

Research Article

Clinical Profile and Etiological Spectrum of Secondary Glaucoma at a Tertiary Eye Care Centre in Karnataka, South India: A Retrospective Observational Study

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ABSTRACT

Objective: To describe the demographic characteristics, etiological spectrum, and clinical presentation profile of secondary glaucoma among patients presenting to a tertiary eye care centre in Karnataka, South India, including comparisons between pediatric and adult subgroups, while distinguishing patient-level from eye-level parameters.

Material and Methods: This retrospective, single-centre, observational study included 300 patients (365 eyes) with a clinical diagnosis of secondary glaucoma presenting to a tertiary eye care hospital in Bangalore, Karnataka, between March 2025 and April 2026. Data were abstracted from medical records and analyzed separately at the patient level (demographic and systemic comorbidity variables) and the eye level (etiology, visual acuity, intraocular pressure [IOP], anterior segment, gonioscopic, and fundus variables) to avoid unit-of-analysis errors arising from inter-eye correlation in bilaterally affected patients.

Results: The mean age of the cohort was 48.6 ± 21.4 years; 170 patients (56.7%) were male, and 34 (11.3%) were younger than 18 years. Bilateral involvement was present in 65 patients (21.7%). Lens-induced glaucoma was the most frequent aetiology (63 eyes, 17.3%), followed by inflammatory/uveitic glaucoma (58, 15.9%), neovascular glaucoma (53, 14.5%), and steroid-induced glaucoma (44, 12.1%). Presenting best-corrected visual acuity was worse than 6/60 in 149 eyes (40.8%), and mean presenting IOP was 27.4 ± 11.8 mmHg. Severe visual impairment, elevated IOP, and advanced optic nerve cupping were concentrated predominantly in the neovascular and lens-induced subgroups. The pediatric subgroup ($n = 34$) differed significantly from adults in aetiology (predominantly developmental anterior-segment anomalies), bilaterality (35.3% vs. 19.9%; $p = 0.044$), and systemic comorbidity burden (82.4% vs. 43.2% with no comorbidity; $p < 0.001$).

Conclusions: Lens-induced and neovascular glaucoma were the leading and most visually damaging categories of secondary glaucoma at this South Indian tertiary centre, while pediatric secondary glaucoma showed a distinct, largely developmental aetiological pattern. These findings identify lens-induced and neovascular glaucoma as priority targets for earlier detection and referral in this population.

Keywords: Secondary Glaucoma, Lens-Induced Glaucoma, Neovascular Glaucoma, Pediatric Glaucoma, Karnataka.

INTRODUCTION

Glaucoma remains a leading cause of irreversible blindness worldwide, and secondary glaucomas — in which an identifiable ocular or systemic process disrupts aqueous humour dynamics — form a diverse and clinically

important component of this burden.^[1,2]

Hospital-based series from India have reported that secondary glaucoma constitutes anywhere from approximately 7% to 17% of all glaucoma diagnoses at tertiary referral centres, with the specific etiological mix varying by region,

referral pattern, and case mix.^[3,4]

Reported leading causes of secondary glaucoma at Indian tertiary centres include post-cataract-surgery (pseudophakic) glaucoma, neovascular glaucoma, pseudoexfoliative glaucoma, steroid-induced glaucoma, lens-induced (phacomorphic/phacolytic) glaucoma, traumatic glaucoma, and glaucoma following corneal or vitreoretinal surgery, with considerable variation between series from northern, eastern, and southern India.^[3-5]

Lens-induced glaucoma related to delayed cataract surgery has historically been highlighted as an important, largely preventable cause of secondary glaucoma in India, reflecting the country's cataract surgical backlog, although its relative contribution appears to vary across contemporary series.^[6,7]

Neovascular glaucoma, arising principally from proliferative diabetic retinopathy and retinal venous occlusive disease, continues to carry a disproportionately poor visual prognosis; Indian multicentre data indicate that a substantial majority of eyes present with compromised vision and that favourable outcomes remain difficult to achieve even after treatment.^[8,9]

Pseudoexfoliation-associated glaucoma shows a distinct South Indian epidemiological signature, with population-based surveys reporting exfoliation syndrome in roughly 3–4% of adults over 40 years of age and glaucoma in a variable minority of these individuals.^[10,11]

Steroid-induced glaucoma remains a preventable but persistent problem in India, related in part to unsupervised topical and periocular corticosteroid use.^[12]

Secondary glaucoma in children differs mechanistically from the adult pattern. South Indian and pan-Indian multicentre pediatric glaucoma series have reported that secondary glaucoma constitutes a substantial proportion of childhood glaucoma, with acquired conditions (trauma, postoperative complications, steroid exposure) and non-acquired ocular anomalies both contributing importantly, alongside a documented tendency toward delayed presentation.^[13,14]

Despite this body of literature, comprehensive tertiary-centre data specifically describing the clinical and etiological profile of secondary glaucoma from Karnataka, South India — combining patient-level demographic and comorbidity data with eye-level clinical, gonioscopic, and fundus findings — remain limited. We therefore undertook a retrospective review of patients with secondary glaucoma

presenting to a tertiary ophthalmology centre in Karnataka, South India, with the objective of describing the demographic characteristics, etiological spectrum, and clinical presentation profile of this population, including comparisons between pediatric and adult subgroups and across etiological categories, while explicitly distinguishing patient-level from eye-level parameters.

MATERIAL AND METHODS

This was a retrospective, single-centre, observational (chart review) study conducted at a tertiary eye care referral centre in Bangalore, Karnataka, South India, of patients diagnosed with secondary glaucoma. The dataset was drawn from a cohort of patients diagnosed with secondary glaucoma who presented during the study period, March 2025 to April 2026. Three hundred patients (365 eyes) with a clinical diagnosis of secondary glaucoma were included. Secondary glaucoma was defined as glaucoma attributable to an identifiable secondary ocular or systemic cause, evidenced by elevated intraocular pressure and/or glaucomatous optic-nerve or visual-field damage, with the secondary aetiology established on clinical examination and relevant history.

Records of all consecutive patients diagnosed with secondary glaucoma presenting during the study period were retrospectively reviewed and abstracted from the Medical Records Department (MRD). Inclusion criteria were: (1) a clinical diagnosis of secondary glaucoma, per the definition above, recorded during the study period; (2) availability of complete case-record documentation for the core demographic, etiological, and clinical variables analyzed (age, sex, laterality, etiology, best-corrected visual acuity, intraocular pressure); (3) eyes with a documented, clinically identifiable secondary cause of glaucoma (lens-induced, inflammatory/uveitic, neovascular, steroid-induced, traumatic, post-surgical, pseudoexfoliative, aphakic, or raised episcleral venous pressure mechanisms); (4) both new and previously diagnosed/follow-up patients presenting within the study window, provided baseline clinical data at presentation were retrievable from the medical records; and (5) patients of any age. Exclusion criteria were: (1) primary open-angle or primary angle-closure glaucoma without an identifiable secondary ocular or systemic cause; (2) incomplete or missing medical records precluding assessment of key demographic or clinical variables; (3)

ocular hypertension without glaucomatous optic-nerve/visual-field damage, where no other secondary cause was identifiable; (4) eyes with pre-existing glaucoma of indeterminate type where a secondary cause could not be clinically established; and (5) records with unresolvable inconsistencies or duplicate entries for the same eye/patient.

Data were collected and analysed separately at the patient level (N = 300; used for demographic, laterality, and systemic comorbidity variables) and at the eye level (N = 365 affected eyes; used for etiology, visual acuity, intraocular pressure, anterior segment, gonioscopic, and fundus variables), in order to avoid unit-of-analysis errors arising from inter-eye correlation in the 65 patients with bilateral involvement. Recorded clinical parameters included best-corrected visual acuity (BCVA, measured using a Snellen chart), presenting intraocular pressure (IOP, measured by Goldmann applanation tonometry), anterior segment and lens status, gonioscopy findings (where assessable), fundus and optic disc evaluation (where assessable), history of steroid exposure, and details of initial medical and surgical management.

Statistical analysis was performed using IBM SPSS Statistics (IBM Corp., Armonk, New York, USA). As this was a retrospective chart-review study, no prospective sample-size calculation was performed; all eligible cases identified during the study period were included, and the analysis was descriptive and comparative in nature. Continuous variables, such as age, are presented as mean $\pm$ standard deviation and median with interquartile range, and were compared between the pediatric and adult subgroups using the independent-samples t-test (or the Mann-Whitney U test where the assumption of normality was not met). Categorical variables, such as sex, bilaterality,

and systemic comorbidity status, are presented as frequencies and percentages and were compared using the chi-square test (or Fisher's exact test where expected cell counts were small). A two-sided p-value of less than 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

A total of 300 patients involving 365 affected eyes with secondary glaucoma were included in the study. The mean age of the study population was 48.6 ± 21.4 years (median, 51.0 years; IQR, 32.0–65.0; range, 4–87 years). There were 170 male patients (56.7%) and 130 female patients (43.3%). Thirty-four patients (11.3%) were younger than 18 years.

At the patient level, 143 patients (47.7%) had no significant systemic comorbidity. Hypertension was the most frequently documented systemic comorbidity (96, 32.0%), followed by diabetes mellitus (72, 24.0%) and concomitant diabetes mellitus with hypertension (45, 15.0%). Other recorded comorbidities included cardiovascular disease in 22 patients (7.3%), thyroid disease in 21 (7.0%), bronchial asthma in 18 (6.0%), autoimmune/inflammatory disease in 15 (5.0%), tuberculosis in 12 (4.0%), and chronic kidney disease in 11 (3.7%).

Laterality

Unilateral involvement was observed in 235 patients (78.3%), whereas 65 patients (21.7%) had bilateral disease, resulting in a total of 365 affected eyes. Among the 65 patients with bilateral involvement, 58 had the same underlying aetiology in both eyes, while 7 had different secondary glaucoma mechanisms between the two eyes.

Table 1. Demographic and clinical baseline characteristics of the study cohort (N = 300 patients)

Characteristic	Value
Age, years (mean $\pm$ SD)	48.6 $\pm$ 21.4
Age, years (median, IQR)	51.0 (32.0–65.0)
Age range, years	4–87
Male sex	170 (56.7%)
Female sex	130 (43.3%)
Age <18 years	34 (11.3%)
No significant systemic comorbidity	143 (47.7%)
Hypertension	96 (32.0%)
Diabetes mellitus	72 (24.0%)
Diabetes mellitus + hypertension	45 (15.0%)
Cardiovascular disease	22 (7.3%)
Thyroid disease	21 (7.0%)

Bronchial asthma	18 (6.0%)
Autoimmune/inflammatory disease	15 (5.0%)
Tuberculosis	12 (4.0%)
Chronic kidney disease	11 (3.7%)
Unilateral disease	235 (78.3%)
Bilateral disease	65 (21.7%)

Etiological Spectrum

Among the 365 affected eyes, lens-induced glaucoma was the most frequent aetiological category, accounting for 63 eyes (17.3%). This was followed by inflammatory/uveitic glaucoma in 58 eyes (15.9%), neovascular glaucoma in 53 (14.5%), and steroid-induced glaucoma in 44 (12.1%).

Traumatic glaucoma accounted for 32 eyes (8.8%), post-vitrectomy glaucoma for 28 (7.7%), pseudoexfoliative glaucoma for 24 (6.6%), and pseudophakic glaucoma for 22 (6.0%). Post-

keratoplasty glaucoma was identified in 15 eyes (4.1%), aphakic glaucoma in 10 (2.7%), and raised episcleral venous pressure in 4 (1.1%); other miscellaneous causes accounted for 12 eyes (3.3%).

Thus, lens-related and inflammatory mechanisms together constituted a substantial proportion of the secondary glaucoma burden. The combined group of post-surgical glaucomas, comprising pseudophakic, post-vitrectomy, and post-keratoplasty glaucoma, accounted for 65 eyes (17.8%) of the cohort.

Table 2. Etiological spectrum of secondary glaucoma (N = 365 eyes)

Etiology	Eyes (%)
Lens-induced glaucoma	63 (17.3%)
Inflammatory/uveitic glaucoma	58 (15.9%)
Neovascular glaucoma	53 (14.5%)
Steroid-induced glaucoma	44 (12.1%)
Traumatic glaucoma	32 (8.8%)
Post-vitrectomy glaucoma	28 (7.7%)
Pseudoexfoliative glaucoma	24 (6.6%)
Pseudophakic glaucoma	22 (6.0%)
Post-keratoplasty glaucoma	15 (4.1%)
Aphakic glaucoma	10 (2.7%)
Raised episcleral venous pressure	4 (1.1%)
Other/miscellaneous	12 (3.3%)
Total	365 (100%)

Specific Underlying Diagnoses

Within the inflammatory/uveitic group, idiopathic uveitis was the most frequently documented underlying diagnosis (27/58), followed by other defined inflammatory diseases (16/58), JIA-associated uveitis (8/58), and tubercular or infectious uveitis (7/58).

Among eyes with neovascular glaucoma, proliferative diabetic retinopathy was the predominant underlying retinal disorder, followed by central retinal vein occlusion and branch retinal vein occlusion. Ocular ischemic syndrome and other retinal ischemic disorders accounted for the remaining cases.

Lens-induced glaucoma comprised a heterogeneous group of lens-related mechanisms, including phacomorphic and phacolytic glaucoma, lens subluxation or dislocation, and microspherophakia. Traumatic glaucoma was predominantly associated with

blunt ocular trauma, while penetrating trauma and chemical injury accounted for the remaining cases.

Visual Acuity

Presenting best-corrected visual acuity (BCVA) was better than 6/18 in 54 eyes (14.8%), between 6/60 and 6/18 in 162 eyes (44.4%), and worse than 6/60 in 149 eyes (40.8%). Among the 149 eyes with BCVA worse than 6/60, counting-finger vision was present in 62 eyes (41.6%), hand-movement vision in 42 (28.2%), perception of light in 31 (20.8%), and no perception of light in 14 (9.4%).

Intraocular Pressure

The mean presenting intraocular pressure (IOP) was 27.4 ± 11.8 mmHg, with a median of 25.0 mmHg and a range of 10–68 mmHg. IOP was below 30 mmHg in 249 eyes (68.2%),

between 30 and 50 mmHg in 75 eyes (20.5%), and greater than 50 mmHg in 41 eyes (11.2%).

Anterior Segment Findings and Lens Status

Anterior-segment examination was available for all 365 eyes. Corneal edema was documented in 71 eyes, keratic precipitates in 43, corneal opacity or scarring in 23, and a corneal graft in 22 eyes. Anterior chamber cells or inflammation were present in 58 eyes, flare in 46, hyphema in 19, hypopyon in 3, and a shallow anterior chamber in 39 eyes. Posterior synechiae were present in 42 eyes, peripheral anterior synechiae in 67, and iris bombe in 14 eyes. Rubeosis iridis/iris neovascularization was documented in 44 eyes.

The lens was phakic in 198 eyes (54.2%), pseudophakic in 126 (34.5%), and aphakic in 41 (11.2%).

Gonioscopy and Mechanism

Gonioscopy was assessable in 286 of 365 eyes (78.4%); examination was not possible or was not documented in 79 eyes (21.6%), predominantly because of media opacity or corneal disease. Among the assessable eyes, 214 (74.8%) had an open angle and 72 (25.2%) had angle closure. Peripheral anterior synechiae were observed in 51 eyes (17.8%), angle neovascularization in 39 (13.6%), and angle recession in 28 (9.8%).

Previous Ocular History and Steroid Exposure

Previous ocular surgery or intervention was documented in 179 eyes. Previous cataract surgery was recorded in 126 eyes, vitrectomy in 28, keratoplasty in 22, retinal procedures in 49, intravitreal injections in 41, retinal laser treatment in 37, and previous glaucoma surgery in 14 eyes.

Steroid exposure history was available in 342 eyes (93.7%) and was unknown or missing in 23 eyes (6.3%). Any documented steroid exposure was present in 86 eyes. Among these, topical exposure was recorded in 48 instances, periocular exposure in 9, intravitreal exposure in 12, systemic exposure in 8, inhaled exposure in 5, and multiple routes in 4. These route-specific categories represent exposure data and were not necessarily mutually exclusive.

Fundus Findings

Fundus examination was assessable in 301 of 365 eyes (82.5%), while examination was precluded in 64 eyes (17.5%) because of opaque media. Among assessable eyes, the

cup-to-disc ratio was less than 0.5 in 83 eyes (27.6%), 0.5–0.8 in 126 (41.9%), and greater than 0.8 in 92 (30.6%). Optic disc pallor was present in 51 eyes (16.9%). Retinal pathology included diabetic retinopathy in 47 eyes (15.6%), central retinal vein occlusion in 13 (4.3%), branch retinal vein occlusion in 4 (1.3%), retinal detachment in 11 (3.7%), and other retinal vascular disease in 9 eyes.

Treatment Profile

At presentation, 113 eyes (31.0%) required three or more topical antiglaucoma medications. Systemic acetazolamide was used in 91 eyes (24.9%). Initial management consisted of medical treatment alone in 248 eyes, laser intervention in 32, glaucoma surgery in 49, cataract or lens surgery in 71, anti-VEGF therapy in 44, vitreoretinal intervention in 18, keratoplasty-related intervention in 13, and other procedures in 9 eyes.

Clinical Severity Across Etiological Subtypes

Clinical severity varied across the major aetiological subgroups (Table 3). Severe visual impairment (BCVA <6/60) was most prominent among eyes with neovascular glaucoma and lens-induced glaucoma, while steroid-induced glaucoma and the aggregated others/raised episcleral venous pressure group showed a lower proportion of severe visual impairment. The highest mean presenting IOP values and the greatest concentration of extreme IOP elevation (>50 mmHg) were also observed in the lens-induced and neovascular glaucoma groups. Advanced optic nerve cupping (C/D ratio >0.8) was particularly prominent among eyes with neovascular and steroid-induced glaucoma.

Pediatric Subgroup

Thirty-four patients (11.3%) were younger than 18 years. The mean age of the pediatric subgroup was 9.8 ± 4.2 years (median, 9.5 years; IQR, 6.0–14.0), compared with 53.5 ± 16.8 years (median, 55.0 years; IQR, 44.0–66.0) among the 266 adult patients ($p < 0.001$).

The pediatric subgroup included 20 males (58.8%) and 14 females (41.2%), compared with 150 males (56.4%) and 116 females (43.6%) among adults. The difference in sex distribution was not statistically significant ($p = 0.791$).

Bilateral involvement was significantly more frequent among pediatric patients (12/34,

35.3%) than among adults (53/266, 19.9%; $p = 0.044$). Systemic comorbidity was also significantly less frequent in the pediatric subgroup. None of the pediatric patients had diabetes mellitus or hypertension, and 82.4% had no significant systemic comorbidity compared with 43.2% of adults ($p < 0.001$).

Within the pediatric subgroup, the most

frequently documented etiological/underlying conditions were Axenfeld–Rieger syndrome (8 patients), microspherophakia (7), other anterior-segment dysgenesis (6), congenital/developmental lens abnormalities (5), uveitic glaucoma (3), traumatic glaucoma (3), and steroid-associated glaucoma (2).

Table 3. Pediatric versus adult comparison

Characteristic	Pediatric (n = 34)	Adult (n = 266)	p-value
Mean age, years (median, IQR)	9.8 ± 4.2 (9.5; 6.0–14.0)	53.5 ± 16.8 (55.0; 44.0–66.0)	<0.001
Male sex	20 (58.8%)	150 (56.4%)	0.791
Bilateral involvement	12 (35.3%)	53 (19.9%)	0.044
No systemic comorbidity	28 (82.4%)	115 (43.2%)	<0.001

Bilateral Discordant Aetiology

Among the 65 patients with bilateral disease, the underlying secondary glaucoma mechanism differed between the two eyes in 7 patients (10.8%), whereas 58 patients (89.2%) had the same aetiological category in both eyes.

DISCUSSION

This retrospective, single-centre study characterized the demographic, etiological, and clinical presentation profile of 300 patients (365 eyes) with secondary glaucoma at a tertiary referral hospital in Karnataka, South India, over a 13-month period. Three findings stand out: lens-induced glaucoma was the single most frequent aetiology, inflammatory/uveitic glaucoma constituted an unexpectedly large share of the cohort, and severity — measured by visual acuity, intraocular pressure, and optic nerve cupping — clustered disproportionately in the neovascular and lens-induced subgroups. A distinct pediatric subgroup, dominated by developmental anterior-segment anomalies rather than the acquired causes that predominate in adults, further distinguished this series.

Etiological Spectrum

Lens-induced glaucoma accounted for the largest share of eyes in this cohort (17.3%), followed by inflammatory/uveitic glaucoma (15.9%), neovascular glaucoma (14.5%), and steroid-induced glaucoma (12.1%). This ranking differs from the two principal Indian tertiary-centre comparators available. In a Northern India series of 419 secondary glaucoma patients, the leading causes were neovascular glaucoma (17.42%), trauma (14.80%), post-keratoplasty glaucoma

(13.60%), post-cataract-surgery glaucoma (13.13%), and lens-induced glaucoma (12.41%).^[4] An earlier Delhi-based series similarly found post-vitrecomy glaucoma, trauma, corneo-iridic scar, aphakia, and neovascular glaucoma as the leading causes,^[5] with neovascular glaucoma well behind post-surgical and traumatic causes. Against this background, the prominence of lens-induced glaucoma as the leading single category in the present cohort, and the substantial burden of inflammatory/uveitic disease — a category not among the top five causes in either comparator series — are the most distinctive findings of this study.

The continued prominence of lens-induced glaucoma is consistent with its long-recognized status in the Indian literature as a largely preventable consequence of delayed cataract surgery, reflecting persistence of a cataract surgical backlog in parts of the country.^[6,7] The high proportion of inflammatory/uveitic glaucoma is harder to reconcile with prior hospital-based series and most plausibly reflects a referral-pattern effect specific to this centre — tertiary hospitals with an active uveitis or glaucoma sub-specialty service tend to draw a disproportionate share of complex inflammatory glaucoma referrals from a wider catchment area, which would inflate this category relative to community-representative estimates. This distinction between hospital-based referral prevalence and true population burden should be made explicit rather than implied, since none of the comparator studies — nor the present one — used a population-based sampling frame.

The combined burden of post-surgical secondary glaucomas (pseudophakic, post-

vitrectomy, and post-keratoplasty; 17.8% of eyes) is broadly comparable in magnitude to the post-cataract-surgery and post-keratoplasty proportions reported in the Northern India series, though the individual sub-categories differ.

A rural Central Indian series similarly identified

lens-induced glaucoma and pseudoexfoliation-associated glaucoma among the leading treatable causes of secondary glaucoma in a tertiary-referral rural population,^[15] reinforcing that lens-related mechanisms remain a recurring theme across Indian series despite regional variation in relative ranking.



Figure 1- Slit-lamp photograph showing anterior displacement of the crystalline lens following ocular trauma, causing phacotopic glaucoma.

Pseudoexfoliative Glaucoma: A Modest Clinical Share Despite High Syndrome Prevalence Pseudoexfoliative glaucoma accounted for only 6.6% of eyes in this cohort, a comparatively modest share given that population-based South Indian surveys have reported exfoliation syndrome in a substantial minority of adults over 40 years of age.^[10,11] This apparent discordance is not necessarily contradictory: population prevalence of exfoliation syndrome is not the

same as clinical glaucoma referral burden, since only a minority of eyes with exfoliation syndrome progress to glaucoma over any given period, and many of those that do may be managed at secondary-level centres without referral. The present finding should therefore be read as a hospital referral-pattern observation, not as evidence against the well-established South Indian epidemiological signature of exfoliation syndrome.

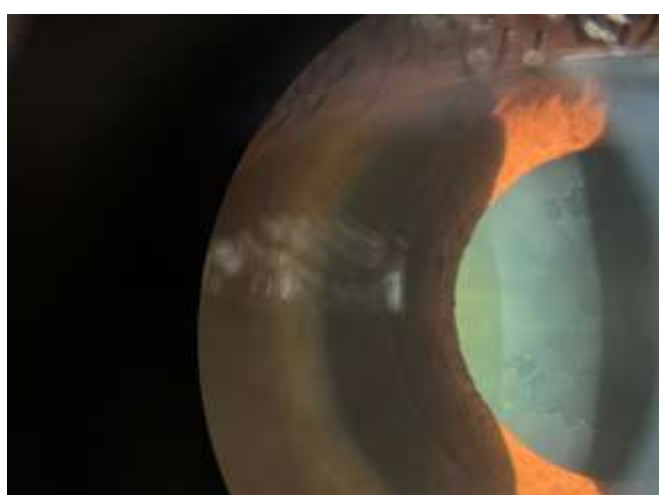


Figure 2 - Slit-lamp photograph showing pseudoexfoliative material on the anterior lens capsule.

Neovascular And Lens-Induced Glaucoma Carried The Greatest Visual Burden

Severe visual impairment, elevated presenting IOP, and advanced cupping clustered most

heavily in the neovascular and lens-induced subgroups. This pattern for neovascular glaucoma is consistent with Indian multicentre data: in a comparison of Indian and UK

neovascular glaucoma cohorts, only 18% of Indian patients (83 of 451) presented with visual acuity of 6/60 or better — meaning the substantial majority presented already below this threshold — with proliferative diabetic retinopathy as the leading underlying cause in both cohorts,^[8] mirroring the predominance of proliferative diabetic retinopathy among neovascular glaucoma eyes in the present series. Long-term Indian data on surgically managed neovascular glaucoma likewise describe it as a difficult-to-control disease requiring individualized surgical selection

between trabeculectomy, drainage device implantation, and cyclophotocoagulation,^[9] underscoring the generally guarded prognosis once neovascular glaucoma is established. The concentration of severe presentation in the lens-induced subgroup, meanwhile, is consistent with the interpretation that many of these cases represent longstanding, untreated cataract that has already progressed to a phacomorphic or phacolytic stage before presentation — itself a marker of delayed access to cataract surgery rather than of the mechanism's inherent severity.

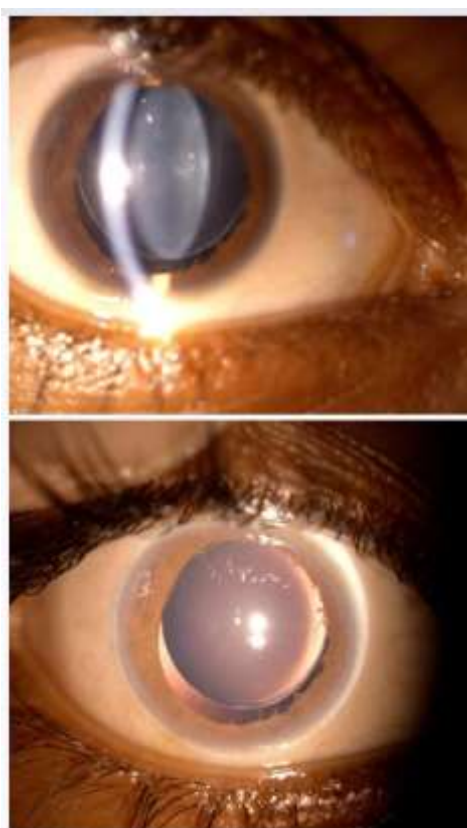


Figure 3 - Slit-lamp photograph showing neovascularization of the iris with ectropion uveae in an eye with neovascular glaucoma secondary to central retinal vein occlusion.

Pediatric Secondary Glaucoma Differs Mechanistically From the Adult Pattern

Secondary glaucoma in patients under 18 years (11.3% of the cohort) was characterized by a markedly different aetiological profile than the adult subgroup: developmental anterior-segment anomalies (Axenfeld–Rieger syndrome, microspherophakia, and other anterior-segment dysgenesis) predominated, in contrast to the acquired, largely preventable mechanisms (lens-induced, inflammatory, neovascular, steroid, traumatic, post-surgical) that dominated the adult cohort. This is consistent with South Indian and pan-Indian multicentre pediatric glaucoma data describing

both acquired and non-acquired (developmental) mechanisms as important contributors to childhood secondary glaucoma, with a documented tendency toward delayed presentation.^[13,14] The significantly higher rate of bilateral involvement among pediatric patients (35.3% vs. 19.9% in adults; $p = 0.044$) is mechanistically plausible given that developmental anterior-segment anomalies are frequently bilateral by nature, unlike most acquired adult causes (trauma, unilateral lens complications, unilateral uveitis), which more often affect one eye. The near-absence of diabetes and hypertension in the pediatric

subgroup, and the correspondingly lower systemic comorbidity burden (82.4% vs. 43.2% with no comorbidity; $p < 0.001$), is an expected age-related finding rather than a novel one, but it usefully reinforces that the

pediatric and adult subgroups in this cohort represent genuinely distinct clinical populations rather than a single population artificially split by age.



Figure 4

- (a) Slit-lamp photograph showing microspherophakia with an abnormally spherical crystalline lens.
(b) Retroillumination view demonstrating the spherical configuration of the lens.



Figure 5 Photograph showing a clear crystalline lens displaced into the anterior chamber in a patient with Marfan syndrome and phacotopic glaucoma.

Overall Interpretation

Taken together, these findings support a two-part interpretation. First, the etiological spectrum of secondary glaucoma at this Karnataka tertiary centre is shaped as much by referral pattern (the disproportionate inflammatory/uveitic burden) as by regional disease epidemiology (the persistence of lens-induced glaucoma as a marker of delayed cataract care). Second, severity of presentation is not evenly distributed across aetiologies: neovascular and lens-induced glaucoma consistently carried the heaviest burden of visual loss, elevated IOP, and advanced cupping, identifying these two categories as priority targets for earlier detection and referral pathways at this centre, consistent with their recognized poor prognosis in the broader Indian and international literature.

Several limitations should be considered when interpreting these findings. This

retrospective, single-centre design carries referral bias, likely under-representing milder disease and limiting how far the etiological spectrum described here can be generalized; reliance on existing medical records also led to incomplete gonioscopy (21.6%) and fundus (17.5%) data, mainly due to media opacity, while the eye-level analyses, which included 65 patients contributing two eyes each, did not formally account for inter-eye correlation, and etiology-based severity differences were described qualitatively rather than through formal statistical testing; further, only presentation and initial management were captured, with no post-treatment outcome data available. Balanced against these limitations, this remains one of the larger single-centre secondary glaucoma series reported from India, with an explicit separation of patient-level and eye-level analyses that avoids the unit-of-analysis error common to studies of bilateral

disease, supported by a comprehensive clinical dataset and a dedicated pediatric subgroup comparison; to the best of the available literature search, it also represents one of the first such profiles specifically from Karnataka. Taken together, these findings support prioritizing earlier detection and referral pathways for neovascular and lens-induced glaucoma given their disproportionate visual burden, without implying that any specific intervention would causally reduce disease severity in this observational design, and they support early screening and genetic counselling for children with anterior-segment dysgenesis syndromes; the unexpectedly high inflammatory/uveitic burden observed in this cohort warrants dedicated phenotypic characterization to clarify whether it reflects a genuine regional pattern or a referral artifact specific to this centre, and prospective, multi-centre studies incorporating post-treatment outcomes and longitudinal pediatric follow-up would help confirm and extend these observations.

CONCLUSION

In this retrospective, single-centre series of 300 patients (365 eyes) with secondary glaucoma at a tertiary eye care centre in Karnataka, South India, lens-induced glaucoma was the most frequent aetiological category, followed closely by inflammatory/uveitic and neovascular glaucoma, with severity of visual loss, IOP elevation, and optic nerve cupping concentrated disproportionately among the neovascular and lens-induced subgroups. Secondary glaucoma in children under 18 years showed a distinct pattern dominated by developmental anterior-segment anomalies and a significantly higher rate of bilateral involvement compared with adults. These findings characterize a previously underdescribed tertiary-centre secondary glaucoma population from Karnataka and identify lens-induced and neovascular glaucoma as the etiological categories associated with the greatest presenting visual morbidity in this setting, supporting continued attention to earlier detection and referral pathways for these two conditions.

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