Original Article

Profile of Glaucoma in the Eastern Region of Saudi Arabia: A Retrospective Study

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Abstract

Background: Glaucomas remain asymptomatic until severe, indicating that the actual number of affected individuals may be higher than those diagnosed.

Objective: To study the clinical patterns of glaucoma cases in the Eastern Province of Saudi Arabia.

Patients and Methods: This retrospective study was conducted at King Fahd Hospital of the University, Al-Khobar, and Dhahran Eye Specialist Hospital, Dhahran, Saudi Arabia. The medical records of all patients with glaucoma who visited these hospitals from January 2015 to December 2018 were critically reviewed. Data regarding patients' demographic characteristic, clinical data and their medical and surgical management techniques were collected and analyzed.

Results: A total of 999 patients were included, of which 52.9% were males, 94.8% were Saudi, and the mean age was 58.8 years. Bilateral involvement was observed in 82.3% of cases. Primary open-angle glaucoma (POAG) was the most prevalent type of glaucoma (27.7%), followed by secondary glaucomas (26.7%), primary angle-closure glaucoma (PACG) (18.2%), primary congenital glaucoma (2.7%), and juvenile open-angle glaucoma (2.2%), which were the most frequent glaucoma subsets.

Conclusion: The study population was most affected by POAG, secondary glaucomas and PACG. Knowledge regarding prevalence of glaucoma is important to plan services, allocate resources, and prevent blindness.

Keywords: Glaucoma, glaucoma patterns, primary open-angle glaucoma, Saudi Arabia, secondary glaucoma

INTRODUCTION

One of the preeminent global causes of irreversible blindness is glaucoma.[1] In 2010, the global estimates indicated that 4.5 million people developed blindness secondary to open-angle glaucoma and another 3.9 million developed blindness due to angle-closure glaucoma. The projections for 2020 reveal that these numbers would increase to 5.9 and 5.3 million, respectively.[1] According to a systemic review, the worldwide prevalence of glaucoma is around 3.54%, with Africa having the highest prevalence. By 2040, 111.8 million people will be affected by glaucoma compared to 64.3 million in 2013, signifying an expected increase by 74%.[2]

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Region-specific information regarding glaucoma patterns is useful in addressing concerns associated with the extent and burden of glaucoma-related visual disabilities. Therefore, community-based studies are necessary to determine the prevalence and incidence of the disease; however, they are costly, time-consuming and challenging to conduct. The patient populations in referral centers are diverse and can provide a general overview of some clinical disease profiles.

Prevalence of glaucoma is considerably varied in the Middle East, Japan and South-East Asia, which warrants caution while interpreting the reported data due to a wide confidence interval in the prevalence rates and the significantly large heterogeneity associated with the published data from these regions.[3]

A population-based study conducted in one region in India found that the estimated prevalence of open-angle glaucoma (OAG) was 1.07%, while the prevalence of primary angle-closure glaucoma (PACG) was around 0.21%.[4] In Germany, a study found that the age-standardized prevalence of primary open-angle glaucoma (POAG) at the age of >50 years was 2.79% and the total incidence rate was 0.38 per 100 person–years. In addition, age, female gender, ocular injury, degeneration of iris and ciliary body, myopia, retinal vascular occlusions, hypertension, and diabetes mellitus were found to be strongly associated with POAG.[5] In a large-scale randomized cohort study conducted in Northern Finland, the estimated prevalence of glaucoma in 45–49-years olds was found to be 1.1%.[6] In another national study from Australia, the prevalence of confirmed glaucoma cases in non-Indigenous Australians and Indigenous Australians was found to be 1.5% and 0.6%, respectively.[7]

In Saudi Arabia, a study from the Central Province suggested that the prevalence of glaucoma is 5.6%,[8] which is similar to rates reported from other Middle East countries.[9-11] However, Saudi Arabia is a geographically vast country, and it would be useful to estimate regional glaucoma patterns and currently there is a paucity of information associated with the epidemiological profile of glaucoma in the Eastern Province of Saudi Arabia. Therefore, this study was conducted to determine glaucoma patterns in Eastern Saudi Arabia and to assess the demographic parameters associated with various glaucoma types, measure the association between glaucoma types and various parameters such as intraocular pressure (IOP) and visual acuity (VA) and to recognize different treatment methods.

PATIENTS AND METHODS

For the purpose of this retrospective study, two major referral centers in the Eastern Province of Saudi Arabia, namely, King Fahd Hospital of the University and Dhahran Eye Specialist Hospital, were selected and all medical records of glaucoma patients who visited the selected medical settings between January 2015 and December 2018 were reviewed and their data were collected. This included demographic data such as gender, age, and nationality as well as clinical data such as diagnoses of glaucoma, site of glaucoma, types of secondary glaucoma, values of VA in different visits, IOP, topical ophthalmic medications used, and surgical and laser interventions applied. Ethical approval was provided by Institutional Review and Ethics Board of both institutions and the study adhered to the guidelines of the Declaration of Helsinki, 2013.

According to European Glaucoma Society, glaucoma subtypes are defined as follows:[12]
1. Primary congenital/childhood glaucoma (PCG) is a type of glaucoma that affects patients from birth until the second year of life. Sub-type categorization depends on the age-of-onset: neonatal, infantile and late-onset. The etiology of PCG is angle dysgenesis or maldevelopment of the trabecular meshwork. To establish a diagnosis of PCG, patients are frequently subjected to an examination under sedation/anesthesia. The examiner usually looks for the presence of high IOP, enlarged corneal diameter, corneal oedema with/without Haab's striae and/or uniform cupping (CDR >0.3)
2. Primary open-angle glaucoma (POAG) is a chronic, progressive disease that is characterized by progressive optic neuropathy, a visual field defect, an open-angle on gonioscopy, and the absence of secondary ocular causes. Depending on whether the IOP is high or not, two subsets are defined: POAG with high pressure and POAG with normal pressure. We defined ocular hypertension (OH) as high IOP with the absence of progressive optic nerve cupping and of a visual field defect
3. Primary open glaucoma suspect is an eye that is normal or suspicious with at least one of the following symptoms: visual field defects or optic disc and/or nerve fiber layers (NFL). In these cases, the IOP could either be normal or increased, and a gonioscopy reveals an open angle
4. Primary juvenile glaucoma is a subset of glaucoma that is diagnosed at a later stage following infancy, usually after puberty or during early adulthood. This disease is asymptomatic until the visual field defect progresses

to an advanced stage. On gonioscopy, the angle is wide open, and its structures are poorly differentiated

5. Primary angle-closure (PAC) is a type of glaucoma that is defined by the presence of iridotrabecular contact (ITC). Gonioscopy remains the gold standard in diagnosing this subset of glaucoma. Following are the three stages of PAC:[13]

   • The primary angle-closure suspect (PACS) stage is characterized by two or more quadrants of ITC with normal IOP and an absence of peripheral anterior synechia (PAS) and glaucomatous optic neuropathy

   • The PAC stage involves the presence of ITC, PAS and an increase in IOP with no evidence of glaucomatous optic neuropathy

   • In the primary angle-closure glaucoma (PACG) stage, glaucomatous optic neuropathy becomes evident.

   In this study, we only included cases involving the PAC and PACG stages. In addition, we included cases involving acute angle-closure crisis (AACC).

6. Secondary glaucomas form a heterogeneous glaucoma group that is characterized by the presence of secondary ocular causes, leading to elevated IOP and, subsequently, to glaucomatous optic neuropathy. Most types of secondary glaucoma involve intricate mechanisms. These are subclassified into open- and closed-angle glaucomas. In this study, we combined all the types of secondary glaucoma under one category. These types include secondary childhood glaucoma, pseudoexfoliation glaucoma (PXFG), pigmentary glaucoma, neovascular glaucoma (NVG), uveitic glaucoma, lens-induced glaucoma, malignant glaucoma or aqueous misdirection syndrome, post-surgery glaucoma, post-trauma glaucoma, steroid-induced glaucoma and glaucomas caused by other miscellaneous causes.

Clinical assessments and diagnoses

All the patients had undergone an assessment that included the following tests: best-corrected visual acuity (BCVA), central corneal thickness, visual field evaluation, pupillary examination and slit-lamp examination of the anterior segment. A Goldmann applanation tonometer (GAT) mounted on the slit lamp was used to measure the IOP for most patients, while for the young and uncooperative patients, a tonopen was used. In these patients, angles were examined using four-mirror Volk gonio lenses (Volk Optical Inc., Mentor/Ohio, USA) or direct gonioscopy lenses in the operation theater. Other ancillary tests such as ultrasound biomicroscopy or anterior segment optical coherence tomography (OCT) were used in some instances, for example, in case of patients with plateau iris configuration/syndrome or pigment dispersion syndrome. Posterior segment OCT was also used to assess NFL loss. Finally, the estimation of the vertical CDR was performed using 90D or 78D aspheric lenses at the slit lamp.

Our management process aimed to achieve the 'target' IOP[14] or to reduce the IOP recorded at presentation by 25% through medical therapy, laser and/or surgery.[15] The medical management consisted of the administration of beta-blockers, alpha-agonists, topical and systemic carbonic anhydrase inhibitors, prostaglandin analogues and intravenous mannitol. The surgical procedures that were performed in both the centers were cataract extraction alone, a combination of cataract extraction with filtration surgery or minimally invasive glaucoma surgery, trabeculectomy with mitomycin C (MMC) (0.02% or 0.04%), deep sclerectomy with MMC, goniotomy, trabeculotomy and glaucoma drainage device (GDD) implantation. In contrast, the laser procedures included laser peripheral iridotomy (LPI), laser iridoplasty, laser anterior hyaloidotomy, selective laser trabeculoplasty, ultrasound cycloplasty, and diode and micropulse cyclophotocoagulation (CPC). Since late 2017, micropulse CPC replaced conventional CPC in both the centers. Endoscopic cyclophotocoagulation is another laser procedure that is performed in combination with cataract extraction to control the IOP.

Calculating the average visual acuity

As recommended, the logarithm of the minimum angle of resolution (LogMAR) method was used to assess VA. The VA values were subsequently converted to their LogMAR equivalents by converting them to decimal notation. The negative value of the logarithm was calculated,[16] and the average LogMAR values were computed. An individual who was able to count fingers that were displayed at a distance of 2 feet was considered to have a vision of 2/200 or 20/2000. An individual who could detect hand motion at a distance of 2 feet was considered to have an equivalent Snellen acuity of 20/20,000. Light perception (LP) with or without projection and no light perception (NLP) are not VA measurements but merely the ability to detect a stimulus. Therefore, these factors were excluded from the analysis. Higher LogMAR values would indicate lower VA since the negative logarithm was used to calculate VA.

Statistical analysis

All statistical analyses were conducted using Statistical Package for Social Sciences (SPSS v. 24; IBM Corp., Armonk, NY, US). Collected data were analyzed using descriptive statistics such

as frequency and percentage for qualitative variables, mean and standard deviation (SD) for quantitative variables while Chi-square test, *t*-test, and one way analysis of variance, where applicable, were applied to compare dependent and independent variables.

RESULTS

A total of 999 records were reviewed. Of these, 528 (52.9%) were male. The mean age of participants ranged from 40 to 70 years (mean: 58.8 ± 17.4 years). The majority of the participants were Saudi (94.8%). Further, the most common site was bilateral glaucoma (82.3%) followed by unilateral glaucoma (16.7%) [Table 1].

Type of glaucoma, visual acuity, and medication history
Data regarding type of glaucoma was missing in 174 (17.4%) patients and 75 (7.5%) were labeled as glaucoma suspect. The three most predominant glaucoma types were POAG (*n* = 277, 27.7%), secondary glaucoma (*n* = 268, 26.8%), and ACG (*n* = 155, 15.5%) [Figure 1]. Congenital glaucoma (22, 2.2%) and juvenile glaucoma (18, 1.8%) represented a small proportion of the study population, while 10 patients (1%) were labeled as mixed mechanism glaucoma. The most common types of secondary glaucoma were PXFG (35.8%), followed by NVG (20.5%) [Table 2]. Regarding the different angle closure glaucoma (ACG) subcategories, the PAC cases accounted for 9.3% of the cases, while the primary chronic angle-closure glaucoma (PCACG) cases comprised around 77.8% of the entire ACG patient samples and 13.7% of the patients presented with acute angle-closure crises (AACC) [Figure 2].

The VA of the participants is summarized in Table 3, the mean and SD of LogMAR was used to summarize the VA of the participants, which are 0.81 ± 0.87 and 0.73 ± 0.85, in the 1st and 2nd visit, respectively. The percentages of LP are 2.60% and 1.92%, respectively, in the 1st and 2nd visit, while the percentage of NLP are 5.9% and 8.41%,

respectively, in the 1st and 2nd visit. We observed that the mean VA recorded during the second clinic visit was lower compared to the mean VA recorded during the first visit.

Regarding topical medical therapy, 145 (15.7%) patients were not using any medications, 101 (10.9%) were being treated with one type of IOP-lowering eye drops, and 127 (13.8%) were using two types. Moreover, 237 (25.7%) patients were using three medications, while 313 (33.9%) were using four different types of drops.

Distribution across glaucoma subtypes
As mentioned in Table 4, the distribution of age and site was significantly different among the glaucoma subtypes ($P < 0.05$), while there was no statistically significant difference between gender, nationality and glaucoma subtypes ($P > 0.05$). The results associated

Table 1: Distribution of participants according to nationality, mean age, and laterality of glaucoma (*n*=999)

Variables	Total, *n* (%)
Nationality	
Saudi	947 (94.8)
Non-Saudi	52 (5.2)
Gender	
Male	528 (52.9)
Female	471 (47.1)
Age (mean±SD)	58.8±17.4
Site of glaucoma	
Bilateral	822 (82.3)
Unilateral	167 (16.7)
No record	10 (1)

SD – Standard deviation

Table 2: Types of secondary glaucoma in the study population (*n*=268)

Variable	Number of patients, *n* (%)
PXFG	96 (35.8)
NVG	55 (20.5)
Uveitic glaucoma	29 (10.8)
Postsurgical glaucoma	20 (7.5)
Lens-induced glaucoma	17 (6.3)
Steroid-induced glaucoma	14 (5.2)
Posttraumatic glaucoma	13 (4.9)
Other	24 (9)

PXFG – Pseudoexfoliation glaucoma; NVG – Neovascular glaucoma
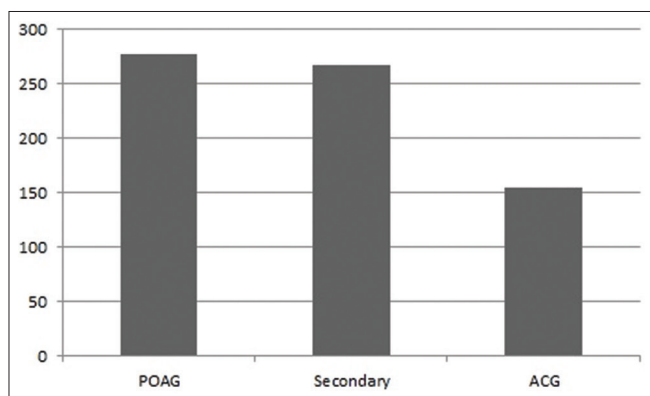
Figure 1: Predominant glaucoma types
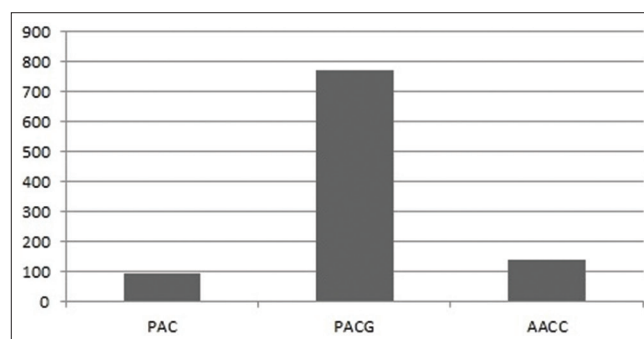
Figure 2: Different angle closure glaucoma subcategories

with pairwise comparisons revealed that the mean age was significantly higher in the POAG group compared with that in the remaining groups ($P < 0.05$), apart from that in the ACG group. Regarding the site of glaucoma, the results revealed that the percentage of patients with bilateral glaucoma was significantly higher among patients with POAG compared to that among those with ACG and secondary glaucoma ($P < 0.05$). Analysis also revealed that the mean IOP was not significantly different between the groups.

As mentioned in Figures 3 and 4, cataract surgery alone was the most commonly performed operation, while LPI was the most commonly performed laser procedure.

DISCUSSION

The findings of study indicates that the most frequent glaucoma type in the Eastern Province of Saudi Arabia is POAG followed by secondary glaucoma and PACG. These findings are within the line of different studies conducted in Saudi Arabia in the recent past.[17-20] Further, our findings also correlate with regional studies conducted in Oman[9] and Qatar.[10] However, the results differ with those of international studies: POAG is more common among the African population than among the European or the Asian population, while ACG is more common among Asians than Africans or Europeans.[1]

In this study, the mean age of patients with POAG and PACG at presentation was approximately 62 years, which is consistent with the results obtained from previous reports.[17]

Table 3: Values of visual acuity of the participants included in the study

	First visit, *n* (%)	Second visit*, *n* (%)
LogMAR (mean±SD)	0.81±0.87	0.73±0.85
LP	41 (2.60)	33 (1.92)
NLP	93 (5.9)	144 (8.41)
Total number (*n*)	1442	1713

*LP – Light perception; NLP – No LP; LogMAR – Logarithm of the minimum angle of resolution

The average IOP in our study was 14.5 mmHg across all the glaucoma subtypes. The measurements were recorded while patients were receiving medical therapy and/or after they underwent surgical or laser procedures. The IOP of around 25.7% and 33.9% of the participants was controlled by three and four different types of topical IOP-lowering medications, respectively. The most frequently performed surgical procedures were cataract surgery alone (57.44%) followed by trabeculectomy + MMC (22.91%), GDD implantation (6.84%) and CPC (6.84%). According to our data, the most frequently performed office-based procedure was LPI (94.75%). Interestingly, cataract surgery was found to have an IOP-lowering effect that has been reported in several studies, most notably in the Ocular Hypertension Treatment Study.[21-23] In contrast, we found that LPI was not as effective as a single modality treatment in managing the PACG cases. These cases required additional treatments including IOP-lowering medications and/or a surgical intervention to control their disease.

Regarding the VA observed in our study, there was a tendency among the participants to have poorer vision at presentation (LogMAR 0.81 ± 0.87 SD). The percentages of cases with LP and NLP vision at presentation were 2.60% and 5.90%, respectively. Compared to the observations recorded during the first visit, we observed both improvements and deterioration in the vision. Examining the vision in the subsequent visit revealed modest improvements (LogMAR 0.73 ± 0.85). We speculate that the reason behind this improvement was the correction of a pre-existent refractive error and/or cataract extraction with the implantation of an intraocular lens. Moreover, deterioration in vision was also noted. A number of cases with LP vision exhibited a reduction of 1.92%. In contrast, cases with NLP vision displayed a rise of 8.41%. This discrepancy could be a manifestation of late presentation, poor compliance to medical therapy, and inadequate health literacy among the Saudi population, which has been addressed in a recent report.[24] Furthermore, the level of education may affect

Table 4: Distribution of sex, age, nationality, and site across glaucoma types (*n* = 740)

Variable	POAG (%)	Secondary (%)	ACG (%)	Congenital (%)	Juvenile (%)	*P*
Gender						
Female	129 (46.6)	113 (42.2)	83 (53.6)	12 (54.5)	11 (61.1)	0.107
Male	148 (53.4)	155 (57.8)	72 (46.4)	10 (45.5)	7 (38.9)	
Nationality						
Non-Saudi	14 (5)	12 (4.5)	4 (2.6)	2 (9.1)	1 (5.56)	0.281
Saudi	263 (95)	256 (95.5)	151 (97.4%)	20 (90.9)	17 (94.4)	
Site						
Bilateral	268 (96.8)	155 (57.8)	140 (90.3)	22 (100)	18 (100)	0.001
Unilateral	9 (3.2)	113 (42.2)	15 (9.7)	0	0	
IOP (± SD)	15.2 (6.4)	15.2 (8.3)	14.8 (6.49)	11.7 (6.4)	15.5 (7.9)	0.16
Age (± SD)	62.4 (13.3)	58.3 (19.2)	61.8 (11.6)	16.4 (12.7)	32.3 (14.4)	0.001

POAG – Primary open-angle glaucoma; ACG – Angle closure glaucoma; IOP – Intraocular pressure
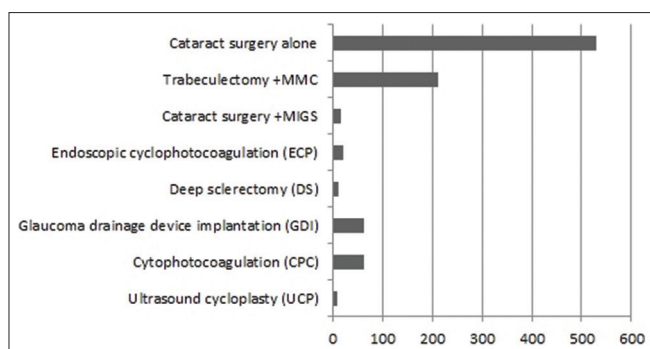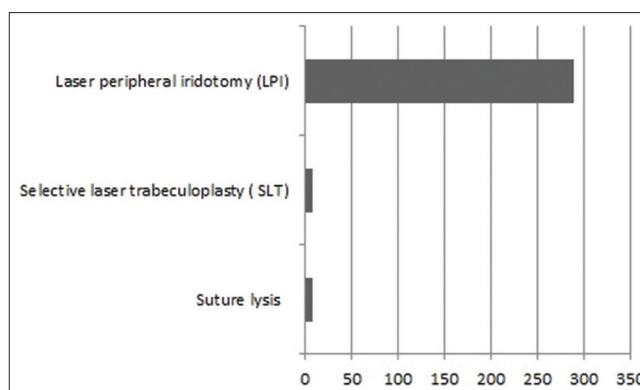
Figure 3: Summary of surgical and laser procedures performed (*n* = 921)

the adherence to the required administration schedule of IOP-lowering topical medications.[25,26]

Compared to the findings of Al Obeidan *et al*.,[17] and AlZuhairy *et al*.,[19] in our study, POAG cases were higher than of PAC, which could be attributed to presence of certain POAG-related risk factors that have been not addressed here, such as, myopia, diabetes mellitus and a family history of this condition. Wang *et al*.[26] found a correlation between air pollution and glaucoma. The Eastern Region harbors the Jubail industrial city, which is a global hub for chemical industries, and this may be responsible for these unique glaucoma patterns compared to other Saudi provinces. However, further studies are necessary to confirm a causal association between air pollution and glaucoma. Finally, many studies have reported that over 50% POAG cases are not detected.[27] Similarly, the overdiagnosis of POAG was studied in the Thessaloniki Eye Study (2018),[28] and the authors stated that 1.3% of the cases were falsely diagnosed as POAG and that around two-third of them were receiving IOP-lowering drops.

PCACG cases comprised 77.8% of the PAC cases. Notably, the percentages of the PAC subcategories may reflect the natural progression of the disease if it is not detected early and treated adequately. Approximately 13% of the cases presented with AACC and two-thirds of them required long-term medical therapy and/or surgical intervention due to the development of PAS, high IOP, and subsequently, the development of glaucomatous optic neuropathy.

The prevalence of PCG among Saudi Arabian individuals (1 in 2500) is considered the second highest in the world after the prevalence among Slovakian gypsies (1 in 1250).[29] In our study, PCG accounted for 2.62% of all the glaucoma cases, while JOAG accounted for 2.14%. Similar figures were reported by Al Obeidan *et al*.[17] Both these diseases are managed surgically. In our study, trabeculectomy and deep sclerectomy were observed to

Figure 4: Summary of office-based laser procedures performed (*n* = 305)

be the most frequent surgical interventions that were performed to treat these cases.

Consistent with findings of Al Obeidan *et al*.,[17] in our study, secondary glaucoma was found to be the second most common type of glaucoma. PXFG was the predominant subset (35.8%) followed by NVG (20.5%), uveitic glaucoma (10.8%), postsurgical glaucoma (7.5%), and lens-induced glaucoma (6.3%). According to Wang *et al*.,[26] exposure to solar ultraviolet radiation could increase the risk of glaucoma, mainly PXFG. Pasquale *et al*.[30] reported a similar finding.

Finally, it is worth mentioning that around 7.5% of the patients were labelled as primary open-angle glaucoma suspects. These patients were referred to the glaucoma clinic due to an enlarged CDR; however, factors such as the size of the disc, the presence of a tilted disc in myopic patients and over-estimated IOP with high central corneal thickness values were not taken into consideration. Based on the recommendations published by the European Glaucoma Society in the fourth edition of the Terminology and Guidelines for Glaucoma (2017),[12] such cases should be scheduled for a follow-up every 6–12 months, and the patients should be examined for changes or abnormalities in the optic nerve head, NFL and visual field test results.

Several limitations need to be acknowledged. Because of the retrospective nature of this study, there were some missing data. In addition, misdiagnosis and misclassification might be an issue as well. Therefore, a large national survey is needed to estimate the prevalence and the burden of glaucoma and to identify its risk factors.

CONCLUSION

This study showed that in the Eastern Province of Saudi Arabia, POAG, secondary glaucoma and PACG were the

most common types of glaucoma observed. Knowledge regarding prevalence of glaucoma is important, especially for the planning of services, allocation of resources, and prevention of blindness.

Ethical considerations

All ethical issues were considered during the process of this study and adherence to the guidelines of the Declaration of Helsinki, 2013, was also ensured. The study proposal was approved from the Institutional Review and Ethics Board at Dhahran Eye Specialist Hospital (Date: December 4, 2018) and Imam Abdulrahman Bin Faisal University (Ref. no.: IRB-2020-01-140; date: May 4, 2020]. As this study is a retrospective chart review, patients were deidentified and the need for informed consent was waived.

Peer review

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Cook C, Foster P. Epidemiology of glaucoma: What's new? Can J Ophthalmol 2012;47:223-6.
2. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: A systematic review and meta-analysis. Ophthalmology 2014;121:2081-90.
3. Cheng JW, Zong Y, Zeng YY, Wei RL. The prevalence of primary angle closure glaucoma in adult Asians: A systematic review and meta-analysis. PLoS One 2014;9:e103222.
4. Addepalli UK, Jonnadula GB, Garudadri CS, Khanna RC, Papas EB. Prevalence of primary glaucoma as diagnosed by study optometrists of L. V. Prasad Eye Institute – Glaucoma epidemiology and molecular genetics study. Ophthalmic Epidemiol 2019;26:150-4.
5. Kreft D, Doblhammer G, Guthoff RF, Frech S. Prevalence, incidence, and risk factors of primary open-angle glaucoma – A cohort study based on longitudinal data from a German public health insurance. BMC Public Health 2019;19:851.
6. Karvonen E, Stoor K, Luodonpää M, Hägg P, Kuoppala J, Lintonen T, *et al*. Prevalence of glaucoma in the Northern Finland Birth Cohort Eye Study. Acta Ophthalmol 2019;97:200-7.
7. Keel S, Xie J, Foreman J, Lee PY, Alwan M, Fahy ET, *et al*. Prevalence of glaucoma in the Australian National Eye Health Survey. Br J Ophthalmol 2019;103:191-5.
8. Khandekar R, Chauhan D, Yasir ZH, Al-Zobidi M, Judaibi R, Edward DP. The prevalence and determinants of glaucoma among 40 years and older Saudi residents in the Riyadh Governorate (except the Capital) – A community-based survey. Saudi J Ophthalmol 2019;33:332-7.
9. Khandekar R, Jaffer MA, Al Raisi A, Zutshi R, Mahabaleshwar M, Shah R, *et al*. Oman Eye Study 2005: Prevalence and determinants of glaucoma. East Mediterr Health J 2008;14:1349-59.
10. Al-Mansouri FA, Kanaan A, Gamra H, Khandekar R, Hashim SP, Al Qahtani O, *et al*. Prevalence and determinants of glaucoma in citizens of Qatar aged 40 years or older: A community-based survey. Middle East Afr J Ophthalmol 2011;18:141-9.
11. Pakravan M, Yazdani S, Javadi MA, Amini H, Behroozi Z, Ziaei H, *et al*. A population-based survey of the prevalence and types of glaucoma in central Iran: The Yazd eye study. Ophthalmology 2013;120:1977-84.
12. European Glaucoma Society Terminology and Guidelines for Glaucoma, 4th Edition – Chapter 2: Classification and terminology Supported by the EGS Foundation. Br J Ophthalmol 2017;101:73-127.
13. Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification of glaucoma in prevalence surveys. Br J Ophthalmol 2002;86:238-42.
14. Sihota R, Angmo D, Ramaswamy D, Dada T. Simplifying "target" intraocular pressure for different stages of primary open-angle glaucoma and primary angle-closure glaucoma. Indian J Ophthalmol 2018;66:495-505.
15. Heijl A, Leske MC, Bengtsson B, Hyman L, Bengtsson B, Hussein M, *et al*. Reduction of intraocular pressure and glaucoma progression: Results from the Early Manifest Glaucoma Trial. Arch Ophthalmol 2002;120:1268-79.
16. Holladay JT. Proper method for calculating average visual acuity. J Refract Surg 1997;13:388-91.
17. Al Obeidan SA, Dewedar A, Osman EA, Mousa A. The profile of glaucoma in a Tertiary Ophthalmic University Center in Riyadh, Saudi Arabia. Saudi J Ophthalmol 2011;25:373-9.
18. Eid TM, El-Hawary I, El-Menawy W. Prevalence of glaucoma types and legal blindness from glaucoma in the western region of Saudi Arabia: A hospital-based study. Int Ophthalmol 2009;29:477-83.
19. Alzuhairy S, Alalola FS, AlAkeel HA, Alayed DM, Al-Harbi IM, Al-Shetwi MM, *et al*. Profile and management outcomes of glaucoma cases at Qassim University Hospital. Int J Health Sci (Qassim) 2018;12:20-4.
20. Al Rashed AS, Al Subaie HA, Al Hathloul HS, Al Shehab KA, Al Naim MA, Kaliyadan KF, *et al*. Types of glaucoma in a University Health Centre in Al-Ahsa, Saudi Arabia: A pilot study. Niger J Ophthalmol 2015;23:12.
21. Mansberger SL, Gordon MO, Jampel H, Bhorade A, Brandt JD, Wilson B, *et al*. Reduction in intraocular pressure after cataract extraction: The Ocular Hypertension Treatment Study. Ophthalmology 2012;119:1826-31.
22. Zetterström C, Behndig A, Kugelberg M, Montan P, Lundström M. Changes in intraocular pressure after cataract surgery: Analysis of the Swedish National Cataract Register Data. J Cataract Refract Surg 2015;41:1725-9.
23. Berdahl JP. Cataract surgery to lower intraocular pressure. Middle East Afr J Ophthalmol 2009;16:119-22.
24. AbuAlreesh A, Alburikan KA. Health literacy among patients with poor understanding of prescription drug label instructions in Saudi Arabia. Saudi Pharm J 2019;27:900-5.
25. Hwang DK, Liu CJ, Pu CY, Chou YJ, Chou P. Persistence of topical glaucoma medication: A nationwide population-based cohort study in Taiwan. JAMA Ophthalmol 2014;132:1446-52.
26. Wang W, He M, Li Z, Huang W. Epidemiological variations and trends in health burden of glaucoma worldwide. Acta Ophthalmol 2019;97:e349-55.
27. Topouzis F, Coleman AL, Harris A, Koskosas A, Founti P, Gong G, *et al*. Factors associated with undiagnosed open-angle glaucoma: The Thessaloniki Eye Study. Am J Ophthalmol 2008;145:327-35.
28. Founti P, Coleman AL, Wilson MR, Yu F, Anastasopoulos E,

Harris A, *et al*. Overdiagnosis of open-angle glaucoma in the general population: The Thessaloniki Eye Study. Acta Ophthalmol 2018;96:e859-64.

29. Senthil S, Badakere S, Ganesh J, Krishnamurthy R, Dikshit S, Choudhari N, *et al*. Profile of childhood glaucoma at a tertiary center in South India. Indian J Ophthalmol 2019;67:358-65.

30. Pasquale LR, Jiwani AZ, Zehavi-Dorin T, Majd A, Rhee DJ, Chen T, *et al*. Solar exposure and residential geographic history in relation to exfoliation syndrome in the United States and Israel. JAMA Ophthalmol 2014;132:1439-45.