



| ORIGINAL RESEARCH PAPER                                                                                                                                                                                        | Ophthalmology                                                                                                    |
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| <b>THREE-DIMENSIONAL TOPOGRAPHIC CHANGES IN ANTERIOR CHAMBER PARAMETERS ON SCHEIMPFLUG IMAGING IN INTUMESCENT CATARACTS (WITH A SHALLOW ANTERIOR CHAMBER LESS THAN 2.8 MM) AFTER ND:YAG LASER CAPSULOTOMY.</b> | <b>KEY WORDS:</b> Intumescent cataract, Nd:YAG laser capsulotomy, anterior segment changes, Scheimpflug imaging. |

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| <b>ABSTRACT</b> | This study aimed to assess three-dimensional topographic changes in anterior chamber parameters on Scheimpflug imaging in intumescent cataracts after Nd:YAG laser capsulotomy. <b>Methods:</b> A prospective interventional study at the Regional Institute of Ophthalmology, M.D. Eye Hospital, Prayagraj, included 40 patients with white intumescent cataract who underwent preoperative Nd:YAG laser anterior capsulotomy. After phacoemulsification, a foldable posterior-chamber intraocular lens was inserted. Parameters such as the anterior chamber depth, specular endothelial cell count and intraocular pressure were compared before and after the procedure. <b>Results:</b> The study included 40 patients with an average age of 55 ± 7.87 years with a higher incidence observed in females compared than in males. A significant reduction in Lens Thickness (LT)and increase in Anterior Chamber Depth were observed. There was also a marked increase in the Anterior Chamber Volume (ACV), suggesting deepening of the anterior chamber.All cases (100%) achieved a-well-centered and intact capsulorrhexis, highlighting the safety and effectiveness of preoperative Nd:YAG laser capsulotomy. <b>Conclusion:</b> Cataract is prevalent in individuals aged 51-60years with a higher incidence in females due to hormonal and socioeconomic factors. Nd:YAG laser anterior capsulotomy reduces lens thickness and improves anterior segment parameters in intumescent cataracts. This procedure deepens the anterior chamber and minimizes intraoperative complications,making it an effective preoperative tool. |
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| <p><b>INTRODUCTION:</b></p> <p>Cataracts are the leading cause of reversible blindness globally, with intumescent cataracts representing a more advanced and complex form of the disease. Intumescent cataracts are characterized by swelling and clouding of the crystalline lens owing to fluid accumulation and progressive protein degeneration. This swelling leads to an increase in intralenticular pressure, resulting in a shallow anterior chamber and significantly impaired vision. These anatomical and physiological changes present unique challenges during cataract surgery. One major intraoperative complication associated with intumescent cataracts is the "Argentinian flag sign." [1] This phenomenon occurs during capsulorrhexis, a critical step in cataract surgery, in which a continuous curvilinear tear is made in the anterior capsule. In intumescent cataracts, sudden decompression of the pressurized lens capsule during the initial puncture can lead to uncontrolled radial extension of the tear. This jeopardizes the integrity of the capsular bag, increasing the risk of capsular rupture, zonular dehiscence, and compromised intraocular lens (IOL) implantation. [2,3]</p> <p>To address this, various preoperative techniques have been developed to decompress the capsular bag and stabilize anterior segment anatomy. [4,5] One such technique is Nd:YAG laser anterior capsulotomy, which is performed preoperatively. This noninvasive procedure allows the pressure within the capsular bag to equilibrate with that of the anterior chamber, thereby minimizing the risk of uncontrolled capsular extension during surgery. [6] <b>Subjects and Methods:</b> Forty eyes of 40 patients were selected for this prospective interventional study, which was conducted at the Regional Institute of Ophthalmology, M.D. Eye Hospital, Prayagraj, a tertiary care referral center in North India. The study was carried out over a one-year period from April 2024 to March 2025 following approval from the Institutional Ethics Committee of the M.L.N. Medical College, Prayagraj. Written</p> | <p>informed consent was obtained from all participants after explanation of the study. Patients with any other ocular pathology, such as lens-induced glaucoma, uveitis, hypermature cataracts with areas of capsular calcification, cataracts with zonular weakness, trauma, and synechial angle closure were excluded from the study. All patients of intumescent cataract with shallow anterior chamber(&lt;2.8mm) were included in the study. Preoperative ocular evaluation included demographic details, visual acuity, slit-lamp examination, intraocular pressure (IOP) measurement, specular microscopy (Topcon SP-1P) for endothelial cell count and Pentacam imaging (OCULUS) to measure ACD, anterior chamber angle, volume and lens thickness. B-scan ultrasonography was performed for posterior segment evaluation when the fundus view was obscured, and IOL power calculation was performed. Every patient underwent a thorough systemic evaluation by a physician to rule out any systemic ailments, such as diabetes, hypertension, asthma, or cardiac morbidities.</p> <p><b>Nd:YAG Laser Procedure:</b> After pharmacological pupil dilation using tropicamide 0.8% and phenylephrine 5%, anterior capsulotomy was performed using a Nd:YAG laser on the day of surgery. One to two laser shots were delivered to the central anterior capsule using slight anterior defocus with energy of approximately 1.2 mJ per shot. [1] The release of intralenticular fluid was confirmed during the procedure. The patients were re-evaluated 30 min after the laser. Following parameters were reassessed post-laser: intraocular pressure, endothelial cell count (specular microscopy), lens thickness, anterior chamber depth, angle and volume (Pentacam).</p> <p>All procedures were performed by a single experienced surgeon under peribulbar anesthesia (5 mL of 2% lignocaine with 1:200,000 adrenaline and 150 IU hyaluronidase). A 2.8 mm clear corneal incision was made, capsulorrhexis was</p> |
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performed followed by phacoemulsification and implantation of a foldable posterior-chamber intraocular lens. 1.4% sodium hyaluronate was used as a viscoelastic agent. Intraoperative complications if any, were documented.

## RESULTS:

Results: On the day of surgery, prior to the Nd:YAG capsulotomy procedure following parameters were measured:-

- Lens thickness
- Anterior chamber volume
- Anterior chamber angle
- Intraocular pressure
- Endothelial cell count

Thirty minutes after Nd:YAG capsulotomy, all of the above parameters were re-evaluated to assess the effects of the procedure.

The following changes in ocular parameter observed –

**Table – Changes in Parameters Pre- and Post YAG Capsulotomy.**

| Parameter                           | Subgroup            | Pre-Nd:YAG (Mean ± SD) | Post-Nd:YAG (Mean ± SD) | P-value | Significance         |
|-------------------------------------|---------------------|------------------------|-------------------------|---------|----------------------|
| Lens Thickness (LT) (µm)            | All patients (N=40) | 4707.93 ± 626.27 µm    | 3918.78 ± 550.90 µm     | <0.001  | Significant          |
|                                     | 3000–4000 (N=7)     | 3831.67 ± 291.05 µm    | 3355.14 ± 144.90 µm     | <0.001  | Significant          |
|                                     | 4000–5000 (N=25)    | 4659.80 ± 272.48 µm    | 3902.76 ± 424.35 µm     | <0.001  | Significant          |
|                                     | 5000–6000 (N=8)     | 5609.75 ± 478.50 µm    | 4349.80 ± 683.31 µm     | 0.001   | Significant          |
| Anterior Chamber Angle (ACA) (°)    | All patients (N=40) | 29.87 ± 5.90°          | 25.93 ± 5.55°           | <0.001  | Significant          |
|                                     | 20–30 (N=23)        | 26.37 ± 2.46°          | 23.38 ± 2.49°           | <0.001  | Significant          |
|                                     | 30–40 (N=16)        | 33.24 ± 1.95°          | 28.72 ± 6.32°           | <0.001  | Significant          |
|                                     | 40–50 (N=1)         | 56.40 ± 0.00°          | 39.80 ± 0.00°           | —       | Not applicable (N=1) |
| Anterior Chamber Depth (ACD) (mm)   | All patients (N=40) | 2.09 ± 0.17 mm         | 2.49 ± 0.19 mm          | <0.001  | Significant          |
|                                     | >2.00 mm (N=24)     | 2.20 ± 0.13 mm         | 2.55 ± 0.17 mm          | <0.001  | Significant          |
|                                     | <2.00 mm (N=16)     | 1.92 ± 0.06 mm         | 2.41 ± 0.20 mm          | <0.001  | Significant          |
| Anterior Chamber Volume (ACV) (mm³) | All patients (N=40) | 133.83 ± 13.59 mm³     | 176.73 ± 19.90 mm³      | <0.001  | Significant          |
|                                     | <150 mm³ (N=34)     | 129.74 ± 9.99 mm³      | 173.32 ± 19.06 mm³      | <0.001  | Significant          |
|                                     | >150 mm³ (N=6)      | 157.00 ± 4.94 mm³      | 196.00 ± 12.93 mm³      | <0.001  | Significant          |
| Intraocular Pressure (IOP) (mmHg)   | All patients (N=40) | 17.03 ± 2.54 mmHg      | 15.23 ± 1.94 mmHg       | <0.001  | Significant          |

|                                    |                     |                            |                            |       |                 |
|------------------------------------|---------------------|----------------------------|----------------------------|-------|-----------------|
| Endothelial Cell Count (cells/mm²) | All patients (N=40) | 2732.65 ± 235.29 cells/mm² | 2703.82 ± 228.88 cells/mm² | 0.290 | Not Significant |
|------------------------------------|---------------------|----------------------------|----------------------------|-------|-----------------|

The mean age of the participants was 55 ± 7.87 years. Demographic analysis revealed that individuals aged 51–60 years had the highest incidence of cataracts. A greater proportion of cases were observed among females than among males due to reduced estrogen levels and socioeconomic status. This study evaluated changes in anterior segment biometric parameters before and after Nd:YAG laser capsulotomy. Outcomes were analyzed across various subgroups based on lens thickness, anterior chamber configuration, and intraocular pressure.

**1. Lens Thickness (LT)**—A statistically significant decrease in lens thickness was observed across all subgroups post-Nd:YAG. Subgroup with pre-laser LT of 3000–4000 µm (N=7), the mean thickness reduced from 3831.67 ± 291.05 µm to 3355.14 ± 144.90 µm (p < 0.001). In subgroup with LT of 4000–5000 µm (N=25), LT decreased from 4659.80 ± 272.48 µm to 3902.76 ± 424.35 µm (p < 0.001). In subgroup with LT of 5000–6000 µm group (N=8), a reduction from 5609.75 ± 478.50 µm to 4349.80 ± 683.31 µm was noted (p = 0.001). The mean lens thickness of 40 patients before the procedure was 4707.93 ± 626.27 µm, indicative of a markedly swollen lens, which is a characteristic feature of intumescent cataract. Following Nd:YAG capsulotomy, the mean lens thickness decreased to 3918.78 ± 550.90 µm, showing a clear decompressive effect.

**2. Anterior Chamber Angle (ACA)**—A significant narrowing of the ACA was recorded post-laser. The mean ACA of 40 patients before Nd:YAG was found to be 29.87 ± 5.90 degrees. However, after Nd:YAG laser capsulotomy, the mean ACA reduced significantly to 25.93 ± 5.55 degrees.

**3. Anterior Chamber Depth (ACD)**—There was a significant increase in the ACD following capsulotomy. The mean AC depth of 40 patients prior to the procedure was 2.09 ± 0.17 mm, which is notably shallow due to the forward displacement of the lens-iris diaphragm in intumescent cataracts. Following Nd:YAG capsulotomy, there was a significant increase in AC depth to 2.49 ± 0.19 mm.

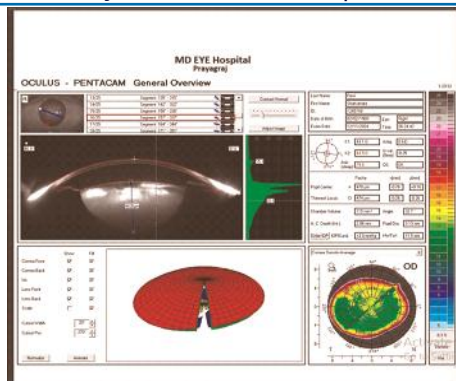
**4. Anterior Chamber Volume (ACV)**—A marked increase in ACV was observed. Mean anterior chamber volume before Nd:YAG Laser Capsulotomy for all study patients was 133.83 ± 13.59 mm³ whereas that after the Nd:YAG was 176.73 ± 19.90 mm³, demonstrating significant increase in ACV after the Nd:YAG capsulotomy.

**5. Intraocular Pressure (IOP)**—A significant reduction in IOP was observed post-laser. Mean IOP of the group decreased from 17.03 ± 2.54 mmHg to 15.23 ± 1.94 mmHg (p < 0.001).

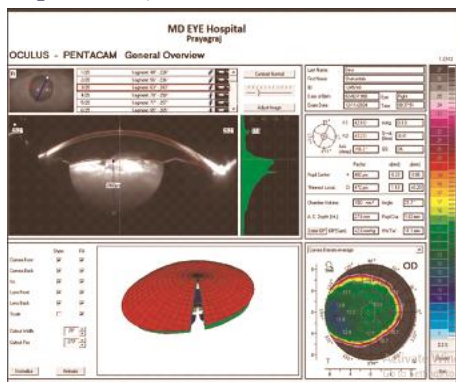
**6. Endothelial Cell Count (ECC)**—There was no statistically significant change. Although values decreased from 2732.65 ± 235.29 cells/mm² pre-laser to 2703.82 ± 228.88 cells/mm² (p = 0.290) post-laser.

Nd:YAG laser capsulotomy significantly improved the anterior chamber parameters, reduced lens swelling and lowered intraocular pressure in patients with intumescent cataract. Importantly, it did not have significant effect on corneal endothelium, confirming the safety and effectiveness of the procedure as a preparatory step to intumescent cataract surgery.

**Figure: Pre YAG laser capsulotomy Pentacam (anterior chamber parameter)**



**Figure: Post YAG laser capsulotomy Pentacam (anterior chamber parameter)**



## DISCUSSION:

Intumescent cataracts represents an advanced and complex form of lens opacification characterized primarily by lens swelling and a decrease in visual acuity. The problem with the capsule is that high intralenticular pressure expands the initial capsule incision in an uncontrolled manner with the development of the Argentinean flag sign. Gimble and Willerscheidt [7] suggested that a small continuous curvilinear capsulorrhexis (CCC) could help identify and tackle high intralenticular pressure. Nabil [5] described a lens decompression technique by aspirating the liquefied cortex with a 25G/30G needle. When a needle is inserted, the opening created is a horizontal slit that has a chance of extending, whereas in our study, the opening created by the laser had a lesser chance of extending. In a study by Gavris M [8] on 70 eyes with intumescent cataract, the capsulorrhexis skidding frequency was 11.43%, and in one case (1.43%), a posterior capsule rupture occurred. Gimble and Willerscheidt [7] originally suggested a two-stage CCC approach with small capsulorrhexis or multipuncture of the anterior capsule before capsulotomy. After emulsification of the nucleus, the small CCC was enlarged to the desired diameter. Using this technique, CCC was achieved in 57 eyes (95%) in a study by Chan DD [9] but Hausmann N [10] reported a 28.3% incidence of incomplete capsulorrhexis, with a very low success rate in white cataracts with a liquefied cortex (68%) compared to those with a solid cortex. Newton Karajunior N [11] compared the results of the 1-stage versus the 2-stage capsulorrhexis in intumescent white cataracts and found anterior capsule tears in 23.07% of the cases in which the 1-stage capsulorrhexis was performed (11 cases), and no ruptures of the anterior capsule were evidenced in which capsulorrhexis was performed in two stages (13 cases).

In our study, Nd:YAG capsulotomy resulted in a considerable reduction in lens thickness (from  $4707.93 \mu\text{m} + 626.27$  to  $3918.78 + 550.90 \mu\text{m}$ ,  $p < 0.001$ ). This aids the decompressive action of the laser by facilitating the outflow of liquefied cortical material and decreasing the intralenticular pressure. Kumar DA [12] found similar effects in their study of anterior

capsulotomy for white and intumescent cataracts, with lens decompression resulting in anatomical normalization and safer subsequent phacoemulsification. Similarly, Rehman AU [13] emphasized the safety and efficacy of Nd:YAG anterior capsulotomy in their series, especially in preventing lens-induced secondary glaucoma. We also performed subgroup analysis for lens thickness, where LT demonstrated significant post-procedural reductions across all patient subgroups, demonstrating that Nd:YAG laser capsulotomy is successful in decompressing the swollen lens in intumescent cataracts. These findings are consistent with those of Kumar (2013) [13] and Rehman (2019), [13] who observed significant lens flattening and anterior segment deepening following intralenticular pressure reduction.

Following the laser capsulotomy, the ACD increased from  $2.09 \text{ mm} + 0.17$  to  $2.49 \text{ mm} + 0.19$  ( $p < 0.001$ ), indicating posterior displacement of the lens-iris diaphragm after decompression. This deepening has been reported in previous studies. Hayashi [14] reported anterior segment deepening following YAG laser treatment in eyes with anterior chamber shallowing due to lens swelling. These findings were also supported by Porwal (2021) [1], in which, there was a mean increase in anterior chamber depth by 0.24 mm. No intraoperative complications were noted, except for capsulorrhexis extension in 1 eye (1.92%).

The ACV increased significantly (from  $133.83 + 13.59 \text{ mm}^3$  to  $176.73 + 19.90 \text{ mm}^3$ ). These results contrast with those observed in phacomorphic glaucoma, in which Yip JL [15] showed angle widening and volume increase following iridotomy or decompression. Phacomorphic glaucoma is associated with higher intralenticular pressure than an isolated intumescent cataract. The markedly swollen lens causes significant anterior displacement of the lens-iris diaphragm, resulting in pupillary block and accumulation of aqueous humor in the posterior chamber. This creates a steep pressure gradient across the iris, leading to exaggerated anterior bowing and acute angle closure. Relief of this pressure results in rapid posterior repositioning of the iris-lens diaphragm. This study's results are similar to that of Porwal, [1] who has also recommended pre-phaco decompression in mature intumescent cataracts, highlighting that early intervention with controlled laser intensity can promote safe surgical progression.

In our study, the ACA decreased significantly (from  $29.87 + 5.90^\circ$  to  $25.93 + 5.55^\circ$ ,  $p < 0.001$ ). In intumescent cataract, the lens became swollen due to fluid accumulation predominantly in the cortex. After Nd:YAG laser decompression, the sudden release of liquefied cortical material can lead to central deepening of the anterior chamber. However, the anatomy of the peripheral iris-lens diaphragm may remain relatively unchanged. This may create a measurement artifact in imaging systems such as Pentacam, which may explain the decrease in the anterior chamber angle, particularly in the periphery. This is fallacious because anatomically the angle has not truly narrowed; it is a misrepresentation due to asymmetrical changes in chamber depth and lens configuration. After capsulotomy, IOP decreased from  $17.03 + 02.54 \text{ mmHg}$  to  $15.23 + 01.94 \text{ mmHg}$ . This reduction provides evidence that easing the lens-induced pupillary block and decompression of lens aids in the normalization of intraocular dynamics.

In our study, we observed decrease in endothelial cell count after Nd:YAG laser capsulotomy (statistically insignificant), a finding that is consistent with the results reported by Hausmann. [16] The main and clinically relevant finding of this study was the achievement of 100% effective and well-centered capsulorrhexis in all patients after preoperative Nd:YAG laser anterior capsulotomy. Nd:YAG laser anterior

capsulotomy relieves increased intralenticular pressure in the closed anterior chamber. However, it also provides surgical predictability and safety, particularly in challenging situations. These findings support Nd:YAG capsulotomy as an effective adjuvant for the treatment of intumescent cataracts. It provides significant preoperative benefits by lowering lens thickness (almost reflects the lowered intralenticular pressure) and increasing anterior chamber depth.

## CONCLUSION

Nd:YAG laser capsulotomy induces significant anatomical changes in the anterior segment of eyes with intumescent cataract. The procedure resulted in a statistically significant reduction in lens thickness along with increased anterior chamber depth and volume. Additionally, a significant decrease in intraocular pressure was observed without a notable loss of corneal endothelial cells. These structural modifications facilitate a 100% success rate in achieving well-centered capsulorrhexis, thereby minimizing complications such as the Argentinean flag sign. Thus, Nd:YAG laser capsulotomy is a valuable preparatory intervention for the surgical management of intumescent cataracts.

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