Anterior chamber depth in open angle glaucoma

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SUMMARY Anterior chamber depth was measured in patients with primary open angle glaucoma, low tension glaucoma, pigmentary dispersion syndrome, and glaucoma suspects. Multiple linear regression analysis demonstrated that anterior chamber depth is a function of sex, age, and refractive error. Values for anterior chamber depth corrected for age and refractive error were greater in patients with pigmentary dispersion syndrome than in patients with other forms of open angle glaucoma or in glaucoma suspects.

The relationships between anterior chamber depth and angle closure glaucoma,^{1,2} pseudoexfoliation,^{3,4} and pigmentary glaucoma⁵ have been investigated. Campbell⁶ has suggested that pigmentary dispersion syndrome results from contact between the pigmented epithelium of the iris and the anterior zonular bundles. This theory is consistent with the clinical finding that pigmentary dispersion syndrome occurs with highest frequency in young myopic males, since this group might be expected to have deep anterior chambers resulting in increased contact between the peripheral iris and lens zonule.

We studied the anterior chamber depth (ACD) of patients with primary open angle glaucoma (POAG), low tension glaucoma (LTG), pigmentary dispersion syndrome (PDS), and glaucoma suspects (GS) in order to gain additional information regarding the relationship of ACD to age, sex, refractive error, and diagnosis.

Patients and methods

All patients included in the study underwent complete ophthalmic examination as routinely performed at the Glaucoma Service Diagnostic Laboratory of the Wills Eye Hospital. This included medical and ocular history, visual acuity test, biomicroscopic examination, gonioscopy, funduscopy, stereoscopic colour disc photography, Farnsworth-Munsell 100-hue colour testing, and Octopus

computerised perimetry. Intraocular pressure (IOP), pulse, and blood pressure were measured every two hours between 7.30 am and 3.30 pm. Sex, age, and refractive error were recorded for each subject; the spherical equivalent refractive error was calculated for each eye. ACD was measured at the slit-lamp with the Haag-Streit depth measuring attachment No. 2, and was performed by the same examiner on all patients.

Patients were classified as GS on the basis of an optic disc with features suspicious but not diagnostic of glaucoma or consistently raised IOP (>21 mmHg), with normal visual field examination. Patients with POAG had glaucomatous optic nerve cupping and typical glaucomatous visual field loss together with a raised IOP or a history of raised IOP. LTG patients had disc abnormalities and visual field loss typical of this disease,^{7,8} with IOP measurements consistently below 21 mmHg. The PDS group displayed a constellation of clinical findings including Krukenberg spindles, mid-peripheral radial transillumination of the iris, and marked pigmentation of the trabecular meshwork; glaucomatous optic disc cupping or visual field loss may or may not have been present.

All eyes treated with miotics were excluded from the study, since these agents are known to shallow the anterior chamber.⁹⁻¹¹ Patients treated with timolol, epinephrine, dipivalyl epinephrine, or oral carbonic anhydrase inhibitors were included in the study.

Statistical evaluation was by single and multiple regression analyses and Student's *t* test. Data are reported as the mean $\pm$ standard error of the mean (SEM). Results were considered statistically significant at $p < 0.05$.

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Results

Table 1 contains data for ACD, age, and refractive error for all groups divided by sex. Thirty-eight eyes (67%) with PDS had glaucoma on the basis of glaucomatous optic nerve changes and visual field loss. There were some statistically significant age differences among the groups: females with LTG and PDS were older than their male counterparts ($p=0.01$ and 0.05 , respectively); males with PDS were younger than males with POAG ($p=0.003$) or LTG ($p=0.04$); and females with LTG were older than females with POAG ($p=0.002$). Males with PDS were more myopic than male glaucoma suspects ($p=0.001$), males with POAG ($p=0.004$), or males with LTG ($p=0.09$). Females with PDS were significantly more myopic than females in all other groups ($p<0.05$).

Mean ACD was significantly greater in males compared with females of each group (GS: $p=0.02$; POAG: $p=0.002$; LTG: $p=0.05$; PDS: $p=0.03$).

Table 1 Age, refractive error, and anterior chamber depth

	Number of patients	Number of eyes	Age (years)	Refractive error* (dioptries)	Anterior chamber depth (mm)
Glaucoma suspects:					
male	51	97	50.5 ± 2.1	-0.94 ± 0.23	2.81 ± 0.03
female	62	121	53.9 ± 2.1	-0.57 ± 0.20	2.71 ± 0.03
Primary open angle glaucoma:					
male	46	78	57.0 ± 2.2	-1.38 ± 0.38	2.83 ± 0.04
female	29	56	59.0 ± 2.5	-0.44 ± 0.27	2.65 ± 0.04
Low tension glaucoma:					
male	14	27	54.7 ± 2.7	-2.14 ± 0.46	2.83 ± 0.06
female	41	75	63.6 ± 2.1	0.05 ± 0.27	2.69 ± 0.04
Pigmentary dispersion syndrome:					
male	23	42	46.2 ± 2.8	-3.36 ± 0.55	3.03 ± 0.04
female	9	15	58.0 ± 5.0	-2.02 ± 0.70	2.87 ± 0.07

*Spherical equivalent.

Fig. 1 Anterior chamber depth (mm) in glaucoma suspects as a function of age (years) in (A) males and (B) females, and as a function of refractive error (dioptries) in (C) males and (D) females. The results of linear regression analysis are given along with the correlation coefficient (r) and associated probability (p).

Fig. 2 Anterior chamber depth (mm) in patients with primary open angle glaucoma as a function of age (years) in (A) males and (B) females, and as a function of refractive error (dioptres) in (C) males and (D) females. The results of linear regression analysis are given along with the correlation coefficient (r) and associated probability (p).

Males with PDS had a significantly greater mean ACD than males with GS ($p=0.001$), POAG ($p=0.007$), or LTG ($p=0.02$). This trend was also true in women but was not as statistically significant, with $p=0.09$, 0.03 , and 0.07 for GS, POAG, and LTG respectively. Such comparisons of mean ACD should be made with caution, however, since significant differences between groups regarding age and refractive error will influence the findings. Accordingly, single and multiple regression analyses were performed to factor out the influences of age and refractive error on ACD.¹²

Fig. 1 through 4 display the measured values of ACD as a function of age and refractive error for males and females of each group. The p value associated with the correlation coefficients are shown on the graphs. There were significant correlations for males and females in most groups between ACD and age, and ACD and refractive error (Figs. 1–4). ACD decreased with increasing age, and increased with increasing myopia. Table 2 contains the results of

multiple regression analysis which simultaneously correlates ACD with age and refractive error. The regression coefficients (a , b , and c) and the correlation coefficient (r) are given for each group. The correlation coefficient of multiple regression analysis representing ACD as a function of both age and refractive error was significant for each group ($p<0.02$). These results allow for the prediction of ACD for a patient of given sex correcting for age and refractive error.

ACD values corrected for age (50 years) and refraction (plano) are given in Table 3. Corrected values for ACD in males and females with PDS were greater than the values for the same sex in all other diagnostic groups. Therefore differences in age and refractive error could not entirely account for the greater ACD found in patients with PDS. There was no significant difference in ACD when eyes with PDS and no visual field loss were compared with eyes with PDS and glaucomatous visual field loss.

Fig. 3 Anterior chamber depth (mm) in patients with low tension glaucoma as a function of age (years) in (A) males and (B) females, and as a function of refractive error (dioptries) in (C) males and (D) females. The results of linear regression analysis are given along with the correlation coefficient (r) and associated probability (p).

Discussion

Anterior chamber depth has been studied in normal subjects,¹³⁻²⁰ in patients with pseudoexfoliation,^{3,4} pigmentary dispersion syndrome,⁵ angle closure glaucoma,^{1,2} after retinal surgery,^{21,22} and in aphakic eyes.^{23,24} Methods have included the use of optical pachymetry,^{1-4,10,14,17,19-24} ultrasonic devices,¹⁸ and photogrammetry.^{5,8,13} Fontana and Brubaker¹³ studied anterior chamber dimensions in normal subjects using a photogrammetric technique. Significant correlations were found with age and refractive error, such that deeper central anterior chambers and greater anterior chamber volume were associated with decreasing age and increasing myopia. Males had deeper anterior chambers than females.

It has been well established that patients with angle closure glaucoma have shallow anterior chambers,⁵ and that eyes with a shallow axial ACD are at increased risk for angle closure glaucoma.^{1,2,25-27} No significant differences in axial ACD have been found

in patients with pseudoexfoliation compared with normal populations.^{3,4} Davidson, Brubaker, and Ilstrup studied the dimensions of the anterior chamber in patients with pigmentary dispersion syndrome.⁵ Their subjects had deeper axial and midperipheral ACDs than could be accounted for by age, sex, or refractive error. Concavity of the midperipheral iris surface was also demonstrated in this group. These results supported Campbell's mechanical theory of iris pigment dispersion.

We measured ACD in four groups of patients: glaucoma suspects, primary open angle glaucoma, low tension glaucoma, and pigmentary dispersion syndrome (with or without glaucoma). Each group was analysed according to sex, age, and refractive error. The mean ACD in each group was greater in males than in females. Multiple regression analysis revealed significant dependence of ACD on age and/or refractive error for males and females of each group. Age- and refractive-error-corrected values of ACD showed deeper anterior chambers in patients

Fig. 4 Anterior chamber depth (mm) in patients with pigmentary dispersion syndrome as a function of age (years) in (A) males and (B) females, and as a function of refractive error (dioptres) in (C) males and (D) females. The results of linear regression analysis are given along with the correlation coefficient (r) and associated probability (p).

Table 2 Multiple regression analysis of anterior chamber depth as a function of age and refractive error

	$z = a + bx + cy^*$			
	a	b	c	$r^\dagger$
Glaucoma suspects:				
male	3.24	-0.009	-0.020	0.517
female	3.16	-0.009	-0.041	0.588
Primary open angle glaucoma:				
male	3.47	-0.012	-0.018	0.486
female	3.04	-0.007	-0.029	0.314
Low tension glaucoma:				
male	2.99	-0.005	-0.062	0.485
female	2.93	-0.004	-0.044	0.390
Primary dispersion syndrome:				
male	3.76	-0.016	0.001	0.588
female	3.48	-0.012	-0.034	0.686

*For the formula $z = a + bx + cy$, z = anterior chamber depth, x = age, y = refractive error, and a , b , and c are regression coefficients.
†The values for the correlation coefficient (r) indicates a statistically significant correlation at $p < 0.02$ for each group.

Table 3 Anterior chamber depth values corrected for age (50 years) and refraction (plano)

	Anterior chamber depth (mm)
Glaucoma suspects:	
male	2.79 ± 0.03
female	2.72 ± 0.03
Primary open angle glaucoma:	
male	2.85 ± 0.04
female	2.70 ± 0.04
Low tension glaucoma:	
male	2.74 ± 0.06
female	2.72 ± 0.04
Pigment dispersion syndrome:	
male	$2.97 \pm 0.04^*$
female	$2.89 \pm 0.07^*$

*These values for anterior chamber depth are significantly greater ($p < 0.05$) than values for the same sex in other diagnostic categories.

with pigmentary dispersion syndrome than in the other diagnostic categories. Corrected values for ACD were greater for males within each group. No significant differences in ACD corrected for age and refractive error were found between groups of patients of the same sex with primary open angle glaucoma, low tension glaucoma, or glaucoma suspects.

These results indicate that patients with pigmentary dispersion syndrome have deeper anterior chambers than can be accounted for by age, sex, or refractive error. Our findings corroborate those of Davidson *et al.*⁵ and lend support to Campbell's theory⁶ of pigmentary erosion secondary to iris-zonular contact.

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