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**TITLE: THE ACCURACY OF ACCREDITED GLAUCOMA OPTOMETRISTS IN THE  
DIAGNOSIS AND TREATMENT RECOMMENDATION FOR GLAUCOMA**

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**Key words:** Glaucoma, optometry, ophthalmology, diagnosis

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## **Abstract**

**Background/aims:** To compare the diagnostic performance of accredited glaucoma optometrists (AGO) for both the diagnosis of, and decision to treat glaucoma with that of routine hospital eye care against a reference standard of expert opinion, i.e. consultant ophthalmologist with a special interest in glaucoma.

**Methods:** A directly comparative, masked, performance study was performed in Grampian, Scotland. 165 people were invited to participate and, of those, 100 (61%) were examined. People suspected of having glaucoma underwent a full ophthalmic assessment both in a newly established, community optometry led, glaucoma management scheme and in a consultant led hospital eye service within a month.

**Results:** The agreement between the AGO and the consultant ophthalmologist in the diagnosis of glaucoma was substantial (89%, kappa = 0.703, SE=0.083). The agreement regarding the need for treatment was also substantial (88%, kappa = 0.716, SE =0.076). The agreement between the trainee ophthalmologists and the consultant ophthalmologist in the diagnosis of glaucoma and treatment recommendation were moderate (83%, kappa = 0.541, SE = 0.098, SE = 0.98; and 81%, kappa = 0.553, SE = 0.90, respectively).

The diagnostic accuracy of the optometrists in detecting glaucoma in this population was high for specificity (0.93 [95% CI 0.85 to 0.97]) but lower for sensitivity at 0.76 (95% CI 0.57 to 0.89).

The performance was similar when accuracy was assessed for treatment recommendation (sensitivity, 0.73[95% CI 0.57 to 0.85]; specificity 0.96[95% CI 0.88 to 0.99]). The differences in sensitivity and specificity between AGO and junior ophthalmologist was not statistically significant.

**Conclusions:** Community optometrists trained in glaucoma provided satisfactory decisions regarding diagnosis and initiation of treatment for glaucoma. With such additional training in glaucoma optometrists are at least as accurate as junior ophthalmologists but some cases of glaucoma are missed.

## **Introduction**

Glaucoma describes a group of eye diseases in which there is progressive damage of the optic nerve characterised by a specific pattern of optic nerve head and visual field loss, and can lead to blindness if untreated. Open angle glaucoma (OAG) is the most common form of glaucoma in the U.K. accounting for 75 to 95 per cent of primary glaucomas.<sup>1</sup> The prevalence of OAG in the UK population aged over 40 is estimated to be 2.0% with 542,000 people with glaucoma and an estimated 65% of cases are currently undetected. Prevalence rises steeply with age from 0.3% at 40 to 3.2% at 70. The most important risk factors for developing OAG, identified from population studies, are raised intraocular pressure (IOP), increasing age, black race, and a family history of glaucoma.<sup>1,2</sup> Many people have raised IOP (ocular hypertension) but do not necessarily develop glaucoma.. Ocular hypertension affects 4-5% of the adult population.<sup>1,2</sup>

In the UK, the majority of people suspected of having glaucoma are referred to the Hospital Eye Service (HES) having been referred from the community optometrist via their GP. Cases are detected amongst people attending for a 'sight' test usually to obtain glasses. Between 20 – 65% of optometry referrals are false positives placing a burden on the already overstretched out patient services in any eye department.<sup>3-7</sup> Definite cases of OAG or suspect OAG require continuing lifetime care. With an ageing population and an increased prevalence glaucoma and ocular hypertension with age the number of people requiring monitoring for glaucoma will probably outstrip the current capacity within existing hospital based glaucoma clinics.<sup>8-10</sup> The concept of shared care for glaucoma, with optometrists and nurses either diagnosing or monitoring glaucoma or both, is under development in the UK.<sup>11-14</sup> Optometrists have suitable skills and equipment in their community practices for diagnostic testing for glaucoma. Late presentation with advanced disease is a risk factor for blindness from glaucoma.<sup>15</sup> Late detection may be due to no contact with health services, or a failure of the involved health professionals to detect glaucoma at an early stage.

In Grampian a new optometric glaucoma service was initiated in June 2004. This service was developed to (1) improve the diagnostic accuracy of glaucoma testing and reduce unnecessary referrals to the hospital glaucoma clinic, (2) initiate promptly anti-glaucoma treatment (instructing the G.P. to provide a prescription of a topical prostaglandin) avoiding delays associated with the referral to the hospital, and (3) monitor people at risk of developing glaucoma in the community. Three local optometrists were enrolled in the scheme and underwent clinical training and accreditation by a Consultant Ophthalmologist and glaucoma specialist (AAB). Training consisted of several practical sessions, attendance to glaucoma clinics, and

teaching on several diagnostic interventions including applanation tonometry, measurement of central corneal thickness, gonioscopy, optic disc examination and interpretation of visual field testing. A new patient pathway was introduced in which all patients with a possible diagnosis of glaucoma were referred first to an accredited glaucoma optometrist (AGO) who would determine the need for further referral and/or treatment.

When redesigning services, and in particular the move towards diagnosis and management in a primary care setting,<sup>16-18</sup> the safety, cost, effectiveness, efficiency and patient satisfaction of the new service needs to be defined. One aspect of this evaluation is determining the accuracy in terms of reliability and diagnostic accuracy of the primary care provider in decisions regarding diagnosis and the need to treat.

Avoiding unnecessary referrals (false positives) is important, but it is equally important to assess referral accuracy in terms of cases missed (false negatives). The purpose of this study was to evaluate the reliability (inter-observer agreement) and diagnostic accuracy of the decision making process of glaucoma optometrists compared with that of junior ophthalmologists against expert diagnosis i.e. consultant ophthalmologist with a special interest in glaucoma (the reference standard).

## **Methods**

### **Participant Selection**

Participants were identified from referrals made by community optometrists in Grampian from June 2004 to September 2005 to the Glaucoma coordinator for the Grampian optometry scheme based at Aberdeen Royal Infirmary. All patients aged over 18 who had been referred by the community optometrist to the AGO were eligible to take part.

All patients referred by the community optometrist were sent a leaflet informing them about the service and that they might be asked whether they would like to take part in a study which would involve them visiting the eye clinic at the hospital for assessment similar to those that their AGO would undertake. Participant selection was by remote allocation an independent researcher based in the Health Services Research Unit, masked to patient details, using a computer generated random number table. Each month 15 patient study numbers were randomly selected from the list using a statistical package (SPSS). Patient lists varied each month ranging from 25 to 71 patients.

Patients who were randomly selected to participate received a further information leaflet giving details of the study and invited to participate.

**Optometrist selection and training:** All Grampian optometrists were invited to participate. The selection process consisted of a written assessment of their overall glaucoma knowledge with presentation of cases, visual field abnormalities and optic discs. A consultant evaluated and marked the answers, and the three optometrists with the highest scores were invited to participate in the scheme. Training consisted of practical sessions, in which the optometrist attended two or three glaucoma clinics (i.e., until both the optometrist and consultant were comfortable with the skills acquired). During the clinics the optometrist was supervised by the consultant on applanation tonometry, gonioscopy, visual field interpretation and optic disc examination. Written referral criteria were provided, including actions to be taken according to IOP, central corneal thickness, gonioscopy, visual field test and optic disc data.

### **Clinical assessment**

All participants had the following assessments for glaucoma made by the AGO in their practice: visual acuity (Snellen chart); visual fields using a threshold-related strategy; corneal thickness using ultrasound pachymetry; slit lamp biomicroscopy to assess the anterior segment and optic disc; tonometry (Goldmann) to measure the intraocular pressure (IOP), and gonioscopy. Refraction and the presence of risk factors for glaucoma were also recorded.

Additionally participants attended the eye outpatient clinic at Aberdeen Royal Infirmary and had the same clinical assessments described above by the glaucoma expert and a junior ophthalmologists (in any order), masked to the decisions made by other assessors, with the exception of IOP measurement, were repeated during a single visit. Visual field testing was done with Humphrey SITA 24-2 perimetry. Intraocular pressure (IOP) measurements were not assessed at this visit to the eye outpatient clinic as differences in IOP level that would influence the management decision could be found. IOP data obtained by the AGO were copied on to the assessment forms by the trial coordinator, and used by the doctors for their patient assessment. Trainees were aware of the study. However, the AGO was unaware of which patients would be included. Participants were specifically asked by the glaucoma coordinator not to provide information regarding the outcomes of previous consultations.

### **Statistical analysis**

The primary outcome of this study was the agreement of management decision as categorised below by the AGO, junior doctor and glaucoma ophthalmologist.

Five possible management decisions were considered: (1) Normal and Discharged; (2) Glaucoma Suspect or Ocular Hypertension (OHT) not requiring treatment but needing a review

visit; (3) Glaucoma Suspect, or OHT, requiring treatment (which included patients with narrow anterior chamber angle and primary angle closure); (4) Glaucoma (defined as presence of glaucomatous damage in optic disc and/or visual field examination); (5) Glaucoma requiring urgent treatment and referral (Table 1).

**Table 1.** Management decisions and guidelines

1. Normal and discharged	Patient does not have any signs of glaucoma and should be discharged
2. Glaucoma Suspect or OHT requiring review	Patients who do not require treatment but who would need to be monitored because of possible abnormal or borderline characteristics such as high IOP (with low to moderate risk of developing glaucoma according to OHTS criteria, <sup>24</sup> ) or suspicious optic disc, or suspicious visual field loss
3. Glaucoma Suspect or OHT requiring treatment	Patients with clinical findings that resemble early glaucoma (see above) or patients with no evidence of glaucoma but high IOP and high risk of developing glaucoma according to OHTS criteria. <sup>24</sup>
4. Glaucoma	Patients with evidence of disc or visual field glaucomatous damage
5. Glaucoma requiring urgent referral	As above with either very severe optic disc damage or very severe visual field loss or very high IOP (40 mmHg or higher)

The proportion of disagreements and precision of the estimates was calculated and the 95% confidence level for each outcome. Two different comparisons were made: presence of glaucoma (decisions No. 4 or 5) versus absence of glaucoma (decisions No. 1, 2 or 3); and treatment required (decisions No. 3, 4 or 5) versus no treatment required (decisions No. 1 or 2) (Table 1). Weighted kappa statistics (and standard error, SE) were estimated, assigning similar weight to disagreements of the above scale (1-5, Table 1).

The sample size calculation was based on an estimate of 20% disagreement in management between the AGO and glaucoma ophthalmologist, based on the results of a previous randomised trial comparing optometric decisions versus hospital decision for established glaucoma monitoring,<sup>19</sup> a sample size of 100 participants gives the opportunity to detect a precision of disagreement of 15% with a 95% confidence level. In addition, sensitivity and

specificity, with corresponding 95% confidence intervals, were estimated for the AGO and the junior ophthalmologists and the differences and associated 95% confidence intervals in sensitivity and specificity for the two groups of health professional estimated.

The study was approved by the Grampian Research Ethics Committee and the Research and Development Board of NHS Grampian. The research was conducted according to the tenets of the Declaration of Helsinki

## Results

Between June 2004 and September 2005 the glaucoma-trained optometrists examined 671 of 694 patients referred to the scheme (Figure 1). Among these patients a total 165 participants were randomly selected. Sixty-five patients did not wish to participate in the study or in the shared care scheme. A total of 100 people (61% of those approached) were enrolled and examined by the consultant ophthalmologist and the junior ophthalmologist at the hospital eye outpatients department. The diagnosis by the consultant ophthalmologist, demographic characteristics, highest IOP and family history of glaucoma are described in Table 2. All patients but one (black) were white.

**Table 2.** Diagnosis (according to the consultant ophthalmologist), highest intraocular pressure (IOP), history of glaucoma in the family, and demographics of patients.

<b>Decision made by Consultant</b>	<b>Frequency (n=100)</b>	<b>Male gender</b>	<b>Family history of glaucoma</b>	<b>Mean age (SD)</b>	<b>Mean IOP (SD)</b>
Normal and discharged	35	15	10	60.5 (13.9)	17.0 (4.1)
Suspect or OHT requiring review	32	11	7	65.0 (14.1)	18.6 (5.0)
Suspect or OHT requiring treatment	8	6	0	64.6 (10.8)	31.2 (6.7)
Glaucoma	23	18	7	71.2 (8.6)	22.4 (4.2)
Glaucoma requiring urgent treatment	2	2	0	73.5 (0.7)	41 (0.0)

Weighted kappa values were 0.534 between optometrist and consultant, 0.452 between consultant and junior physician, and 0.450 between optometrist and junior physician (Table 3). The agreement between the AGO and the consultant ophthalmologist in the diagnosis of glaucoma was substantial (89%, kappa = 0.703, SE=0.083). The agreement regarding the need for treatment was also substantial (88%, kappa = 0.716, SE =0.076). Patients needing urgent referral (n=2) were correctly identified.

The agreement between the trainee ophthalmologists and the consultant ophthalmologist in the diagnosis of glaucoma was moderate (83%, kappa = 0.541, SE = 0.098, SE = 0.98), and the agreement in recommending treatment was also moderate (81%, kappa = 0.553, SE = 0.90).

The agreement between the AGO and the junior physician in detecting glaucoma was fair (66%, kappa = 0.222, SE=0.101), while the agreement to treat was substantial (85%, kappa = 0.624, SE = 0.088) (Table 3).

The diagnostic accuracy of the AGO in detecting glaucoma in this population was high for specificity (0.93 [95% CI 0.85 to 0.97]) but lower for sensitivity at 0.76 (95% CI 0.57 to 0.89) (Table 4). The performance was similar when accuracy was assessed against a decision that treatment was required (sensitivity, 0.73[95% CI 0.57 to 0.85]; specificity 0.96[95% CI 0.88 to 0.99]). Differences in performance between AGO and junior ophthalmologist were not statistically significant (Table 4).

## Discussion

In the U.K. community optometrists are responsible for detecting eye diseases in patients visiting their practices. After using a variety of tests and completing an ocular examination the optometrists refer to the hospital eye service those patients who have some abnormal findings. Due to the ageing population, the increasing prevalence of glaucoma and ocular hypertension, the limited resources of the hospital eye services, and the convenience of health care delivery at the local level, part of glaucoma care is likely to be transferred to optometrists.

The quality of referrals of patients with glaucoma from community optometrists to hospital eye services has been reported in several studies. A substantial proportion of possible glaucoma patients were false positives. In the largest study reported to date, Bowling et al.<sup>20</sup> reported that nearly half (45.8%) of all patients referred to a glaucoma clinic were discharged at first visit. Similar outcomes were observed in other studies.<sup>3-6</sup> False-positive referrals add unnecessary workload to busy outpatient departments, incur in financial costs and impact in



patients' well being. None of the reported evaluations of the performance of optometrists estimated the rate of false negatives, which was assumed to be low. In this study the specificity of the glaucoma trained optometrist is high, reducing the false positive referrals to a minimum. The performance of the glaucoma-trained optometrist is at least comparable to that of decisions made by junior ophthalmologists assessing new referrals for glaucoma in a general ophthalmology clinic. Data reporting the diagnostic accuracy of community optometrists for glaucoma detection has not been identified, despite a systematic search of the literature,<sup>2</sup> but has been estimated as 32% sensitivity and 99% specificity.<sup>2</sup> These estimates are based on a survey conducted on behalf of the International Glaucoma Association involving 241 optometrists in England and Wales who carried out 275,600 sight tests (equivalent to 5% of the national total) over a six-month period in the late 1980s.<sup>5</sup>

Interventions to improve glaucoma detection rates in the community have been tried with variable success. Vernon and Ghosh found little effect after providing specific referral guidelines to local optometrists.<sup>21</sup> However, Patel et al.<sup>9</sup> proved that ongoing training of optometrists resulted in an increase rate of detection of glaucoma in the community. A community-based scheme to improve the referral accuracy of suspect glaucoma cases was also successful.<sup>12</sup> Standard glaucoma referrals were referred to trained optometrists for repeat diagnostic testing with suspect cases then referred on to the HES. The number of suspect glaucoma cases referred to the Manchester Royal Eye Hospital was reduced by 40% and the scheme produced a small financial cost saving to the NHS of approximately £17 pounds per patient. The percentage of false negatives was not known. In Bristol a randomised controlled trial examined community optometric care for monitoring glaucoma patients versus standard hospital care and found no difference in terms of health outcome at two years.<sup>11</sup> The latter study had a population of known glaucoma patients already attending the hospital eye service. A costs analysis found the community service, including costs of referral back to hospital for cases of uncertainty, more expensive than standard hospital care.

In this study two different aspects of the performance of accredited glaucoma optometrists has been assessed: diagnosis and indication for treatment. The gold standard was the judgment of an experienced consultant ophthalmologist. Overall, the agreement between optometrists and the consultant ophthalmologist was high, supporting the current role of trained glaucoma optometrists in the detection of glaucoma and initiation of treatment. Most disagreements occurred at the lower end of the severity scale (normal and suspect/OHT requiring review). These disagreements may not have clinical relevance for patients although unnecessary review of suspects would increase the cost of the service. Two patients requiring urgent referral were correctly identified. Among patients with glaucoma requiring non-urgent referral (n=23),

two were missed by the optometrists and three by junior doctors. The effect of further training, increased clinical experience, or more detailed guidelines to avoid such disagreements is unknown but it is likely that the agreement would improve. From the clinical point of view, accredited glaucoma optometrists could potentially manage and treat patients with ocular hypertension in the community without attending the hospital eye service. Another advantage of this scheme is that patients diagnosed with glaucoma would start treatment immediately while waiting to be seen at the hospital eye service. The quality of care would be at least as good as the one provided by junior doctors at the Outpatients Department. However, it is possible that specialist training in glaucoma would also improve the performance of trainees.

To our knowledge, this is the only study that has evaluated the performance of trained glaucoma optometrists including the rate of false negatives in a community setting. Banes et al.<sup>14</sup> have recently reported good agreement on clinical management decisions between optometrists and consultant ophthalmologists in a hospital-based setting. Our study has the strengths of having used a clinical examination of each patient performed by a consultant rather than medical records, and having evaluated actual practice of accredited glaucoma optometrists working in the community. Although the AGOs knew the study was in progress they were unaware of which of the patients they had seen would be part of the research study. The study design was strong in that all participants were assessed by all three categories of health professionals and as such provide a direct comparative estimated of the reliability of the management decisions. Additionally, the study also provides comparative diagnostic accuracy estimates of the performance of optometrists compared with junior ophthalmologists. There are limitations in that a true reference standard for glaucoma would be best provided by a longitudinal follow-up. However such a cohort study would need many years of follow up, and as such expert opinion is the most feasible and best reference standard currently available.

Community optometrists trained in the glaucoma are potentially a very valuable resource for the detection and management of this disease glaucoma, and indeed other significant eye disease, and have the advantage of easy access in the community and helping reduce the demand on stretched hospital eye services. In this study not only the detection of glaucoma was overall satisfactory but also decisions regarding management and initiation of treatment. With such additional training in glaucoma optometrists are at least as accurate as junior ophthalmologists but some cases of glaucoma are missed. It is possible that with further clinical experience the performance of the optometrists might improve with time.

There are potential disadvantages of an optometrist-based scheme such as the possible increased cost of health care (e.g., in a fee-per-service contract) or for some patients the cost concern of purchasing spectacles that may prevent people from poor socio-economic background

attending for testing. Given limited health care resources the cost effectiveness of establishing such a service across the UK needs to be compared with alternative strategies and current hospital-based care.

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**Legends:**

**Figure 1.** Patient selection process





**Table 3.** Table of agreement between Ophthalmologist, Optometrists and Junior Doctors

		Optometrist						Junior Doctor					
		ND	SR	ST	GR	GU	Total	ND	SR	ST	GR	GU	Total
Consultant	Normal and discharged	15	19	0	1	0	35	17	15	0	2	1	35
	Suspect or OHT requiring review	12	18	0	2	0	32	8	20	1	3	0	32
	Suspect or OHT requiring treatment	0	4	2	2	0	8	0	4	2	2	0	8
	Glaucoma to be referred	2	3	1	16	1	23	3	5	0	13	2	23
	Glaucoma urgent referral	0	0	0	1	1	2	0	0	1	1	0	2
	Total	29	44	3	22	2	100	28	44	4	21	3	100
Weighted agreement 85.25% Kappa 0.53; SE 0.07; p<.001							Weighted agreement 83.25% Kappa 0.45; SE 0.07; p<.001						
Junior Doctor	Normal and discharged	12	16	0	0	0	28						
	Suspect or OHT requiring review	17	20	1	6	0	44						
	Suspect or OHT requiring treatment	0	2	1	0	1	4						
	Glaucoma to be referred	0	6	1	13	1	21						
	Glaucoma urgent referral	0	0	0	3	0	3						
Total		29	44	3	22	2	100						
Weighted agreement 82.50% Kappa 0.45; SE 0.07; p<.001													

**Table 4.** Sensitivity and Specificity of Optometrists and Junior Ophthalmologist (JO) compared with Consultant Ophthalmologist. Top: diagnosis of glaucoma. Bottom: recommendation of treatment.

	Consultant		
Optometrist	Glaucoma	No Glaucoma	Total
Glaucoma	19	5	24
No Glaucoma	6	70	76
Total	25	75	100

	95% CI		
Sensitivity	0.76	0.57	0.89
Specificity	0.93	0.85	0.97

	Consultant		
JO	Glaucoma	No Glaucoma	Total
Glaucoma	16	8	24
No Glaucoma	9	67	76
Total	25	75	100

	95% CI		
Sensitivity	0.66	0.48	0.81
Specificity	0.89	0.80	0.95

	Consultant		
Optometrist	Treat	No treat	Total
Treat	24	3	27
Not Treat	9	64	73
Total	33	67	100

	95% CI		
Sensitivity	0.73	0.57	0.85
Specificity	0.96	0.88	0.99

	Consultant		
JO	Treat	Not Treat	Total
Treat	21	7	28
Not Treat	12	60	72
Total	33	67	100

	95% CI		
Sensitivity	0.64	0.47	0.78
Specificity	0.90	0.80	0.95