniques and optimize patient outcomes in the era of precision medicine.

Demographic data

A study was done with patients who had Rigid IOL and Foldable IOL implantation . A Total of 45 eyes were enrolled for this study . Group 1 included patients with Rigid IOL (n= 21, Right eye: 10, Left eye: 11) and Group 2 with foldable IOL (n=24, Right eye: 12, Left eye: 12). The mean age (in years) for patients in Group 1 is 48.6±5.7 and group 2 is 49.2 ±6.3. The male-to-female ratio in Group 1 is 8:13 and foldable IOL is 11:13.The mean duration of presentation after surgery (in years) for Rigid IOL is 1.7± 1.3 and Foldable IOL is 2.2 ± 1.4.

Visual outcome

Visual acuity was correlated within the 2 groups before and after laser therapy. There is no significant intergroup variation in visual acuity before or after laser use and is statistically significant.Correlation of refractive parameters before and after laser therapy within the 2 groups was done. The residual Spherical component in Objective refraction at presentation in Group 1 patients is +1.75±0.50D, and in Group 2 patients is +2.00 ± 0.75D (P=0.051). The residual cylindrical values (Astigmatism) on presentation were -1.25 ± 0.30D, Group 2 patients were -1.50 ± 0.40D with (P=0.04*). The Spherical component after laser in Group 1 patients is +0.50 ±0.20D, and in Group 2 patients is +0.75 ± 0.30D (P=0.036*). The residual astigmatism value after the laser changed to -0.75 ± 0.25D in gruop 1 and -1.00 ± 0.35D in group 2 patients with (P=0.85). Correlation of refractive parameters before and after laser therapy within the 2 groups was done. In group 1, The residual spherical value is +1.75 ± 0.50D before and after the laser is +0.50 ± 0.20D (P<0.001). The residual astigmatism in group 1 changed from -1.50 ± 0.30D before the laser to -1.00 ± 0.25D after the laser (P<0.001). The spherical equivalent in group 2 patients before laser is +2.00 ± 0.75D and after laser +0.75 ± 0.30D (P<0.001). The residual astigmatism in group 2 before the laser is -1.25 ± 0.40D and after the laser is -0.75 ± 0.35D with a (P<0.001).

Conclusion:

In conclusion, the choice of intraocular lens (IOL) type plays a critical role in influencing posterior capsular opacification (PCO) risk and post-operative refractive stability following cataract surgery. Modern foldable IOLs, characterized by flexible materials, enhanced optic edge designs, and optimized haptic configurations, offer superior biocompatibility and PCO prevention properties compared to traditional rigid IOLs. Clinicians can maximize long-term visual results for patients following cataract surgery and reduce the need for subsequent procedures like Nd: YAG laser capsulotomy by utilizing these developments in IOL technology. Nd: YAG (Neodymium-doped yttrium aluminium garnet) laser capsulotomy is an effective intervention for restoring vision in patients with PCO following cataract surgery. This study demonstrates that foldable IOLs are associated with more stable refractive outcomes compared to rigid IOLs, making them a preferable choice for cataract surgery to minimize post-operative refractive changes.

REFERENCES

1. Awareness on cataract among elderly women- A survey. *Int J Pharm Res*. 2020;12(02). doi:10.31838/ijpr/2020.12.02.373
2. Khairallah M, Kahloun R, Bourne R, et al. Number of People Blind or Visually Impaired by Cataract Worldwide and in World Regions, 1990 to 2010. *Invest Ophthalmol Vis Sci*. 2015;56(11):6762-6769.
3. Resnikoff S, Pascolini D, Etya'ale D, et al. Global data on visual impairment in the year 2002. *Bull World Health Organ*. 2004;82(11):844-851.
4. Brian G, Taylor H. Cataract blindness--challenges for the 21st century. *Bull World Health Organ*. 2001;79(3):249-256.
5. Apple DJ, Solomon KD, Tetz MR, et al. Posterior capsule opacification. *Surv Ophthalmol*. 1992;37(2):73-116.
6. Zarepour A, Rafati N, Khosravi A, Rabiee N, Iravani S, Zarrabi A. MXene-based composites in smart wound healing and dressings. *Nanoscale Adv*. 2024;6(14):3513-3532.
7. Findl O, Buehl W, Bauer P, Sycha T. Interventions for preventing posterior capsule opacification. *Cochrane Database Syst Rev*. 2010;2010(2):CD003738.
8. Karahan E, Er D, Kaynak S. An Overview of Nd:YAG Laser Capsulotomy. *Med Hypothesis Discov Innov Ophthalmol*. 2014;3(2):45-50.
9. Hemalathaa R, Suryapriya R, Divya N, Keerthika E, Tamil SB, Ananthi N. Correlation Between Serum and Tear Fluid Interleukin 6 Levels in Day and Night Shift Health Care Workers. *Biomedical and Pharmacology Journal*. 2024;17(2):1239-1247.
10. Wormstone IM, Wang L, Liu CSC. Posterior capsule opacification. *Exp Eye Res*. 2009;88(2):257-269.
11. Nishi O, Nishi K. Preventing posterior capsule opacification by creating a discontinuous sharp bend in the capsule. *J Cataract Refract Surg*. 1999;25(4):521-526.
12. Nishi O, Nishi K, Wickström K. Preventing lens epithelial cell migration using intraocular lenses with sharp rectangular edges. *J Cataract Refract Surg*. 2000;26(10):1543-1549.
13. Konopińska J, Młynarczyk M, Dmuchowska DA, Obuchowska I. Posterior Capsule Opacification: A Review of Experimental Studies. *J Clin Med Res*. 2021;10(13). doi:10.3390/jcm10132847
14. Pandey SK, Apple DJ, Werner L, Maloof AJ, Milverton EJ. Posterior capsule opacification: a review of the aetiopathogenesis, experimental and clinical studies and factors for prevention. *Indian J Ophthalmol*. 2004;52(2):99-112.
15. Vock L, Menapace R, Stifter E, Georgopoulos M, Sacu S, Bühl W. Posterior capsule opacification and neodymium:YAG laser capsulotomy rates with a round-edged silicone and a sharp-edged hydrophobic acrylic intraocular lens 10 years after surgery. *J Cataract Refract Surg*. 2009;35(3):459-465.