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Original article

Normative Values of Intraocular Pressure and Optic Disc Cup-to-Disc Ratio in Adults in Benghazi, Libya

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Abstract
Intraocular pressure and the optic disc cup-to-disc (C/D) ratio are essential clinical parameters in the early detection of glaucomatous optic neuropathy. Variations in these measurements may occur due to age, gender, and individual anatomical differences, making population-based data important for clinical interpretation. This study aimed to evaluate intraocular pressure and optic disc cup-to-disc ratio among adult patients. A cross-sectional study was conducted in the Ophthalmology Outpatient Department of Benghazi Eye and Ophthalmic Surgery Teaching Hospital between January and March 2025. Adults aged 18 years and older attending for routine eye examinations or minor non-glaucomatous complaints were recruited. Intraocular pressure was measured in both eyes using Goldmann applanation tonometry between 9:00 and 11:00 AM. Optic disc C/D ratio was assessed by slit-lamp biomicroscopy with a fundus lens. A total of 139 participants were analyzed (mean age: 60.28 ± 9.08 years; 59.4% females). The mean IOP was 13.36 ± 2.80 mmHg in the right eye and 12.79 ± 2.62 mmHg in the left eye. The mean C/D ratio was 0.36 ± 0.19 in the right eye and 0.37 ± 0.19 in the left eye. IOP showed no statistically significant association with age or gender. However, males had significantly higher C/D ratios in both eyes compared to females ($p < 0.05$). Intraocular pressure values were within normal limits and were not significantly influenced by age or gender. Optic disc C/D ratios demonstrated significant gender-related differences, with higher values observed in males. Routine assessment of optic disc morphology is recommended, with consideration of gender-related differences.
Keywords. *Intraocular Pressure; Cup-to-disc Ratio; Optic Disc; Glaucoma; Goldmann, Tonometry.*

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Introduction

Glaucoma is a chronic, progressive, multifactorial optic neuropathy characterized by typical structural damage to the optic nerve head and corresponding visual field defects, with intraocular pressure (IOP) recognized as the most important modifiable risk factor [1]. Globally, glaucoma represents the second leading cause of irreversible blindness after cataract and accounts for approximately 12% of worldwide blindness, affecting millions of individuals [2,3]. It is estimated that glaucoma affected over 60 million people worldwide by 2010, with projections rising to nearly 80 million by 2020, a substantial proportion of whom suffer from primary angle-closure disease [3,4]. Primary open-angle glaucoma (POAG) is more prevalent among Caucasian and African populations, whereas primary angle-closure glaucoma (PACG) is more common in Asian populations, and normal-tension glaucoma (NTG) is particularly prevalent in East Asian countries [5].

The role of heredity in the development of glaucoma has been well established; however, the heritability of intraocular pressure (IOP) and optic disc cup-to-disc ratio (CDR) has not been extensively investigated [6]. Familial aggregation of glaucoma was first described by von Graefe in 1869 [7], followed by Duke–Elder's report of autosomal dominant inheritance patterns [8]. Subsequent epidemiological studies have proposed multiple inheritance models, including autosomal dominant, autosomal recessive, sex-linked, and multifactorial patterns [9–15]. Twin and family studies have suggested that chronic open-angle glaucoma follows a polygenic, multifactorial mode of transmission, with heritability estimates of approximately 13% [16]. To date, several chromosomal loci have been implicated in POAG, including the MYOC and OPTN genes [17,18].

Although elevated IOP is no longer universally required for the diagnosis of POAG, it remains a major risk factor for disease development and progression [19]. The heritability of IOP has been reported to range between 0.36 and 0.50 [20,21]. Similarly, the optic disc cup-to-disc ratio has demonstrated strong genetic influence, with heritability estimates ranging from 0.48 to 0.80, supporting a polygenic inheritance pattern [22–24]. The vertical CDR is considered more clinically relevant than the horizontal CDR for early detection of glaucomatous optic nerve damage [22].

Objective assessment of the optic nerve head is central to glaucoma evaluation. Several quantitative parameters have been proposed to describe optic disc morphology, including disc tilt, disc rotation, peripapillary atrophy indices, and optic disc diameter ratios [25–28]. However, many of these parameters remain limited in their clinical applicability, as critical features of cupping and vascular changes are often

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qualitative and difficult to measure objectively [28]. Optic disc evaluation using the cup-to-disc ratio continues to be one of the most practical and widely adopted tools in routine clinical practice.
Despite the known global burden of glaucoma, data regarding disease detection and progression under routine clinical conditions remain limited [29,30]. The rate of progression is a crucial determinant of visual disability and is a key element in international glaucoma management guidelines [31,32]. Many affected individuals remain undiagnosed, particularly in developing regions, emphasizing the importance of early detection through simple, non-invasive clinical markers such as IOP and CDR [33,34]. Given the scarcity of regional data and the importance of early identification of glaucoma suspects, this cross-sectional study was designed to evaluate intraocular pressure and optic disc cup-to-disc ratio among adult patients attending a tertiary ophthalmology outpatient clinic. This study aimed to evaluate intraocular pressure (IOP) and optic disc cup-to-disc (C/D) ratio in adult subjects.

Methods

Study Design and Population

This cross-sectional study was conducted in the Ophthalmology Outpatient Department at Benghazi Eye and Ophthalmic Surgery Teaching Hospital between January and March 2025. A total of 138 participants were enrolled during the study period.

Inclusion and Exclusion Criteria

Adults aged 18 years and older who attended the ophthalmology clinic for routine eye examinations or minor complaints not related to glaucoma or elevated intraocular pressure (IOP) were eligible for inclusion. Participants were excluded if they had a history of ocular trauma, glaucoma, previous intraocular surgery (including cataract extraction), corneal ulcer, corneal scarring, or monocular vision. All participants provided written informed consent prior to enrollment. The study protocol was reviewed and approved by the Institutional Ethics Committee of Benghazi Eye and Ophthalmic Surgery Teaching Hospital.

Data Collection

Demographic data, including age and gender, were recorded. Ophthalmic examination included measurement of intraocular pressure (IOP) in both eyes using a Goldmann Applanation Tonometer. IOP was measured in the sitting position between 9:00 AM and 11:00 AM to minimize diurnal variation. Optic disc cup-to-disc (C/D) ratios were assessed in both eyes via slit-lamp biomicroscopy with a fundus lens.

Statistical Analysis

All data were entered into SPSS version 25 and analyzed statistically. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. Comparisons between right and left eye IOP and C/D ratios were performed using paired t-tests. Associations with age and gender were evaluated using independent t-tests or ANOVA where appropriate. A p-value of <0.05 was considered statistically significant.

Results

A total of 138 adult participants were included in the final analysis. The mean age of the study group was 60.28 ± 9.08 years, ranging from 28 to 85 years, with most individuals falling within the 49–68-year age range table 1 and Figure 1). Females represented 59.4% of the sample, while 40.6% were males (Figure 2). The mean intraocular pressure (IOP) was 13.36 ± 2.80 mmHg in the right eye and 12.79 ± 2.62 mmHg in the left eye, with values remaining within the normal physiological range in both eyes. The optic disc cup-to-disc (C/D) ratio was recorded in 135 participants, with a mean of 0.36 ± 0.19 in the right eye and 0.37 ± 0.19 in the left eye, ranging between 0.10 and 0.80 (Table 1).

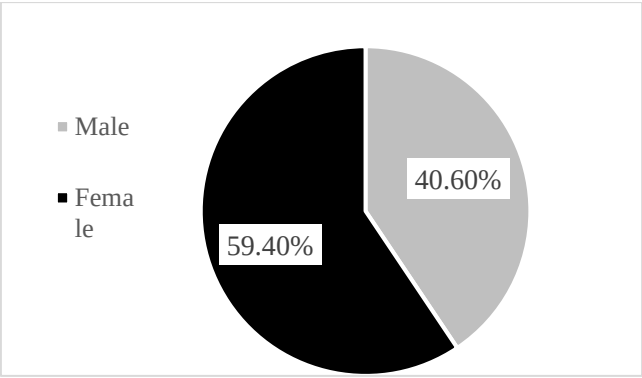

Figure 1. Male and Female distribution of the study population

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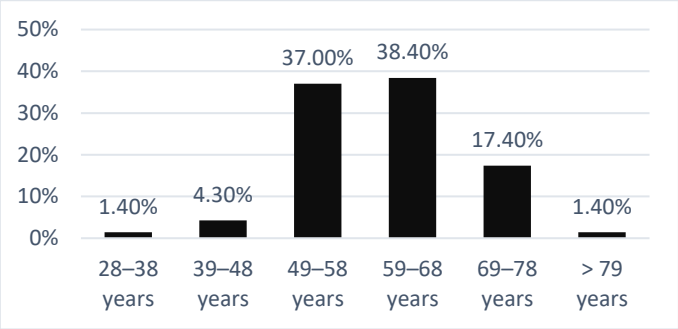

Figure 2. Distribution of the age categories among the study population

Table 1. Demographic and Clinical Characteristics of the Study Population (n = 138)

Variable	Category / Metric	Mean ± SD	Min – Max
Age (years)	—	60.28 ± 9.08	28 – 85
Intraocular Pressure (mmHg)	Right Eye	13.36 ± 2.80	6 – 22
	Left Eye	12.79 ± 2.62	6 – 20
Optic Disc C/D Ratio	Right Eye	0.36 ± 0.19	0.10 – 0.80
	Left Eye	0.37 ± 0.19	0.10 – 0.80

The mean rank for age was higher in males (74.71) compared to females (65.94), indicating a slightly higher median age in males. However, this difference was not statistically significant (Mann-Whitney U = 2004.00, Z = -1.268, p = 0.205), suggesting that age distribution was similar between the two gender groups. Gender-based analysis using the Mann–Whitney U test showed no statistically significant difference in intraocular pressure between males and females in either eye (p = 0.881 for right eye; p = 0.108 for left eye). However, optic disc cup-to-disc (C/D) ratios demonstrated significant gender-related variations. Males exhibited higher C/D ratio ranks compared with females in both the right and left eyes, with statistically significant differences observed (p = 0.048 and p = 0.031, respectively) (Table 2).

Table 2. Comparison of Intraocular Pressure and Optic Disc C/D Ratio by Gender (n = 138)

Variable	Gender	Mean ± SD	Mean Rank	p-value
Age in years	Male (n=56)	61.17 ± 9.2	74.71	0.205
	Female (n=82)	59.67 ± 8.9	65.94	
Right eye Intraocular Pressure (mmHg)	Male (n=56)	13.36 ± 2.80	68.89	0.881
	Female (n=82)	13.36 ± 2.80	69.91	
Left eye Intraocular Pressure (mmHg)	Male (n=56)	12.79 ± 2.62	63.01	0.108
	Female (n=82)	12.79 ± 2.62	73.93	
Right eye Optic Disc C/D Ratio	Male (n=54)	0.36 ± 0.19	75.97	*0.048*
	Female (n=81)	0.36 ± 0.19	62.69	
Left eye Optic Disc C/D Ratio	Male (n=54)	0.37 ± 0.19	76.68	*0.031*
	Female (n=81)	0.37 ± 0.19	62.22	

p < 0.05 indicates statistical significance for gender differences.

There were no statistically significant differences in intraocular pressure or optic disc cup-to-disc (C/D) ratio across the different age groups. The mean ranks for right and left eye IOP did not vary meaningfully between age categories (p = 0.747 and p = 0.787, respectively). Similarly, the C/D ratios in both eyes showed no significant age-related variation (p = 0.781 for the right eye and p = 0.985 for the left eye) (Table 3).
Mann-Whitney U tests showed no significant gender differences in intraocular pressure (IOP) or optic disc cup-to-disc (CD) ratio in most age groups. Exceptions included a significant difference in left-eye IOP in the 69–78 years group (p = 0.031). In participants over 79 years, tests could not be performed for males due to zero cases. (Table 4)

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Table 3. Comparison of Intraocular Pressure and Optic Disc C/D Ratio Across Age Groups (n = 138)

Variable	Eye	Age Category	n	Mean Rank	p-value
Intraocular Pressure (mmHg)	Right	28–38 yrs	2	58.00	0.747
		39–48 yrs	6	51.67	
		49–58 yrs	51	74.18	
		59–68 yrs	53	69.32	
		69–78 yrs	24	67.00	
		>79 yrs	2	50.00	
Intraocular Pressure (mmHg)	Left	28–38 yrs	2	49.25	0.787
		39–48 yrs	6	57.25	
		49–58 yrs	51	66.29	
		59–68 yrs	53	73.85	
		69–78 yrs	24	72.44	
		>79 yrs	2	57.75	
Optic Disc C/D Ratio	Right	28–38 yrs	2	78.75	0.781
		39–48 yrs	6	58.83	
		49–58 yrs	50	69.43	
		59–68 yrs	50	63.69	
		69–78 yrs	24	76.21	
		>79 yrs	2	57.50	
Optic Disc C/D Ratio	Left	28–38 yrs	2	65.00	0.985
		39–48 yrs	6	62.67	
		49–58 yrs	51	68.86	
		59–68 yrs	50	65.83	
		69–78 yrs	24	72.52	
		>79 yrs	2	65.00	

Table 4. Comparison of Intraocular Pressure and Optic Disc Cup-to-Disc Ratio Between Male and Female Participants Across Different Age Categories

Age Category	Gender	Eye laterality	Mean Rank	P value
28–38 Years	Male	Right	2.00	0.317
	Female		1.00	
	Male	Left	2.00	0.317
	Female		1.00	
39–48 Years	Male	Right	2.50	0.340
	Female		4.00	
	Male	Left	2.25	0.171
	Female		4.13	
49–58 Years	Male	Right	26.89	0.707
	Female		25.33	
	Male	Left	25.20	0.733
	Female		26.60	
59–68 Years	Male	Right	27.47	0.871
	Female		26.76	
	Male	Left	25.19	0.532
	Female		27.93	
69–78 Years	Male	Right	11.00	0.254
	Female		14.27	

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	Male	Left	9.69	0.031
	Female		15.82	
>79 Years	Male	Right	0.00	-
	Female		1.50	-
	Male	Left	0.00	-
	Female		1.50	-

Discussion

This study evaluated intraocular pressure (IOP) and optic disc cup-to-disc (C/D) ratio in an adult outpatient population attending a tertiary eye care center. The mean IOP values in both eyes were within the normal physiological range, and the mean C/D ratios were consistent with values reported in healthy populations. These findings provide useful local reference data and support the role of routine ocular screening in detecting early structural and functional changes suggestive of glaucoma. The mean IOP in our study (13.36 ± 2.80 mmHg in the right eye and 12.79 ± 2.62 mmHg in the left eye) aligns with previously reported normative values ranging between 10 and 21 mmHg [35], and with population-based data reporting average IOPs of approximately 15–16 mmHg [36]. Similar to the findings of [37], our results showed minimal difference in IOP between the right and left eyes, reinforcing the concept that significant asymmetry is uncommon in normal individuals.

In contrast to some studies that reported a positive correlation between age and increasing IOP [38], our study found no statistically significant association between age and IOP. These findings are consistent with reports indicating that age-related IOP changes may be influenced by confounding cardiovascular factors such as blood pressure and metabolic conditions [39–45]. Furthermore, Japanese studies have reported an inverse or weak association between age and IOP after adjusting for systemic variables [46,47], supporting our observation of stable IOP values across different age groups. Our study demonstrated no significant gender-based differences in IOP, which is similar to observations reported in [48]. However, the optic disc C/D ratio showed significant gender-related differences, with males exhibiting larger C/D ratios in both eyes. This finding is consistent with previous reports describing greater C/D ratios and higher glaucoma risk in males, as documented in other large epidemiological studies [49–51]. The mean C/D ratios observed in our study (0.36 in the right eye and 0.37 in the left eye] fall within the normal ranges reported by Jonas et al. and Hrynchack et al. [52,53]. The lack of significant variation in C/D ratios across age groups in our sample is also consistent with findings reported in [48], which indicated that C/D ratio is largely independent of age in non-glaucomatous populations. Our findings support the concept that C/D ratio variability is more strongly influenced by anatomical and genetic factors than by aging alone [24,54].

The significant association between male gender and higher C/D ratio in our study reinforces previous evidence suggesting that optic disc morphology may be partly genetically determined and influenced by inherited structural susceptibility to glaucomatous damage [49–51,55,56]. Experimental and histological studies have suggested that reduced mechanical compliance of the optic nerve head and alterations in the lamina cribrosa may predispose certain individuals to optic nerve damage independent of IOP levels [57,58]. These mechanisms may explain the observed gender differences in optic disc parameters in our population. Unlike studies that included glaucomatous patients with markedly elevated IOP and advanced optic nerve damage [59], our study deliberately excluded patients with known glaucoma and major ocular pathology. This explains the relatively lower IOP values and moderate C/D ratios observed in our sample. While [59] reported a high proportion of patients with IOP values above 25 mmHg and advanced cup-to-disc changes, our findings represent normative data in a non-glaucomatous adult population, which is useful for early risk stratification and screening.

The role of heritability in determining IOP and C/D ratio has been well described, with moderate heritability reported for IOP and higher heritability for C/D ratio [21,23,24]. Although genetic analysis was not performed in this study, the variation observed, particularly in C/D ratio, supports the concept of inherited structural susceptibility of the optic nerve head. This study has several limitations. The cross-sectional design limits causal interpretation of associations. C/D ratio assessment was based on clinical biomicroscopic evaluation rather than stereoscopic photographic documentation, which may introduce subjective variability (Paper1). In addition, the study was conducted in a single-center setting, which may limit the generalizability of the findings. Despite these limitations, this study provides valuable baseline data on IOP and optic disc morphology in an adult Libyan population, a group for which limited data are currently available.

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Conclusion

This study demonstrates that intraocular pressure in an adult non-glaucomatous population remained within normal limits and was not significantly affected by age or gender, whereas optic disc C/D ratio showed significant gender-related differences.

Conflict of interest

The authors declare that they have no conflicts of interest related to this study.

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