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Original Research Article

Estimation of mean Nd: yag laser capsulotomy energy level for posterior capsular opacification- Our experience of 76 patients in rural setup

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Abstract

Background: Posterior capsular opacification (PCO), commonly known as "after cataract" or secondary cataract, is a frequent complication following cataract surgery with intraocular lens (IOL) implantation. It occurs when lens epithelial cells proliferate, migrate, and transform into fibroblasts, leading to the formation of an opaque secondary membrane. PCO can cause vision impairment, glare, and monocular diplopia by obstructing or scattering light. Early treatment with Nd:YAG laser capsulotomy has improved outcomes, though complications remain a concern.

Aim: The aim of this study is to determine the Nd:YAG laser capsulotomy energy level in millijoules (mJ), required to achieve a clear visual axis in patients diagnosed with posterior capsule opacification (PCO).

Materials and Methods: The study comprised 76 eyes of patients who had undergone cataract surgery via routine extracapsular cataract extraction (ECCE) or phacoemulsification with intraocular lens implantation. All patients presented with posterior capsule opacification and underwent Nd:YAG capsulotomy at the Department of Ophthalmology, N.C. Medical College, Panipat, between January 2023 and December 2023.

Results: Out of the 76 eyes treated for posterior capsular opacification (PCO) with Nd:YAG laser, the maximum energy required ranged from 1.2 to 10.0 mJ, with a mean of 2.9 mJ. The range of pulse shots varied from 4 to 34, with a mean of 14, which falls within a safe range, thereby minimizing the rate of complications.

Conclusion: The Nd:YAG laser treatment is indeed an effective method for improving vision hindered by posterior capsular opacification (PCO). However, it's important to note that it's not without complications. Therefore, it's advisable to be mindful of the energy level used during treatment to prevent any potential damage to ocular tissues and minimize the risk of complications.

Keywords: Posterior capsule opacification, visual axis, Nd:YAG laser capsulotomy, Energy level.

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1. Introduction

Posterior capsular opacification (PCO), also referred to as "after cataract" or secondary cataract, is a common complication that arises after cataract surgery with PCIOL implantation.[1] The name PCO is somewhat misleading because the capsule itself does not become opaque; instead, the opacity is caused by the migration of equatorial capsular epithelial cells towards the posterior capsule. PCO develops when lens epithelial cells proliferate, transform into fibroblasts with contractile properties, and deposit collagen, leading to the formation of an opaque secondary membrane.[2] PCO is the most prevalent delayed complication following cataract surgery, resulting in reduced vision, glare, and symptoms resembling the original cataract. It impairs visual acuity and contrast sensitivity by blocking or scattering light, which patients experience as glare. Additionally, PCO narrows the field of view during diagnostic and therapeutic procedures and can lead to monocular diplopia.[3]

Posterior capsular opacification (PCO) usually manifests in three distinct forms: thin membranous, the ring of Sommerring, and Elschnig pearls, which form a dense or fibrous membrane. The most prevalent type is the

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membranous form, characterized by capsular wrinkling due to the myofibroblastic differentiation of migrating epithelial cells that develop contractile properties. The precise trigger for the proliferation, migration, and metaplasia of lens epithelial cells remains unclear. Another significant form of PCO involves the formation of Elschnig pearls and bladder cells, typically occurring months to years after surgery. The term Hirschberg-Elschnig pearls, introduced by Elschnig in 1911, describes a phenomenon where surgical trauma leads to the rupture of the anterior lens capsule, allowing disrupted lens epithelial cells to escape through the tear into the aqueous humor and settle on the iris and other anterior segment structures. Clinically, these cell clusters resemble pearls when viewed through a slit lamp examination.[4]

The rate of PCO formation is influenced by various factors, including the type of surgery performed (either ECCE or phacoemulsification), the patient's age, the surgeon's expertise, the type of lens implanted, and the time elapsed since the surgery. PCO is more prevalent in younger patients and those with uveitis or traumatic cataracts. Studies have shown that the incidence of PCO is 20.7% at two years and 28.5% at five years post-cataract surgery.[5]

With the introduction of the neodymium yttrium aluminum garnet (Nd:YAG) laser in the early 1980s, treating PCO became significantly easier.[6] The Nd:YAG laser, which operates at a wavelength of 1064 nm, works on the principle of photodisruption.[7] When the laser is precisely focused and delivered in a short burst, it causes ionization of atoms at the focal point due to the intense electromagnetic field. This ionized state of the tissue, known as plasma, can reach temperatures up to 15,000°C, creating acoustic and mechanical shock waves that disrupt the tissue.[8] This mechanism underlies the laser's microsurgical capabilities. The procedure clears the visual axis by creating a central opening in the opacified posterior capsule.[9] This is done by focusing a Nd:YAG laser pulse, with energy levels of a few millijoules and a duration of a few nanoseconds, just behind the posterior capsule.

Although Nd:YAG laser capsulotomy is widely accepted as the standard treatment for posterior capsular opacification (PCO) and is generally considered safe and effective, it is not without potential complications, some of which can be sight-threatening, such as retinal edema and detachment.[10] Several studies have documented various risks associated with the procedure, including intraocular lens (IOL) damage, increased intraocular pressure (IOP), glaucoma, retinal hemorrhage, iritis, vitreous prolapse, corneal injury, vitritis, pupil blockage, hyphema, cystoid macular edema, retinal detachment, IOL dislocation, and exacerbation of endophthalmitis.[11-15] Researchers have observed that adverse effects may be more pronounced with higher single-pulse energy compared to higher total energy levels.[16,17] Numerous studies have explored damage rates and thresholds for different lens materials.

2. Materials and Methods

The study was a retrospective analysis of all patients with posterior capsular opacification (PCO) who visited the ophthalmology outpatient department (OPD) at NC Medical College and Hospital, Israna, at least six months after undergoing uncomplicated cataract surgery. The study covered a period of 12 months, from January 2023 to December 2023, and included a total of 76 patients.

2.1. Inclusion criteria

1. All patients with posterior capsular opacification (PCO) who attend the ophthalmology outpatient department (OPD) are seen after a minimum period of 6 months following uncomplicated surgery.

2.2. Exclusion criteria

1. Patients with previous ocular surgery.
2. Patients with congenital glaucoma, primary open angle glaucoma, angle closure glaucoma, pigmentary glaucoma, in exfoliation syndrome associated glaucoma, or secondary glaucoma

After obtaining informed consent, all patients underwent a comprehensive ophthalmic examination. This included slit-lamp examination, assessment of uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), and noncontact tonometry (NCT), fundus with 90D lens and indirect ophthalmoscopy. Fundoscopy was performed to rule out any retinal problem hampering the visual disability. The type and extent of PCO was carefully noted after mild pupillary dilation.

2.3. Grading criteria

The grading of PCO was conducted based on slit-lamp examination using a scale from grade 0 to 4. Following our own investigations into the impact of PCO on visual function, we adopted a protocol similar to that described by Kruger et al.,[18] utilizing a grading system ranging from 0 to 3 to assess capsule opacification. The criteria applied for grading were:

0- Absent; 1 - very mild; 2 – moderate; 3 - dense white

Procedure followed for capsulotomy was:

1. Topical anesthetic was instilled in the eye to be treated.
2. An Abraham YAG capsulotomy lens, along with a coupling agent, was utilized for the procedure.
3. The red 4 point Diode laser beam was used for accurate aiming and focusing of the invisible therapeutic beam using NdYag Laser machine.
4. The parameters of laser system was adjusted accordingly to the need of patients depending upon the extent and type of PCO.
5. As capsulotomy was performed for optical purposes, its size was limited to a diameter of 2-3 mm using the spiral technique.

6. After laser capsulotomy, the patients was given rest for 1 hour. Post laser evaluation was carried out. Topical fluorometholone was advised four times daily. The intraocular pressure (IOP) was measured after one hour of the procedure, in cases where it was raised, topical beta-blocker was advised and monitored accordingly.
7. Patients were evaluated on day 1, 7, 1M, 3M & 6M. On each visit, BCVA, IOP, SLE with 90D and IDO.
8. A record of energy required to produce the optimum capsulotomy size and the number of pulse shots was maintained.

3. Results

A total no of 76 patients who were treated for posterior capsule opacification by the Nd: YAG laser capsulotomy technique at N.C Medical college Panipat were included in the study for a period of 12 months from January 2023 to December 2023. The age range was 20 - 90 years with a mean of 58 SD ± 13.20, out of which 45 were male and 31 were female patients (**Figure 1**), with a predilection for left eye 43 (56.5%) and right eye 33 (43.4%)(**Figure 2**). The visual acuity as recorded by Snellen's chart was less than 6/60 vision in 5 (6.5%), 6/60 -6/24 in 44 (57.8%), 6/18-6/24 in 27(35.5%) and with none of the patients having visual acuity 6/9-6/6 before Nd Yag capsulotomy, which was improved to 6/9 -6/6 in 70(92.1%), 6/18-6/24 in 4(5.2%) and 6/60 -6/24 in 2 (2.6%) (**Figure 3**). The energy utilized to clear the visual axis by the Nd; YAG laser was measured in millijoules with a mean of 2.9 SD± 1.63 and range of 1.2- 10.0 mJ was used (**Figure 4**). The range of pulse shots was 4-34 with a mean of 14.01 SD± 24.38.

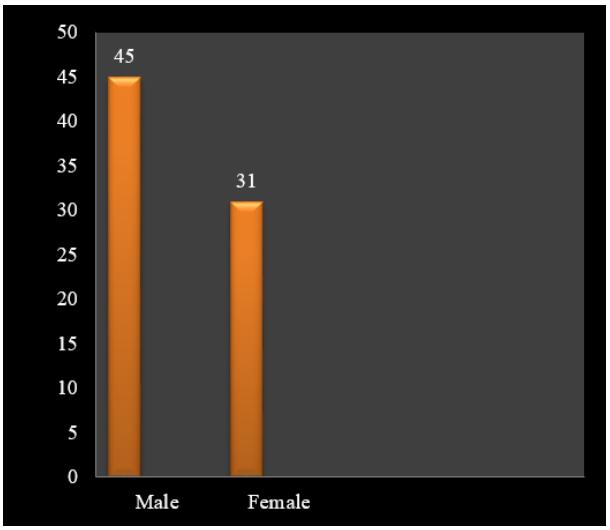

Figure 1: Sex distribution (n=76)

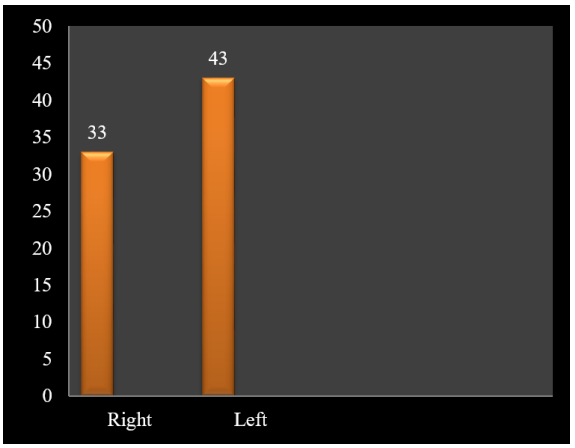

Figure 2: Eye involved (n=76)

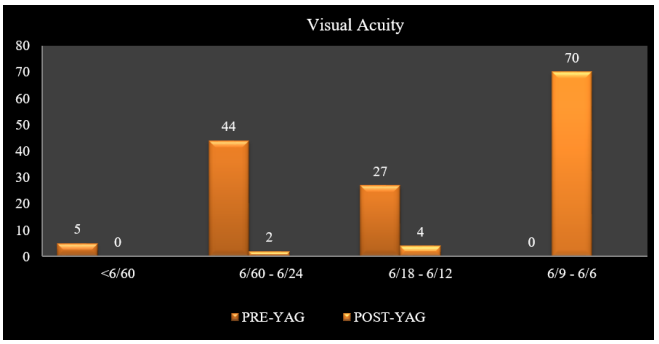

Figure 3: Visual acuity (n=76)

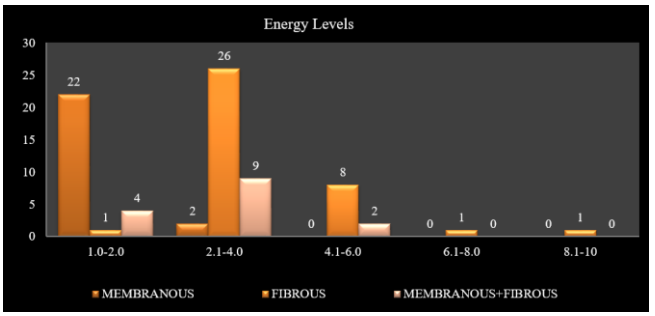

Figure 4: Nd: YAG laser energy in mJ (n=76)

4. Discussion

Opacification of the capsule typically arises from the proliferation of lens epithelial cells, leading to the formation of pearls or fibrosis.[19] The primary goal of Nd:YAG laser capsulotomy discussed in this study was to enhance visual clarity by creating an opening in the opaque posterior capsule. This procedure involves directing Nd:YAG laser pulses towards the posterior capsule, usually employing energy levels in the range of a few millijoules (mJ) and lasting 2-3 nanoseconds.[20] Existing literature has not extensively explored the direct effects of laser energy on complication rates, nor has it thoroughly examined the influence of factors like intraocular lens (IOL) type and fixation, as well as the type of posterior capsular opacification (PCO), on the energy requirements. This study aims to evaluate how these variables influence the energy levels required for capsulotomy and to determine any

correlation between total laser energy levels and the occurrence of complications.

In a study conducted by Auffarth et al., an analysis of energy levels used for capsulotomy in 172 patients revealed an average total energy usage of 12.7 +/- 9.4 mJ.[21] Similarly, our study found a mean energy level of 22.8 mJ for membranous posterior capsular opacification (PCO), which closely aligns with their findings. Auffarth et al. observed that 26 patients required a second Nd:YAG laser capsulotomy, indicating that fibrous PCO may necessitate higher energy levels. Membranous PCO, being thinner, required a lower initial energy level (1.8 mJ) and total energy for capsulotomy compared to thicker fibrous capsules (3.1 mJ). The challenge in achieving optimal initial energy levels may contribute to the observation that fibro-membranous PCO requires higher total laser energy despite starting with a lower energy level (2.7 mJ).

In a study by Bhargava et al., different types of posterior capsular opacification (PCO) were found to require varying initial and total laser energy levels, depending on the thickness of the posterior capsule (1.8 mJ for membranous, 3.1 mJ for fibrous, and 2.7 mJ for fibro-membranous opacities). The authors recommended using lower single-pulse energy levels rather than higher total energy to reduce the risk of complications.[22] In our study, we observed a mean initial energy of 1.8 mJ for pearl and 2.8 mJ for fibrous forms of PCO, which is consistent with Bhargava et al.'s findings. Additionally, there was a significant difference ($P < 0.001$) in the total laser energy levels required for capsulotomy between fibrous and pearl subtypes of PCO.

Singh et al. concluded that the patient's sex does not influence the predictability of posterior capsule opacification following surgery.[23] Furthermore, Tetz et al. investigated the energy requirements for Nd:YAG laser capsulotomy in patients with polymethylmethacrylate (PMMA) intraocular lenses (IOLs) and observed that sulcus-fixated IOLs required higher energy levels. This observation was particularly notable in a single-center study where the IOL was positioned close to the posterior capsule.

Nd:YAG laser capsulotomy remains the predominant treatment for posterior capsular opacification (PCO). Over time, there has been a decrease in the overall incidence of complications linked to this procedure. This progress can be credited to an enhanced comprehension of the mechanisms underlying laser-induced damage and a heightened awareness of the necessity to minimize the total laser energy administered at the treatment site.[24,25]

5. Conclusion

Nd:YAG laser treatment is widely recognized as an effective technique for improving vision impaired by posterior capsular opacification (PCO). However, it is not without complications. Therefore, it is important to be conscious about the energy levels used to prevent unnecessary damage to ocular tissues and minimize the risk of complications.

6. Source of Funding

None.

7. Conflict of Interest

None.

8. Ethical Approval

Ethical No.: IEC/Approval/2024/119.

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