Long-term scanning laser ophthalmoscopy and perimetry in different severities of primary open and chronic angle closure glaucoma eyes

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Purpose: To determine rate of change over time on scanning laser ophthalmoscopy, HRT, compared to perimetry, and to determine incidence, parametric changes, and risk factors for progression in primary open angle glaucoma (POAG) and chronic primary angle closure angle glaucoma (CPACG) eyes.

Methods: Prospective clinical study of 116 POAG eyes and 129 CPACG eyes of different severities of glaucoma. Standard automated perimetry and optic nerve head topography were studied at baseline and thereafter every 6 months. Changes in HFA and HRT parameters, in response to IOP, were compared over at least 5 years. Results: Forty-four POAG eyes (12.1%) and 20 CPACG eyes (15.5%) showed progression on SAP over time. Percentage drop of IOP was similar in eyes that progressed and in stable eyes. The change in MD in CPACG eyes was 1.8 dB/year on SAP and 1.36 dB/year in POAG eyes, P = 0.1. Twenty-nine eyes showed progression on HRT with 24 confirmed on SAP. Trend analysis picked up progression more frequently than other HRT parameters. Eyes that progressed in both groups, in all severities of glaucoma, had intermittent fluctuations of ≥ 4 mmHg over mean IOP and duration of disease were associated with progression in POAG and CPACG eyes.

Key words: Chronic angle closure glaucoma, long term, primary open angle glaucoma, scanning laser ophthalmoscopy

Primary glaucomas, primary open angle glaucoma (POAG), and chronic primary angle closure angle glaucoma (CPACG), are responsible for a significant proportion of blindness worldwide. Long-term studies have reported various risk factors for progression in POAG, but there are only a few long-term studies of CPACG in literature. [1-4]

This study was performed to evaluate the long-term course, while on therapy, of POAG and CPACG eyes of the same population, by scanning laser ophthalmoscopy and perimetry, to specifically assess optic nerve head changes and progression on standard automated perimetry.

Methods

Consecutive patients with adult primary glaucoma, attending the glaucoma service of a tertiary ophthalmic center, were recruited for the study. A detailed medical and ocular history was obtained, and all patients underwent slit lamp biomicroscopy, ultrasonic pachymetry, (Sonomed 300, Sonomed Escalon, NY, USA), stereoscopic fundus examination, Goldmann applanation tonometry, gonioscopy, ultrasound biometry, and perimetry. All Primary angle closure/glaucoma eyes underwent a Nd YAG iridotomy prior to recording IOP.

Primary open angle glaucoma eyes had open angles on gonioscopy, and in chronic primary angle closure glaucoma, an occludable angle, having at least 180 degrees of synchial closure on indentation/manipulative gonioscopy after iridotomy. Common criteria for diagnosis of the primary glaucomas included age of onset >40 years, IOP >22 mmHg on at least 3 separate occasions, and glaucomatous optic neuropathy consistent with visual field loss in at least one eye. Glaucomatous disc changes were defined as a vertical cup to disc ratio of >0.7, asymmetry of >0.2 between the two eyes, neuroretinal rim changes consisting of pallor or localized notching, and presence of RNFL defects in the absence of any other ocular or neurological pathology.

Patients with a visual acuity of less than 6/18, media opacities, any other ocular pathology, refractive errors ≥ 6 D, history of an attack of acute angle closure, secondary glaucomas were not enrolled in the study. Patients unable to review periodically, those in whom a good image on HRT II was not reproducible, and those who could not perform reliable perimetry or tonometry were excluded.

Full threshold, 30-2 program, standard automated perimetry was performed using Humphrey field analyzer, (Model 750, Carl Zeiss Meditec, Dublin CA, USA). Perimetry was repeated.
till a reliable and consistent visual field result was obtained on at least two fields, and visual field defects were graded by Mills criteria into earliest, early, moderate, advanced, and severe glaucoma. Perimetry was repeated every 6 months, and progression was confirmed when 3 repeat fields showed a reproducible change in at least 3 locations, on Glaucoma Progression analysis, or if patients jumped from one stage of glaucoma to the next stage on at least 3 fields.

Optic nerve head topography was performed by Heidelberg retinal tomography II, software version 2.01, at baseline and every 6 months thereafter by a single, experienced technician. Only images with a standard deviation of <40 microns were selected for analysis. HRT parameters, which were taken into consideration for analysis included disc area, vertical cup disc ratio, cup area and volume, rim area and rim volume, and cup shape measure. A worsening of ≥0.05 of normalized parameter values on trend analysis, in 3 consecutive images, was considered as progression. Topographic Change Analysis’’ (TCA), areas of worsening coded as red in color-coded images on HRT III, and a 5% increase in cup volume were also analyzed at final review.

All patients underwent a diurnal phasing of IOP at baseline, 7 am, 10 am, 1 pm, 4 pm, 7 pm, and 10 pm. Medical therapy was prescribed to attain target IOP as per clinical practice, taking into account, baseline IOP, the severity of glaucomatous damage, systemic diseases, age etc. The ‘target’ IOP for earliest and early glaucomas was 18-21 mmHg, moderate was 16-18 mmHg, advanced and severe 14-16 mmHg. Surgery was undertaken for patients with an inadequate control of IOP on maximum tolerated medical therapy.

Patients were reviewed every 6 months or earlier if necessary, e.g. those with a raised intraocular pressure on any visit or recent progression. Best corrected visual acuity, slit lamp examination, applanation tonometry, perimetry, and scanning laser ophthalmoscopy by HRT were repeated at each follow up at the same time of day.

A database was maintained. Only those patients, who followed up for at least 5 years with a minimum of 2 visits in a year, were included for the final analysis.

Statistical analysis

One eye per patient was analyzed. If both eyes met the selection criteria, one eye was selected for analysis by computer-generated randomization.

Percentage differences in all variables were calculated from baseline values, for each time point, for each subject and were then grouped and evaluated by diagnosis and stage of glaucomatous damage as defined by Mills et al. Repeated measures (LSD method) was used for assessment of change in a variable over time, in each group.

SPSS software version 17.5 was used for the analysis. Significance was measured using one-way ANOVA, and correlations were evaluated using Spearman and Pearson’s correlation tests.

Results

Four hundred and twelve patients of adult primary glaucoma were reviewed, 258 met all baseline criteria. Two of these patients were excluded in the first year because of poor HRT images while 4 were excluded due to unreliable visual fields on repeated testing. Seven patients with a subsequent change in diagnosis to steroid induced- (3), traumatic- (2), or uveitic glaucoma- (2) were excluded from the final analysis.

A total of 245 eyes of 245 patients, 116 POAG eyes and 129 CPACG eyes completed follow up and were analyzed. The mean age of patients was 61.69 ± 10.24 years and 61.74 ± 12.63 years, P = 0.8, with a ratio of males to females of 90:26 and 78:51, P = 0.6 in POAG and CPACG patients, respectively. There was a median, prospective follow up of 64 and 62 months, respectively, in POAG and CPACG patients, P = 0.7.

There was no statistically significant difference at baseline, in disc area, or in linear vertical cup disc ratio on HRT between the two groups as a whole, P = 0.9, or in comparing each grade of glaucomatous damage in POAG and CPACG.

Table 1: Percentage changes of IOP and HRT parameters in individual eyes from baseline over time in POAG and CPACG eyes

| Stage        | Baseline | 1st year | 3rd year | 5th year |
|--------------|----------|----------|----------|----------|
|              | POAG/CPACG | POAG/CPACG | POAG/CPACG | POAG/CPACG |
| Earliest (n = 21) |          |          |          |          |
| IOP          | 23.8/24.8 | -19.4/-21.7 | -21.5/-32.7 | -30.1/-35.6 |
| CA           | 1.27/1.23  | 2.36/6.5   | -14.9/8.9  | -15.7/10.0 |
| RA           | 1.19/1.59  | -2.5/-4.4  | 13.4/-6.9  | 14.2/-5.03 |
| CV           | 0.44/0.4   | 11.3/15    | -22.7/10   | 15.9/15    |
| RV           | 0.29/0.3   | -13.7/10   | 48.2/0     | 37.9/0     |
| Early (n = 84) |          |          |          |          |
| IOP          | 25.3/29    | -27.5/-36.5 | -33.9/-36.8 | -32.0/-42.7 |
| CA           | 1.12/1.28  | -0.89/-0.78 | -6.25/6.25 | 0.89/0.0   |
| RA           | 1.19/1.59  | 0.77/0.8   | 6.9/-0.4   | 0.0/-0.8   |
| CV           | 0.31/0.4   | 6.5/4.0    | 25.8/0.0   | 6.4/0      |
| RV           | 0.29/0.28  | 10.3/-28.5 | 68.9/12    | 0.12/0.0   |
| Moderate (n = 56) |        |          |          |          |
| IOP          | 28.7/28.8  | -36.9/-38.8 | -42.8/-41.6 | -43.9/-42.7 |
| CA           | 1.37/1.18  | -9.4/-2.4  | 1.45/-5.08 | 9.4/0.0    |
| RA           | 1.0/1.18   | 12.1/-2.5  | -2.0/0.0   | -7.4/-3.2  |
| CV           | 0.5/0.4    | -16/-2.5   | 4.0/2.5    | 8.0/2.3    |
| RV           | 0.21/0.31  | 28.5/-12.9 | -9.5/-3.2  | -14.2/-3.2 |
| Advanced (n = 41) |       |          |          |          |
| IOP          | 29.47/29.1 | -37.9/-46.8 | -42.9/-46.6 | -47.6/-51.9 |
| CA           | 1.55/1.51  | -1.2/-5.9  | -0.6/-11.9 | 0.0/-10.5  |
| RA           | 0.79/1.1   | 2.53/8.1   | 3.7/11.8   | 0.0/10.0   |
| CV           | 0.53/0.54  | 0.0/-12.9  | 9.4/11.8   | 5.6/-14.8  |
| RV           | 0.14/0.24  | 7.1/14.6   | 7.14/45.8  | 0.0/50.0   |
| Severe (n = 43) |        |          |          |          |
| IOP          | 27.8/31.7  | -32.6/-48.8 | -40.2/-47.6 | -43.9/-47.5 |
| CA           | 1.83/1.46  | -4.9/1.36  | -1.6/-3.4  | -0.5/-2.05 |
| RA           | 0.87/1.01  | 3.4/1.9    | 3.4/1.9    | 1.1/0.0    |
| CV           | 0.77/0.55  | -2.5/0.09  | 1.29/20.0  | 6.4/-27.7  |
| RV           | 0.18/0.21  | 11.1/-4.7  | 5.5/23.1   | 0.0/14.2   |

CA = cup area, CV = cup volume, RA = rim area, RV = rim volume, IOP = intraocular pressure.
One hundred and twelve POAG eyes and 120 CPACG eyes were controlled on ≤2 medications at baseline. After 5 years, 107 POAG and 127 CPACG eyes continued to require ≤2 drugs. During follow up, 18 of 116, 15.5%, POAG eyes underwent trabeculectomy and 17, 14.6%, argon laser trabeculoplasty, while among CPACG eyes, 21 of 129, 16.3%, underwent trabeculectomy to achieve target pressure.

Fourteen of 116 POAG eyes, 12.1%, and 20 of 129 CPACG eyes, 15.5%, showed progression on achromatic perimetry over time. The change of mean deviation over 5 years was 4.9 ± 3.7 db and -7.04 ± 4.7 db in POAG and CPACG eyes, respectively. The rate of change in MD was higher in CPACG eyes, 1.8 db/year, than POAG eyes, 1.36 db/year, P = 0.1. CPACG eyes showed

### Table 2: Comparison of stable (A) and progressing eyes on SAP (B) and HRT in different severities of POAG and PACG eyes

|                | POAG eyes n = 116 |               | CPACG eyes n = 129 |               |
|----------------|-------------------|---------------|-------------------|---------------|
|                | Stable eyes       | Progressing eyes | P value   | Stable eyes       | Progressing eyes | P value   |
| Earliest glaucoma n = 21 | n = 8             | n = 1         |               | n = 11           | n = 1           |               |
| Age            | 59 ± 11.0         | 66 ± 11.5     | 0.6             | 60.7 ± 11.7      | 60 ± 0.8        | 0.8             |
| CCT            | 562.8 ± 28.2      | 515 ± 30.6    | 0.8             | 542.8 ± 25.6     | 531 ± 0.6       | 0.6             |
| Review–months  | 58 ± 0.6          | 60 ± 4.7      |               | 51 ± 83          | 51 ± 0.8        | 0.9             |
| Baseline IOP   | 23.8 ± 4.7        | 20 ± 2.4      | 0.6             | 25.5 ± 2.9       | 17.3 ± 0.9      | 0.02           |
| IOP <18 mm     | 8 ± 1             |               |               | 5 ± 0            |               |               |
| IOP > 21 mm    | 0 ± 0             |               |               | 0 ± 1            |               |               |
| Early glaucoma n = 84 | n = 33            | n = 2         |               | n = 40           | n = 8          |               |
| Age            | 61.8 ± 9.5        | 69 ± 15.5     | 0.5             | 63.3 ± 18.5      | 61.1 ± 10.6     | 0.8             |
| CCT            | 531.2 ± 25.1      | 496 ± 34.6    | 0.1             | 536.9 ± 28.8     | 529.5 ± 25.7    | 0.6             |
| Review–months  | 78 (10-245)       | 86, (52-120)  | 0.7             | 60, (12-269)     | 63, (19-247)    | 0.9             |
| Baseline IOP   | 24.9 ± 8.19       | 34 ± 8.19     | 0.8             | 30.01 ± 12.5     | 33 ± 7.1        | 0.2             |
| IOP <18 mm     | 31 ± 2            |               |               | 20 ± 1           |               |               |
| IOP > 21 mm    | 2 ± 0             |               |               | 4 ± 2            |               |               |
| Moderate glaucoma n = 56 | n = 22          | n = 7         |               | n = 19           | n = 6          |               |
| Age            | 60 ± 9.1          | 64 ± 10.8     | 0.3             | 60.7 ± 7.9       | 66 ± 4.3        | 0.06           |
| CCT            | 535.5 ± 3.5       | 523 ± 16.3    | 0.2             | 526 ± 27.5       | 524 ± 15.4      | 0.3             |
| Review–months  | 62.5 (12-242)     | 81, (33-182)  | 0.05            | 70, (12-294)     | 158, (82-252)   | 0.01           |
| Baseline IOP   | 28.3 ± 5.3        | 30 ± 8.1      | 0.3             | 30.18 ± 8.2      | 26.82 ± 5.6     | 0.5             |
| IOP <18 mm     | 16 ± 4            |               |               | 12 ± 3           |               |               |
| IOP > 21 mm    | 2 ± 0             |               |               | 1 ± 1            |               |               |
| Advanced glaucoma n = 41 | n = 15         | n = 4         |               | n = 16           | n = 4          |               |
| Age            | 64.4 ± 10.07      | 55.5 ± 9.9    | 0.9             | 62.3 ± 9.7       | 58.2 ± 1.7      | 0.4             |
| CCT            | 533 ± 36.1        | 525 ± 26.9    | 0.6             | 529.1 ± 35.4     | 509 ± 20.8      | 0.2             |
| Review–months  | 71 (14-241)       | 91, (49-240)  | 0.8             | 52, (30-180)     | 47.5, (31-61)   | 0.6             |
| Baseline IOP   | 29.6 ± 9.04       | 29 ± 3.37     | 0.7             | 28.4 ± 12.2      | 32.6 ± 9.8      | 0.3             |
| IOP <18 mm     | 11 ± 2            |               |               | 13 ± 2           |               |               |
| IOP > 21 mm    | 13 ± 1            |               |               | 0 ± 1            |               |               |
| Severe glaucoma n = 43 | n = 22        | n = 0         |               | n = 20           | n = 1          |               |
| Age            | 62.7 ± 11.9       |               |               | 62.4 ± 9.1       | 60 ± 0.9        | 0.9             |
| CCT            | 512 ± 35.9        |               |               | 519 ± 37.8       | 517 ± 0.9       | 0.9             |
| Review–months  | 49.6-238          |               |               | 45.21-145        | 52 ± 0.7        | 0.7             |
| Baseline IOP   | 27.7 ± 9.0        |               |               | 29 ± 8.9         | 40 ± 0.3        | 0.3             |
| IOP <18 mm     | 14 ± 0            |               |               | 11 ± 0           |               |               |
| IOP > 21 mm    | 2 ± 0             |               |               | 1 ± 1            |               |               |

Significant P values in bold and underlined
progression earlier, i.e. at 36.2 months, cf POAG eyes, at 44.7 months. The change of mean deviation in stable eyes during follow up was -0.36 ± 3.8 dB and -0.37 ± 3.4 dB in POAG and CPACG eyes, respectively, \( P = 0.9 \), i.e. a rate of change of mean deviation by 0.06 dB/year in each group. The difference in the rate of change of MD between stable and progressing eyes was significant in both groups, \( P < 0.001 \) [Table 2].

POAG and CPACG eyes showing progression had similar baseline IOPs, 29.8 ± 6.8 mmHg cf 26.9 ± 8.3 mmHg, \( P = 0.2 \), and had similar records of peak IOP on therapy, \( P = 0.2 \). However, the minimal IOP recorded on therapy was lower in POAG cf CPACG eyes, 13.3 ± 2.9 mmHg cf 15.6 ± 3.2 mmHg, respectively, \( P = 0.05 \). In both groups, all eyes that progressed had ≥33 records (median 3.08 visits, range 3-10 visits) of a rise of IOP of ≥4 mm, over the mean IOP, during follow up, \( P < 0.001 \). The percentage drop of IOP with therapy was similar in eyes that progressed and in stable eyes. There was no statistically significant difference in the age of the patients showing progression, cf stable eyes, \( P = 0.1 \) in POAG and \( P = 0.4 \) in CPACG eyes, [Table 1].

The IOP drop was constant in stable eyes of both groups, with there being none or only a single episode of an IOP rise during follow up. Baseline IOPs were higher in stable CPACG eyes, 29.5 ± 10.4 mmHg cf 26.9 ± 7.8 in POAG eyes, \( P = 0.04 \) [Table 1]. There was no statistical difference in age, follow up period, maximal and minimal IOP or corneal thickness in a comparison of stable eyes of POAG and CPACG groups.

The topographical optic nerve head parameters, including rim area and rim volume, were better in the CPACG group at all points of time, and in all stages of glaucoma, except eyes with early glaucomatous damage [Table 1]. On scanning laser ophthalmoscopy, the cup area and rim area changes in POAG eyes were statistically significant at 2 and 3 years, \( P = 0.05 \), 0.02. CSM values changed significantly in CPACG eyes at 2, 4, and 5 years, \( P = 0.03 \), 0.001, 0.01, but showed no significant difference in POAG eyes, \( P = 0.3 \) to 0.8. A significant improvement in HRT rim or cup parameters by trend analysis was analyzed in eyes having different degrees of IOP lowering from baseline. Eyes having an IOP lowering by <25% showed an improvement in 42% of POAG cf 11% of CPACG eyes, \( P = 0.007 \), while eyes having a 25-50% IOP reduction showed an improvement in 56.2% of POAG and 47.4% of CPACG eyes, \( P = 0.4 \). In eyes where the IOP fell by >50% from baseline, HRT parameters improved in 38.5% of POAG and 48.7% of CPACG eyes, \( P = 0.1 \).

Of the 34 eyes that progressed on SAP, 24 showed a progression on HRT with corresponding changes. HRT changes predated visual field abnormalities in 8 eyes, in each group, by 13.6 months in POAG and 30.7 months in CPACG eyes, \( P = 0.03 \). Progression by HRT parameters was seen in 29 eyes overall, confirmed by SAP in 24 eyes, Table 3. Ten eyes showed progression on SAP alone and 5 on HRT alone. Only one patient demonstrated a change in all three HRT analyses, viz. worsening pixel change, trend analysis, and a 5% increase in cup volume. Topographic trend analysis showed a worsening trend in 35% POAG and 45% CPACG eyes that progressed, while a 5% increase in cup volume and pixel changes suggestive of worsening were seen in 14% of POAG eyes and 10-15% of CPACG eyes that progressed. Three POAG eyes and 2 CPACG eyes showed progression on HRT alone by trend analysis. Fluctuations in HRT parameters that returned to baseline values were seen in 6 POAG eyes and 4 CPACG eyes and were correlated to IOP fluctuations.

Changes in scanning laser ophthalmoscopy and perimeter of POAG and CPACG eyes having different stages of glaucomatous damage are detailed in Tables 1 and 4.

Twenty-one eyes had ‘earliest’ glaucoma with significant HRT changes on follow up in 75% of POAG eyes where the cup area fell by 15.7% and the rim area increased by 14.2%, while only 28.5% of CPACG eyes showed a significant HRT improvement, \( P = 0.02 \). All eyes showing a reversal of HRT parameters had an IOP of <16 mmHg at all times. Eighty-four eyes had ‘early’ glaucoma, with a marginal alteration in HRT parameters in POAG eyes, but none in CPACG eyes, despite a greater and more consistent drop in IOP over 5 years [Table 1]. All eyes that progressed showed intermittent rises of IOP ≥4 mmHg on at least 3 occasions. ‘Moderate’ glaucoma was present in 56 eyes, and a significant improvement in HRT parameters were seen in POAG eyes only with a 12.1% increase in rim area and 9.4% decrease in cup area, while CPACG eyes showed a loss of 4.2% in HRT rim area from baseline. All eyes that progressed showed an intermittent rise in IOP ≥4 mmHg in POAG and 4.01 ± 0.4 mmHg in CPACG eyes, on ≥3 visits. In 41 eyes having ‘advanced’ glaucoma, longitudinal HRT changes were not significant for POAG eyes, but significant changes on HRT were observed in CPACG eyes where the cup area decreased by 13.9% and the rim area increased by 14.5%. The average time to progression was higher in the POAG group, 45.5 months, as compared to CPACG, 25 months. Forty-three eyes had ‘severe’ glaucoma, and significant alterations in HRT parameters were seen only in POAG eyes where the cup area fell by 6.5% and the rim area increased by 13.7%.

Overall, time to progression correlated strongly in both groups with duration of follow up, \( r = 0.6, P = 0.001 \), and patients age, \( r = 0.5, P = 0.01 \). Regression analysis for change in mean deviation and IOP showed no linear relationship in either group. Baseline IOP correlated with baseline MD in POAG

| Table 3: MD changes in progressing and stable POAG and CPACG eyes |
|-------------------------|-------------------|-------------------|------|
|                         | MD Change in progressing eyes per yr | MD Change in stable eyes per yr | \( P \) value |
| **POAG**                | -1.36 dB/year     | -0.36 ± 3.8 dB    | \( < 0.001 \) |
| **CPACG**               | -1.8 dB/year      | -0.37 ± 3.4 dB    | \( < 0.001 \) |
| **P value**             | \( P = 0.1 \)     | \( P = 0.9 \)     |      |

| Table 4: Progression on HRT parameters by different criteria, seen in 24 of the 34 eyes that progressed on SAP |
|-----------------------------------------------|-----------------|-----------------|-----------------|
| **Progression on trend analysis**             | **Cup volume increase by 5%** | **Significant pixel change** |
| **POAG (n = 14)**                            | 6 (42.8%)       | 2 (14.2%)       | 2 (14.2%)       |
| **CPACG (n = 20)**                           | 9 (45%)         | 3 (15%)         | 2 (10%)         |
| **14/24 = 58.3%**                            | 5/24 (20.8%)    | 4/24 (16.6%)    |
eyes only \( r = -0.2, P = 0.008 \) and did not correlate with any parameter in CPACG eyes. Central corneal thickness correlated with mean deviation in CPACG eyes, \( r = 0.2, P = 0.005 \) but not in POAG. Age could be correlated to cup area, \( r = -0.2, P = 0.03 \) in POAG eyes only.

### Discussion

Glucomatous neuropathy in POAG and CPACG eyes has a raised IOP as a major risk factor, and in CPACG additionally, probable ischemic changes in ocular tissues, during intermittent attacks of angle closure.

To the best of our knowledge, there are no prospective, long-term studies in a single cohort of patients having both kinds of primary adult glaucoma. Our study evaluated the effect of therapy on function, by standard automated perimetry and ONH structure using the scanning laser ophthalmoscope, in POAG and CPACG eyes having different stages of glaucomatous damage.

In our study, the rate of change of MD in progressing POAG and CPACG eyes was 1.36 dB/year and 1.8 dB/year, respectively, while stable eyes changed at a much slower rate of 0.06 dB/yr in both groups. Quigley and associates estimated a rate of visual field deterioration in POAG eyes of blacks to be 2 grading levels per decade, and the severity of field damage correlated with age, IOP, and history of glaucoma treatment. The Early Manifest Glaucoma Trial showed a decline of 1.93 dB in eyes that progressed. Other studies have reported different rates of progression in POAG eyes.

Our study found that HRT predated visual field changes in 57.1% of POAG and 40% of CPACG eyes, earlier in POAG eyes. Fayers et al. evaluated change criteria for rim area on HRT, which detected visual field progression. Chauhan et al. have shown that patients with perimetric progression were 3 times more likely to have prior HRT changes.

In this study, IOP control in stable eyes of both groups over the years was consistent, whereas eyes that showed progression on SAP had a longer follow up and showed intermittent fluctuations at 3 or more visits by ≥4 mmHg over their mean IOP. There was no association of progression with baseline IOP or mean IOP over time. The Early Manifest Glaucoma trial concluded that mean elevated IOP is a major risk factor for progression while fluctuations are not. A change of IOP by 1 mmHg, higher or lower on follow-up, was associated with an approximate 10% increased or decreased risk of progression.

The Advanced Glaucoma Intervention Study found that patients with IOP<18 mmHg throughout follow up were more likely to have stable visual fields than those who had higher IOPs. De Moraes et al. found mean IOP, peak IOP, and IOP fluctuation to be significant risk factors for progression. Singh and Srivastava found that there is no conclusive evidence that IOP fluctuation/variation are independent risk factors for glaucoma progression and suggested that mean IOP should also be kept in mind.

A worsening of ≥0.05 of normalized parameter values on trend analysis in 3 consecutive images appeared to be the best parameter for diagnosing progression on HRT, cf pixel changes or a 5% increase in cup parameters. There was no difference in the baseline cup or rim parameters on HRT II at baseline between the stable and progressing eyes in each group. Leske and Kalaboukhova et al. showed that there were significant differences in parameters like cup area, rim area, and cup shape measure among the stable and progressed group of POAG or ocular hypertensive eyes progressing to POAG.

IOP reduction by 30-60% was achieved in all eyes after treatment in our study. POAG eyes responded more often to a drop of <25%, while a higher fall in IOP resulted in an improvement in HRT rim parameters in about 40-50% of both POAG and CPACG eyes. Eyes with a greater severity of glaucomatous damage required a greater percentage drop by 40-50% for stabilization and improvement of optic nerve head parameters in both groups. Change was considered significant only if it was reproduced on at least 3 consecutive images. If it were just noise, we would have observed this in many more patients. However, this change could have been due to a reduction of IOP, releasing pressure on the lamina cribrosa, and not a reversal of the neuropathy. Improvement in early glaucoma more often than advanced glaucoma cases probably reflects the greater organic changes, e.g. gliosis and atrophy in advanced glaucoma eyes, which would not change. The Collaborative Normal Tension Glaucoma study found a slower rate of field loss in cases with 30% or more lowering of intraocular pressure.

In our study, other risk factors for progression, besides IOP, were also studied. Progression correlated strongly within duration of disease, signifying that a long-term follow up is necessary to identify progression after treatment. There was no correlation between a change in visual field indices with age, baseline or mean IOPs, severity of glaucomatous damage or systemic diseases. Drance et al. evaluated the risk factors for progression in normal tension glaucoma and found that Asians had a slower rate of progression \( P = 0.005 \), and age, family history, and untreated level of IOP was not related to the rate of progression. Different risk factors have been independently identified in different ethnic groups.

According to the EMGT, progression increased with higher baseline IOP, exfoliation, bilateral disease, worse mean deviation, vascular problems and older age, as well as with frequent disc hemorrhages during follow-up. In CPACG, a 90% success rate of long-term IOP control in PACG was reported, with progression seen in eyes with a persistently elevated IOP and a larger baseline cup disc ratio.

In this study, baseline IOP was found to correspond with an increasing severity of glaucoma in both POAG and CPACG eyes, with IOPs ranging from 23 mmHg in eyes having early glaucoma and ≥27 mmHg in eyes with more advanced glaucomatous damage. The association of raised IOP with glaucoma and its progression is known. The Baltimore eye survey reported that the risk of glaucomatous damage in open angle glaucoma increases at IOP levels of 22-29 mmHg.

Limitations of this study were that only a few eyes progressed, making statistical analysis of small measurement values in a small number of eyes less meaningful. There were also fluctuations on both perimetry as well as HRT over time, making clinical judgments and trend analyzes difficult.
Conclusion
In conclusion, CPACG eyes appeared to show an earlier and greater progression on perimetry, as compared to POAG eyes. Fluctuations of ≥4 mmHg above the treated mean IOP on at least ≥3 visits and duration of the disease were significant correlates for progression in both adult POAG and CPACG eyes.

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Conflicts of interest
There are no conflicts of interest.

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