Original Article

Agreement of findings of glaucoma screening between trained vision center technicians and glaucoma specialists at a tertiary hospital in South India

Ramakrishnan Rengappa, Shivkumar Chandrashekharan[1], Ranitha Gunaselvi, Devendra Maheshwari, Mohideen Abdul Kader, Sabyasachi Chakrabarty[2]

Purpose: To study the agreement of findings of glaucoma screening between trained vision center (VC) technicians and glaucoma specialists in patients referred from VC to the glaucoma services of a tertiary eye care hospital in south India. **Methods:** This was a retrospective study comparing the findings of the VC technicians and the specialists of the glaucoma services in the base hospital, in patients referred from 13 VCs between January and June 2019. Medical records of 277 referred patients (out of 533 referrals) who attended the glaucoma clinic were analyzed. **Results:** Of the 277 patients, 111 (40%) were confirmed having glaucoma, 133 (48%) were suspects, 29 (10.4%) were normal, and four (1.4%) had other pathology. The mean age of the patients was 59.7 ± 13 years and 60.6% were females. There was no statistically significant difference between the mean intraocular pressure (IOP) measured (17 ± 7.2 mmHg at the VC and 18 ± 8.7 mmHg at the clinic, $p = 0.16$) and the cup-to-disc ratio (CDR) (0.7 ± 0.13 at the VC and 0.6 ± 0.18 at the clinic, $p = 0.57$). Bland–Altman plots with 95% limits of agreement supported that mean differences were close to zero, and the intraclass correlation coefficient at 95% CI showed good consistency between the measurement of IOP (0.78 [0.74 to 0.81]) and CDR (0.90 [0.88 to 0.92]) at the base hospital and vision center. **Conclusion:** There is good agreement between the findings of VC technicians and glaucoma specialists. VC technicians can help in detecting glaucoma in the community.

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_1390_20

Quick Response Code:

Key words: Glaucoma screening, vision technician, vision center, intraocular pressure, teleophthalmology

Glaucoma is an optic neuropathy characterized by progressive degeneration of retinal ganglion cells with characteristic optic nerve head (ONH) changes and corresponding visual field defects with intraocular pressure (IOP) as an important risk factor. It is one of the leading causes worldwide of irreversible visual impairment projected to be affecting 79.6 million by 2020 with 11.2 million (14%) likely to be bilaterally blind.[1] Another estimate predicts an increase in the number of glaucoma patients from 64.3 million in 2013 to 76 million in 2020 and 111.8 million in 2040 worldwide with a disproportionate prevalence in Asia and Africa.[2] Among those blind in the world due to primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG), at least 12.9% and 12.7%, respectively are in India.[3]

Glaucoma is of concern because the majority of the cases remain asymptomatic until irreversible vision loss occurs. Patients, therefore, are unlikely to seek an opinion in the initial stages. When patients present with loss of vision further prevention and management become difficult. Despite increasing awareness a high proportion of cases remain undetected in the community, and even in the developed countries more than half of the patients remain undiagnosed (Blue Mountain Eye Study 51%, Rotterdam Study 53%, Baltimore Eye Survey 50%, Thessaloniki study Greece -50.5%),[4-7] and a large number of cases are diagnosed at a later stage of the disease.[8,9] In the Baltimore Eye Survey, it was found that 4.7% of the persons above the age of 45 years residing within a 5-km radius of the Wilmer Eye Institute were disabled by glaucoma.[10] A high prevalence of undiagnosed glaucoma is not only consistent with the lack of effective screening methods but also with the lack of awareness about glaucoma, especially in the developing world. In the Andhra Pradesh Eye Disease Study (APEDS) awareness (defined as having heard of the disease) was found to be low for glaucoma (2.3%) as compared to cataract (69.8%) in an urban population.[11]

The poor population residing in rural areas has no access to eye care services owing to a lack of resources, manpower, screening facilities, and financial constraints. Furthermore, the utilization of the existing services is also low due to various barriers – 59% and 67% among the visually impaired in the urban and rural areas of India, respectively did not seek treatment.[12-14] Moreover only 10% of the rural patients diagnosed with glaucoma in the Aravind Comprehensive Eye Survey (ACES) had received medication or surgery underlining the fact that even if the patients had a consultation, it did not result in appropriate treatment.[14]

Vision centers (VCs) which cover a population of about 50,000 around a 5 km radius play an important role in providing primary comprehensive eye care services in the rural areas which include promoting health education and awareness, timely detection, and referral for specialty care and treatment,

Departments of Glaucoma, [1]Cataract and IOL Services and General Ophthalmology, and [2]Paediatric Services and General Ophthalmology, Aravind Eye Hospital and Post Graduate Institute of Ophthalmology, Tirunelveli, Tamil Nadu, India

Correspondence to: Dr. Shivkumar Chandrashekharan, Aravind Eye Hospital and Post Graduate Institute of Ophthalmology, S.N. High Road, Tirunelveli - 627 001, Tamil Nadu, India. E-mail: shiv_shekhar@yahoo.com

Received: 08-May-2020 Revision: 19-Jul-2020
Accepted: 27-Sep-2020 Published: 16-Mar-2021

Cite this article as: Rengappa R, Chandrashekharan S, Gunaselvi R, Maheshwari D, Kader MA, Chakrabarty S. Agreement of findings of glaucoma screening between trained vision center technicians and glaucoma specialists at a tertiary hospital in South India. Indian J Ophthalmol 2021;69:871-5.

follow-up, and rehabilitation.[15,16] VCs make eye care more accessible to rural people and can play a role in addressing diseases causing treatable blindness like cataract, refractive errors, and diabetic retinopathy. A comprehensive eye examination can also help in screening for glaucoma if adequate training is given to the technicians in this regard. VCs can also have the facility of teleophthalmology wherein the technician shares the findings with the ophthalmologist in the tertiary/base hospital.[15] The patient can also have an interaction with the ophthalmologist and this addresses the issue of accessibility as well as satisfaction. Diseases like glaucoma which require special investigations and treatment are referred to the specialty clinic of the hospital.

The decision for a referral from a VC to the base hospital will largely depend upon the accuracy and the confidence that the attending ophthalmologist can place on the findings of the technician. Therefore, this depends on the clinical knowledge and skill of the concerned technicians. The aim of this study, therefore, was to assess the agreement of the findings of the technicians with those of the glaucoma specialists in the referred patients who attended the Glaucoma clinic.

Methods

This was a retrospective study conducted in the glaucoma clinic of a tertiary eye hospital in south India after obtaining approval from the Institutional Ethics Committee. A clinical audit of the case sheets of patients referred to the glaucoma clinic from 13 VCs from January to June 2019, and who came for further investigation and management to the base hospital till December 31, 2019, was done.

In these 13 VCs associated with our hospital, we have technicians who are trained in performing refraction and anterior segment and posterior segment examination (with the 90 diopter lens) on the slit-lamp. They are also trained in measuring the IOP with the Goldman Applanation Tonometer (GAT) (AT 900; Haag Streit International, Koeniz, Switzerland). The unique feature of these VCs is access to the internet which enables real-time consultation with the doctor, (a general ophthalmologist) at the base hospital. The ophthalmologist goes through the findings presented by the technician through the Electronic Medical Records, advises regarding medication, glasses, or surgery, and decides on the need for referral to specialty clinics at the base hospital. The doctor then directly counsels the patient regarding the advice offered over the internet call which ensures a real-time interaction with the patient.

The criteria for referral of patients for glaucoma evaluation were any one of the following: IOP >21 mmHg, shallow anterior chamber (Van Herick grade 1 and 2), cup: disc ratio (CDR) more than 0.6, or asymmetric cupping more than 0.2 between the two eyes, and patients with a family history of glaucoma.

The parameters compared between the technicians and the glaucoma specialists from the medical records were visual acuity, anterior segment findings on slit-lamp examination, IOP (with Goldman Applanation Tonometer), and CDR on fundus examination. Cases with media haze where accurate CDR measurements were not possible, were not included in the comparison.

The data analysis was carried out with STATA 14.0 (Texas, USA). Continuous variables were presented as mean ± standard deviation (SD) and categorical data were presented as frequency (n) and percentages (%). Normality was assessed using the Box-Whisker plot and the Shapiro-Wilk test. As not all data were normally distributed, nonparametric statistical methods were used. IOP and CDR measurements between the base hospital and VCs were compared using the Wilcoxon signed-rank test. Bland–Altman plot was used to visually present the comparison of the differences in IOP and CDR for each eye between the centers. The intraclass correlation coefficient (ICC) was calculated between the base hospital and VCs to find the consistency of the measurement of IOP and CDR. A p value ≤0.05 was considered to be statistically significant.

Results

During this period (from January to June 2019), a total of 64,268 patients were examined in the 13 VCs, and 533 patients were referred to the glaucoma clinic of the tertiary hospital for further evaluation of glaucoma. Of the 533 patients referred, 277 (52%) attended the clinic till December 31, 2019.

Of the 277 cases, 168 were females (60.6%) [Table 1]. The mean age was 59.71 ± 13.0 years (range 11–90 years). The mean best-corrected visual acuity in both eyes was 6/18 [Table 1] and the mean IOP measured in the VC was 17.36 ± 7.5 mmHg in the right eye (274 eyes) and 16.89 ± 6.9 mmHg in the left (277 eyes). IOP measurement was unrecordable in the right eye of three patients (two absolute eyes with corneal opacity and one with phthisis bulbi).

Of the 277 cases, 111 (40%) were confirmed to have various types of glaucoma. Among the rest, 133 (48%) patients were suspected to have glaucoma (45 primary open-angle suspects and 88 primary angle-closure suspects). Four cases (1.44%) had other pathology and 29 (10.4%) cases were normal [Table 2 and Fig. 1]. The breakup of the different types of glaucoma of confirmed cases is also shown in Table 2. Around 15% of the cases referred were in an advanced stage of glaucoma. Among the referred patients examined by the glaucoma specialists, 89.6% of the patients were diagnosed to be having or suspected to be having glaucoma.

Out of 111 patients confirmed to be having glaucoma, 95 patients were advised a single modality of treatment – antiglaucoma medication (AGM) in 36 patients, laser peripheral iridotomy (Laser PI) in 15, glaucoma surgery with or without IOL in 23 patients (which included four cases of trabeculectomy with trabeculotomy, and one case of glaucoma drainage device implantation), and cataract surgery with or without IOL in 21 patients, 15 of which were for lens-induced glaucoma. The remaining 16 patients required a combination of two modalities (Laser PI and AGM -3, Laser PI and surgery -5, and surgery with AGM-8). Among the suspects, 55 patients underwent Laser PI, 17 cataract extraction with IOL, and two, a combination of Laser PI and cataract extraction with IOL [Table 3].

The comparison of the IOP measured in all 277 cases (551 eyes, as it was not possible to record in three eyes) did not show a statistically significant difference (18 ± 8.7 mmHg at

Table 1: Gender distribution and BCVA of the participants

Gender Distribution		
Variables	**Number**	**Percentage**
Female	168	60.6
Male	109	39.4
Total	277	100
Best-corrected visual acuity (BCVA)		
Eye	**Mean (SD) Snellen's Equivalent**	**Range**
Right eye (*n*=274)*	0.44±0.84 6/18	0-3.2
Left eye (*n*=277)	0.44±0.79 6/18	0-3.2

*Absolute eye - 2, Phthisical eye - 1

the base hospital and 17 ± 7.2 mmHg at the VC, $p = 0.16$). The comparison of the cup: disc ratio was done in 212 cases in which the media allowed evaluation (media mentioned as hazy in 65 cases). This also did not show a statistically significant difference (0.6 ± 0.18 at the base hospital and 0.7 ± 0.13 at the VC, $p = 0.57$). Table 4 shows the breakup of the readings for the right and left eyes showing no statistically significant difference in both the parameters.

The Bland–Altman plot of individual eye differences in the measurement of IOP between the glaucoma specialists and the VC technicians showed the mean to be 1.11 mmHg with the differences being close to zero [Fig. 2]. The ICC for the differences in IOP for all eyes (551) was 0.78 (0.74–0.81) and showed a good agreement between the specialists and the VC technicians.

The Bland–Altman plot of individual differences in CDR measurements between the glaucoma specialists and the VC technicians showed the mean difference to be 0.06 and the mean difference between the specialists and the VC technicians was close to zero [Fig. 3]. The ICC for the differences in CDR measurement for all eyes (424) was 0.90 (0.88-0.92) and showed a good agreement between the specialists and technicians

Discussion

Glaucoma is now increasingly being recognized as a major cause of ocular morbidity that requires urgent attention. The projected number of glaucoma patients worldwide in 2020 is 76 million[2] to 79.6 million[1] and the majority of the cases are likely to be from Asia which accounts for 60% of the world population.[2] India being the second-most populous country is likely to have the majority of cases. Being asymptomatic till an advanced stage, many cases of glaucoma remain undiagnosed and untreated till irreversible blindness sets in. A study by Grant and Burke found that one-third of the patients had become blind before seeking glaucoma care.[17] Persons at increased risk are often from populations with low rates of eye

Table 2: Tabulation of diagnosis for glaucoma among referred patients

Diagnosis	Frequency	Percentage
POAG	37	13.36
PACG	23	8.3
PAC	4	1.44
JOAG	6	2.17
Lens-induced Glaucoma	15	5.42
PXF Glaucoma	9	3.25
NVG	5	1.81
Chronic Angle Closure Glaucoma	3	1.08
Pseudophakic glaucoma	3	1.08
Acute Angle Closure Glaucoma	2	0.72
Secondary Angle Closure Glaucoma	2	0.72
Traumatic Glaucoma	2	0.72
Primary Angle Closure Suspect	88	31.77
Primary Open Angle Suspect	45	16.25
Ocular Hypertension	1	0.36
Absolute Eye	2	0.72
Phthisical Eye	1	0.36
Normal	29	10.47

POAG - Primary open-angle glaucoma, PACG - Primary angle-closure glaucoma, PAC - Primary angle-closure, JOAG - Juvenile open-angle glaucoma, PXF Glaucoma - Pseudo exfoliation glaucoma, NVG - Neovascular glaucoma

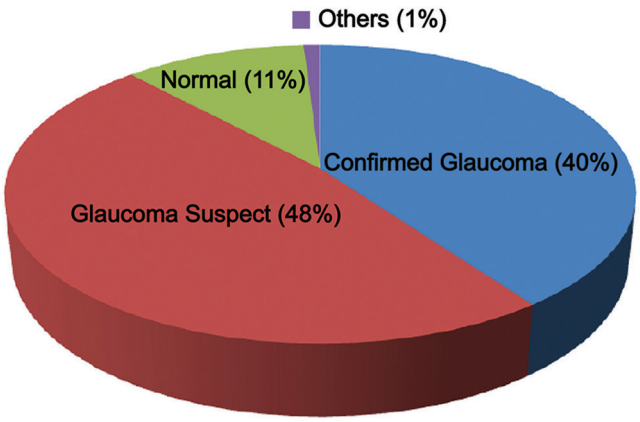

Figure 1: Diagnosis break-up of referred patients examined by the glaucoma specialists

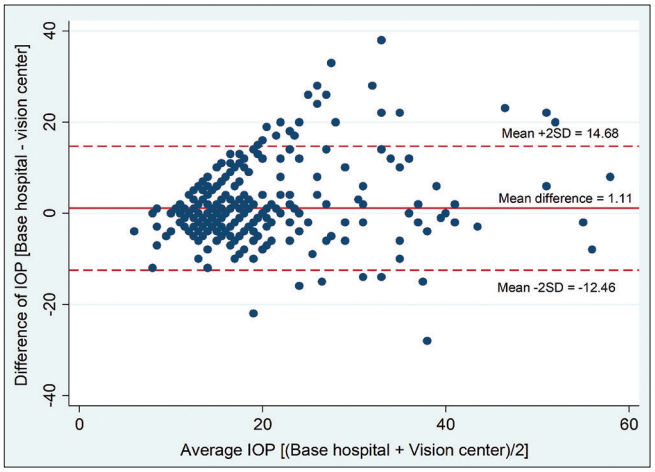

Figure 2: Bland–Altman plot of intraocular pressure (IOP). The solid line represents the mean difference of IOP between the base hospital and vision center (1.11 mmHg). The dotted lines represent the upper and lower limits of agreement. This shows that the mean difference between both the base hospital and vision center was close to zero

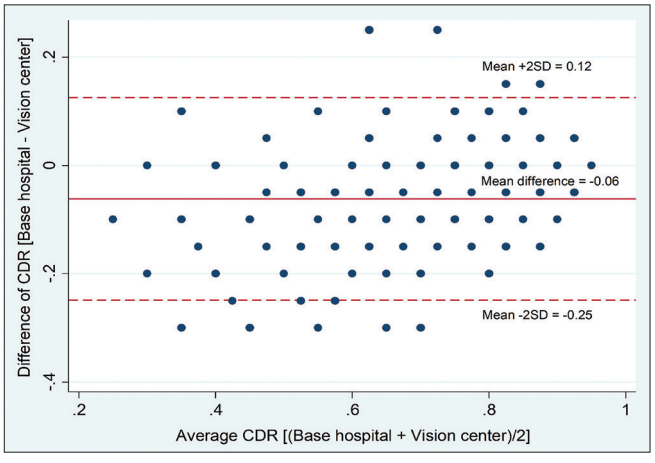

Figure 3: Bland–Altman plot of cup:disc ratio (CDR). The center solid line represents the mean difference of CDR between the base hospital and vision center (0.06 mm). The dotted lines represent the upper and lower limits of agreement. This shows that the mean difference between the base hospital and vision center was close to zero

Table 3: Treatment advice details after glaucoma evaluation of referred patients by glaucoma specialist at the base hospital

Treatment advice details	Frequency	Percentage in total cases
Confirmed Glaucoma		
AGM	36	13
Laser PI	15	5
Laser PI + AGM	3	1
Laser PI followed by Trabeculectomy with or without IOL	5	2
Trabeculectomy with or without IOL	18	6
Trab + Trab	4	1
AADI implantation	1	0
Trabeculectomy with or without IOL + AGM	8	3
Cataract surgery	6	2
Cataract Surgery for Lens induced Glaucoma	15	5
Subtotal	111	40
Glaucoma Suspects		
Laser PI	53	19
Laser PI + Cataract surgery	2	1
Cataract Surgery	17	6

AGM - Antiglaucoma Medication LASER PI - Laser Peripheral Iridotomy, Trab + Trab - Trabeculectomy with Trabeculotomy, AADI - Aurolab Aqueous drainage implant, IOL - Intraocular lens

Table 4: Agreement of IOP and CDR measurement by an ophthalmologist at the base hospital and technicians at the vision center

Comparison of IOP measurement by an ophthalmologist at the base hospital and technicians at the vision center								
Eye	Base hospital			Vision center			*p*	Intraclass correlation coefficient (ICC)
	n	Mean (SD)	Range	*n*	Mean (SD)	Range		
Right eye	274	18.42±9.0	2-62	274	17.36±7.5	10-60	0.134	0.82 (0.76-0.85)
Left eye	277	18.06±8.3	5-58	277	16.89±6.9	10-52	0.192	0.74 (0.67-0.79)
Both eyes	551	18.25±8.7	2-62	551	17.12±7.2	10-60	0.163	0.78 (0.74-0.81)
Comparison of CDR measurement by an ophthalmologist at the base hospital and technicians at the vision center								
Eye	Base Hospital			Vision Center			*p*	Intraclass correlation coefficient (ICC)
	n	Mean (SD)	Range	*n*	Mean (SD)	Range		
Right eye	212	0.63±0.17	0.2-0.95	212	0.70±0.13	0.4-0.9	0.752	0.89 (0.85-0.91)
Left eye	212	0.63±0.18	0.2-0.95	212	0.70±0.13	0.4-0.9	0.388	0.91 (0.89-0.93)
Both eyes	424	0.63±0.18	0.2-0.95	424	0.70±0.13	0.4-0.9	0.57	0.90 (0.88-0.92)

Values were presented with ICC and 95% confidence interval. The Intraclass Correlation Coefficient (ICC) shows good reliability (ICC >0.75) that exists between the measurement of IOP and CDR at the base hospital and vision center.

care utilization.[5,18] Published data suggests that the prevalence of glaucoma is 2.6% in the rural population of India.[19] This is further complicated by the lack of awareness of glaucoma in the rural population.[20] Adequate access and effective utilization of eye care facilities can improve people's knowledge about glaucoma, need for early diagnosis, intervention, adherence to treatment, and the need for lifelong follow-up.[15] We can retard or delay visual function loss in most, but not all patients with glaucoma if the disease is both detected and treated successfully.[21-25]

Providing primary eye care through VCs is an effective model for reaching the underserved population and the services provided encompass screening, referral for treatment, follow-up, and awareness creation by health education.[15,16] In the EQUALITY study, the VC optometrist educated the patients regarding glaucoma, and a significant improvement was reported in patient awareness – about 98% reported that they are likely to undergo Comprehensive Eye Examination (CEE) in 2 years as compared to 63% who had undergone CEE in the 2 years preceding it.[26] Tele-ophthalmology-aided VCs could be particularly useful in primary eye care where the distance to an eye care facility could be a barrier to seeking care.

For glaucoma screening to be effective, the vision technicians should be well trained.[15] This analysis aims to study the agreement between the findings of the VC technicians and the glaucoma specialists at the tertiary hospital. The study shows that close to 90% of the 277 referred patients, who attended the base hospital between January and December 2019, had glaucoma or were suspected to be having glaucoma. Further, a comparison of the IOP ($p = 0.16$) and the CDR ($p = 0.57$) measured by the VC technicians and the glaucoma specialist did not show a statistically significant difference. The Bland–Altman

plot of differences in measurements of IOP and CDR between glaucoma specialists and the VC technicians for each eye, and the ICC to study the consistency of the findings between the glaucoma specialist and the VC technicians showed a good level of agreement. Thus trained vision technicians at the VCs have the clinical skill to detect glaucoma at the community level and refer the cases to the tertiary center.

One of the limitations of the study was that we were not aware of the cases they may have missed and, therefore, failed to identify and refer to as glaucoma cases. The technicians were not trained in performing gonioscopy, and hence their suspicion of angle-closure was based on the slit-lamp examination alone. Also, we could not compare this parameter between the technicians and the specialists. Moreover, only 52% of the total cases (277 out of 533 patients) had come to the tertiary center, and only those case sheets were available for analysis. A well-defined protocol, criteria for diagnosis and referral, good counseling, and continuous medical education to improve the awareness can help in improving the rates of glaucoma detection in the rural community.

Good referral coordination with the base hospital also plays a key role in the success of specialty referrals and patient satisfaction. Periodic monitoring of the referral system can be done to improve the detection and treatment of glaucoma, and thus help in preventing irreversible visual impairment and vision loss.

Conclusion

Early detection and treatment of glaucoma are important to minimize the risk of irreversible vision loss in patients. VCs can ensure proper patient education and awareness, early detection and referral for treatment, adherence to treatment, and periodic review. Trained technicians at VCs can facilitate early detection of glaucoma in the community as they are more accessible to the rural patient, thus helping in preventing irreversible vision loss. Our results suggest that trained technicians can facilitate glaucoma detection at early stages. With the aging population and rising chronic disease burden, the demand for eye care services will also grow and integrated models of care such as VCs are necessary.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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