SCIENTIFIC REPORT

The role of scanning laser polarimetry using the GDx variable corneal compensator in the management of glaucoma suspects

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Aim: To determine the role of scanning laser polarimetry using the GDx variable corneal compensator (VCC) in the management of glaucoma suspects.

Methods: Over a 12-month period, 43 of 447 (9.6%) patients referred to a glaucoma screening clinic were classified as ''glaucoma suspects'' when it was not possible to categorise the optic disc appearance and visual fields as definitely glaucomatous or definitely normal. Of these patients, 39 underwent a full ophthalmic review, including assessment of the visual fields and analysis of the retinal nerve fibre layer with the GDx VCC.

Results: After the review, 17 of 39 (43.6%) patients were discharged because of normal GDx VCC results. The remaining 22 of 39 (56.4%) were considered to be at risk of developing progressive glaucoma, and further follow-up in the hospital eye service was recommended. 3 (7.7%) patients received treatment. Of the 22 patients, 12 were considered to have pre-perimetric normal tension glaucoma, 7 normal tension glaucoma and 1 primary open-angle glaucoma (POAG). In 19 of these patients, abnormal GDx VCC results were found, particularly inter-eye asymmetry in the nerve fibre layer thickness. However, in 2 of 39 (5.1%) patients the GDx VCC was normal, despite the presence of a neuroretinal rim defect in the optic disc with corresponding visual field loss, and in 1 patient with POAG.

Conclusions: Scanning laser polarimetry using the GDx VCC is an important tool in defining the management strategies of glaucoma suspects. In screening for glaucoma, however, GDx VCC results should not be used in isolation, but in conjunction with conventional methods of optic disc and visual field assessment.

Chronic glaucoma is an ideal disorder for screening, in that it is an asymptomatic condition with an extended course before visual impairment occurs. Detection of the disease in the early stages can be difficult. The diagnosis is based on careful clinical examination including an assessment of the intraocular pressure (IOP), optic nerve head appearance and visual field performance. The retinal nerve fibre layer (RNFL) is not routinely evaluated despite RNFL defects being the earliest sign of glaucoma, and such defects can be found several years before visual field and optic nerve head changes are detected.[1]

In the glaucoma screening clinic at the Oxford Eye Hospital, Oxford Radcliffe Hospitals NHS Trust, Woodstock Road, Oxford, UK, a standardised protocol has been used to collect data relating to the initial assessment of every new referral to one consultant for suspected glaucoma. A 10-year survey at this centre showed that around 2–8% of patients every year were classed as ''glaucoma suspects''.[2] In these patients it was not possible to categorise the appearance of the optic nerve and visual field results of either eye as clearly glaucomatous or definitely non-glaucomatous; hence long-term follow-up in the hospital eye service was recommended. This group of patients has not been studied as a distinct entity before, mainly because glaucoma suspects are usually grouped with patients who have ocular hypertension in an ''uncertain, follow-up required'' category in previously published studies.[2]

The purpose of this study was to determine the role of RNFL analysis in the management of glaucoma suspects using scanning laser polarimetry (SLP) with the GDx variable corneal compensator (GDx VCC; Laser Diagnostic Technologies, San Diego, California, USA), which has high sensitivity in the detection of early glaucoma.[3]

METHODS

Over a 12-month period from August 2004 to July 2005, a glaucoma specialist assessed a total of 447 patients in the glaucoma screening clinic. Of these, 199 (44.5%) were considered to be normal and discharged, 68 (15.2%) were diagnosed with glaucoma and 116 (25.9%) with ocular hypertension. In 43 (9.6%) patients, a diagnosis of ''glaucoma suspect'' was made (irrespective of IOP) if it was not possible to categorise the appearance of the optic nerve and visual field of either eye as definitively glaucomatous or definitely non-glaucomatous (table 1). Of the 43 glaucoma suspects, 39 were brought back to the hospital before their normal follow-up visit for reassessment and RNFL analysis using the GDx VCC polarimeter. There were 26 women and 13 men, and the

Table 1 Outcome of all patients examined between August 2004 and July 2005

Total number of patients	447
1. Normal	199 (44.5%)
2. Ocular hypertension	116 (26%)
3. Glaucoma	68 (15.2%)
4. Other pathology	21 (4.7%)
5. Glaucoma suspects	43 (9.6%)
a. ''Glaucoma suspects'' reassessed with GDx VCC	39
b. Outcome ''discharge''	17 (43.6%)
c. Outcome ''follow-up''	22 (56.4%)

Abbreviations: FDT, frequency doubling technology; IES, inter-eye symmetry; IOP, intraocular pressure; NFI, nerve fibre index; NTG, normal tension glaucoma; POAG, ; primary open-angle glaucoma, ; RNFL, retinal nerve fibre layer; SAP, standard automated perimetry; SLP, scanning laser polarimetry; VCC, variable corneal compensator

mean age was 65 years (range 47–87). All the subjects were white.

Each patient underwent a comprehensive ophthalmic examination including a review of the medical history, visual acuity, slit-lamp biomicroscopy, IOP measurement with Goldmann applanation tonometry, gonioscopy and dilated fundus examination. The IOP was corrected for central corneal thickness and a note was made of whether oral β-blockers such as atenolol (which reduce IOP) were being used. The appearance of the optic disc was compared with stereophotographs taken at the initial consultation. The patients underwent visual field assessment with the frequency doubling technology (FDT) perimeter (Leiss Humphrey Systems, Dublin, CA, USA) (C-20-1 screening protocol); in the event of any abnormality or unreliability on the FDT, Humphrey 24-2 full threshold standard automated perimetry (SAP) was undertaken. All patients underwent SLP imaging with the GDx VCC. The scan was considered normal if there was no deviation ($p<5\%$) in the parameters table, no abnormality on the deviation map and a nerve fibre index (NFI) $\leqslant 30$.

RESULTS

Of the 39 glaucoma suspects, 17 patients (43.6%) were discharged from follow-up after GDx scanning (table 2). On initial consultation and on follow-up, all of these patients had a corrected IOP of $\leqslant 21$ mm Hg and all except one (patient 17) were considered suspect on the basis of suspicious or asymmetrical optic discs. Patient 17 was initially categorised as a glaucoma suspect on the basis of a family history of glaucoma and a visual field abnormality, despite a normal optic nerve appearance. On review, both FDT and SAP were normal, as was the RNFL analysis. Four patients had visual field defects on presentation and although two of these (patients 2 and 14) were found to have a small defect on SAP on reassessment, their performance of the test was unreliable. Patients 6 and 13 had an NFI of >30 in one eye, but no focal RNFL defect and no inter-eye symmetry (IES). In the presence of normal IOP and SAP, these patients were deemed to be normal and discharged.

The remaining 22 patients (56.4%) were given follow-up appointments, including three who were placed on topical treatment (table 3). Of these, 12 were classified as having pre-perimetric normal tension glaucoma (NTG), 7 as having NTG and 1 as having primary open-angle glaucoma (POAG). Two patients had normal GDx VCC parameters but suspicious optic discs and corresponding, non-progressive field loss, and were classified as ''glaucoma suspects'' until the exact cause of their clinical appearance was determined.

All 12 patients in the pre-perimetric glaucoma category had a corrected IOP of $\leqslant 21$ mm Hg, 5 had a positive family history of glaucoma, 2 had field defects on FDT and SAP on presentation but not on follow-up, 8 had NFI $\geqslant 30$ but $\leqslant 50$, and 8 had significant IES values. Of the seven patients categorised as NTG (table 3), five had unreliable results on FDT and SAP on presentation and follow-up, two had a family history of glaucoma, four had NFI $\geqslant 30$ but $\leqslant 50$, and three had NFI >50. Patient 15 had optic disc asymmetry with bilateral, unreliable but unchanged field defects on FDT and SAP, normal NFI, no abnormality on the deviation map and normal IOP. Patients 16, 17 and 18 had bilateral, unreliable visual field loss, normal IOP, suspicious optic discs and grossly abnormal NFI (table 3). Patient 20 was categorised as having POAG. On review, he was found to have raised IOP, normal fields and no abnormalities on SLP, but had an early, unilateral optic disc notch and splinter haemorrhage. Patients 21 and 22 had a non-progressive, unilateral field defect associated with a corresponding neuroretinal rim defect in the optic disc suggestive of glaucoma. However, there was no nerve fibre layer thinning, the GDx VCC parameters were completely normal and there was no IES of the RNFL. Additional investigations, including magnetic resonance imaging, showed no neurological abnormality. As there was no nerve fibre loss, these patients were labelled as being ''glaucoma suspects'' rather than as having normal tension glaucoma until a change in their visual field or ocular parameters could be shown.

DISCUSSION

In the detection of glaucoma, IOP measurement has relatively poor discriminating power. Approximately 32–53% of patients with glaucoma on first presentation have an IOP within the normal range ($\leqslant 21$ mm Hg).[4 5] In this study, none of the patients had raised IOP on initial examination and only one had raised IOP on follow-up. It is difficult to differentiate physiological optic disc variation from

Table 2 Discharged patients

Patient	Family history	Suspect disc	IOP on presentation* R	IOP on presentation* L	IOP on review* R	IOP on review* L	VF defect on presentation	VF defect on review	NFI R	NFI L	Statistically significant IES‡	Oral atenolol
1	+	+	16	20	16	18			22	20		
2		+	20	20	16	16	+	+†	20	15		
3	+	+	18	18	20	20			3	18		
4	+	+	16	20	13	14			13	12		
5		+	20	21	20	21			9	15		
6		+	21	20	21	20			37	23		
7	+	+	17	17	16	16			27	22		
8		+	20	18	20	18			9	8	+	
9	+	+	14	18	14	18			28	18	+	+
10	+	+	19	20	20	19			12	18		+
11	+	+	14	12	14	12			18	20		
12		+	14	22	14	14	+		22	22		
13		+	18	18	18	18			24	38		
14	+	+	20	20	19	19	+	+†	25	17	+	
15		+	18	18	16	16			21	26		
16		+	21	21	21	21			17	17	+	
17	+		16	18	14	14	+		23	26		

IES, inter-eye symmetry; IOP, intraocular pressure; L, left; NFI, nerve fibre index; R, right; VF, visual field.
*Corrected for central corneal thickness.
†Unreliable visual fields on standard automated perimetry.
‡Measure based on the degree of symmetry between the right and left eyes by correlating the temporal-superior-nasal-inferior-temporal functions from the two eyes. Significant in the event of inter-eye asymmetry.

Table 3 Follow-up patients

	Patient	Family history	Suspect disc	IOP on presentation* R	IOP on presentation* L	IOP on review* R	IOP on review* L	VF defect on presentation	VF defect on review	NFI R	Statistically significant IES value** L		Oral ortenolol
Pre-Perimetric normal tension glaucoma	1		+	16	16	10	10			18	26	+	+
	2	+	+	16	18	14	14			20	17	+	
	3		+	19	19	19	19	+		45	17	+	+
	4	+	+	16	17	15	16			29	49		+
	5		+	21	21	19	19			31	47	+	
	6		+	17	17	17	17	+		26	56	+	
	7		+	18	19	18	18			25	40		
	8	+	+	16	18	16	18			20	35		
	9†		+	14	16	21	16			39	26	+	
	10		+	20	21	20	19			14	28	+	
	11	+	+	20	18	21	18			28	14	+	+
	12	+	+	15	15	17	15	+		27	46		
NTG	13	+	+	16	16	16	16	+	+	27	49	+	
	14	+	+	17	19	17	18	+	+	33	29		
	15		+	17	17	17	17	+	+‡	23	18	+	+
	16		+	12	12	12	10	+	+‡	69	51	+	
	17§		+	18	18	20	18	+	+‡	69	26	+	
	18§		+	19	19	21	19	+	+‡	79	60	+	
	19		+	17	17	14	14	+	+‡	32	28	+	
POAG	20¶	+	+	21	20	29	27			19	17		
Suspects	21		+	16	13	16	13	+	+	15	24		
	22		+	19	20	19	20	+	+	28	17		

IES, inter-eye symmetry; IOP, intraocular pressure; L, left; NFI, nerve fibre index; NTG, normal tension glaucoma; POAG, primary open angle glaucoma; R, right; VF, visual field.

*Corrected for central corneal thickness.

†Has pseudoexfoliation, also receiving oral prednisolone.

‡Unreliable visual fields on SAP.

¶Decision to treat made on clinical grounds. High intraocular pressure and glaucomatous optic disc with splinter haemorrhage. Normal visual field on standard automated perimetry (SAP) and normal GDx.

§Decision to treat made on the basis of abnormal GDx.

**Measure based on the degree of symmetry between the right and left eyes by correlating the temporal-superior-nasal-inferior-temporal functions from the two eyes. Significant in the event of IES.

pathological cupping, particularly in early glaucoma.[6] In our experience, this difficulty occurs in approximately 5% of patients referred to a specialist glaucoma screening clinic.[2] The main weakness of screening using automated perimetry is the subjective nature of the test and the high variability of the results.[7] In addition, histological studies have found that as many as half of all ganglion cells can be lost before a field defect can be detected.[8] Evidence suggests that FDT perimetry may be more sensitive than SAP when screening for early glaucoma.[9 10]

The GDx VCC is a scanning laser polarimeter that measures RNFL thickness using polarised light. The advantage of the GDx VCC over previous models is the ability of the instrument to measure and individually compensate for anterior segment bi-refringence, thereby eliminating measurement inaccuracies in RNFL thickness.[11] Objective RNFL data are provided that are compared with an extensive normative database. A close association is observed between SLP measurements using variable corneal polarisation compensation and visual function measured by SAP in glaucomatous eyes.[12] There is also evidence that thin RNFL measurements on SLP can predict future visual field loss among glaucoma suspects.[13]

The purpose of this survey was to assess the use of the GDx VCC in the management of glaucoma suspects. The GDx VCC proved extremely helpful, as we were able to discharge 43.6% of patients from the hospital eye service after normal examination on SLP. Two of these had an NFI >30, but no focal nerve fibre defect was present and there was no IES. The fact that many of these patients do not have to be followed on a regular basis has considerable financial implications if these results are applied nationally. As nerve fibre layer loss often occurs years before visual field deteriorates, this technology allows us to detect patients with pre-perimetric glaucoma (28.6% of the total) and confirm the diagnosis in those with normal tension glaucoma (16.7% of the total). These patients can be followed on a yearly basis with considerable justification and treatment can be instituted if their visual field or ocular parameters change. However, the fact that GDx VCC results were normal in three patients, who clearly were abnormal on clinical examination, highlights a concern. One of these patients had raised IOP and morphological changes in the disc of one eye, consistent with early glaucoma. The visual fields on the FDT and SAP were normal, as was SLP on the GDx VCC. Two patients had a marked neuroretinal rim notch in one eye, associated with a corresponding visual field defect and yet no abnormalities were found in the GDx VCC parameters.

In conclusion, the GDx VCC is an important tool in the management of patients with normal IOP, suspicious optic discs and unreliable visual field performance because the technology detects RNFL loss in pre-perimetric glaucoma. However, our study suggests that the GDx VCC results should not be used in isolation but in conjunction with conventional methods of glaucoma screening.

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