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Glaucoma: Confrontation visual field test using Bagolini striated glasses — a new screening method for detecting visual field defects

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ABSTRACT

INTRODUCTION. Glaucoma diagnosis is based on elevated intraocular pressure, altered morphology of the optic disc, and perimetric visual field defects. Next to funduscopy and optical coherence tomography, perimetric data are important. In developing countries, large parts of the population have only limited access to medical care. Especially in these cases, a quick and affordable method for detecting visual field defects would be desirable. The aim of this study was to investigate the potential use of Bagolini striated glasses in detecting glaucomatous visual field defects.
MATERIALS AND METHODS. Ninety subjects of the Erlangen Glaucoma Register (ISSN 2191-5008, CS-2011. ClinicalTrials.gov, Identifier: NCT00494923) were tested using the confrontation visual field test with Bagolini striated glasses [10 normals, 17 ocular hypertensions (OHT), 31 preperimetric open-angle glaucomas (preOAG), 16 normal tension glaucomas (NTG), 16 open-angle glaucomas (OAG)]. All probands underwent standard ophthalmological examination including slit-lamp biomicroscopy, funduscopy, and Goldmann-tonometry. Additionally, standard white-on-white perimetry and measurements of the global retinal nerve fibre layer (RNFL) of the optic disc were performed.
RESULTS. 1. All normals, all OHTs, and 96% of preOAGs showed normal Bagolini test results. 2. 74% of NTGs and 73% of OAGs yielded pathological Bagolini test results. 3. Specificity of patients with normal visual fields was 98% and sensitivity was 73–80%. 4. Visual field defects resulted in altered Bagolini test results. 5. Localised visual field defects were detected in 78% (NTG) and 80% (OAG) using Bagolini striated glasses.
CONCLUSIONS. Glaucoma-related visual field defects can be detected by confrontation visual field testing using Bagolini striated glasses. This quick, easily performed, and affordable method can be used as a bedside test and is suitable as a screening method for persons in developing countries.

KEY WORDS: glaucoma, Bagolini striated glasses, screening method, visual field, perimetry, bedsite method

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INTRODUCTION

Glaucoma, a neurodegenerative disease, shows a progressive loss of nerve fibres with consecutive impairment of visual field. As the second leading cause of blindness [1], glaucoma disease is, next to the individual psychological burden, a relevant economic issue. For many years it has been the aim of glaucoma research to improve diagnosis, medical treatment, and follow-up. To date, glaucoma diagnosis is based on elevated intraocular pressure, morphologic changes of the optic disc, and perimetric visual field defects. In addition to funduscopy, morphological data can be acquired by optical coherence tomography (OCT) [2].

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Table 1. Demographic data of probands

Variable	N (n = 10)	OHT (n = 17)	Pre-OAG (n = 31)	NTG (n = 16)	OAG (n = 16)
Age (years)	48 ± 15.5	42.8 ± 12.5	50.9 ± 11.5	59.1 ± 8.4	55.3 ± 9.9
Visual acuity (best corrected)	1.1 ± 0.1	1.1 ± 0.2	1.1 ± 0.1	0.9 ± 0.2	0.9 ± 0.2
IOP [mm Hg]	17.2 ± 2.7	21.2 ± 1.7	19.9 ± 5.7	16.8 ± 2.1	19.2 ± 1.7
MD [dB]	0.5 ± 1.1	0.3 ± 1.6	0.9 ± 0.9	6.3 ± 4.7	9.9 ± 7.9
CLV [dB^2]	0.4 ± 0.5	1.1 ± 2.2	0.9 ± 1.5	38.1 ± 40.7	36.5 ± 27.9

N — number of patients; IOP — intraocular pressure; MD — mean defect; CLV — corrected loss variance (standard deviation of MD); OHT — ocular hypertension; pre-OAG — preperimetric open-angle glaucoma; NTG — normal tension glaucoma; OAG — open-angle glaucoma

As one diagnostic basis, perimetry plays an important role in glaucoma diagnosis. In 1998 Jünemann introduced, for the first time, Bagolini striated glasses in the testing of visual field. This test is quick, easy to handle, and performable as a bedside test. The correct diagnosis of homonymous and heteronymous quadrantanopia as well as haemianopia seems to be appropriate using Bagolini striated glasses [3]. In the year 1958 Bagolini established these striated glasses ("test del vetro striato") for testing binocular vision [4] and measurements of cyclotropia [5]. Furthermore, they were used in diagnosis of strabismus with small [6] or large angle of squint [7].

In the present study the potential use of Bagolini striated glasses for detecting glaucomatous visual field defects was investigated.

PATIENTS AND METHODS

Ninety subjects were recruited from the Erlangen Glaucoma Register of the Department of Ophthalmology and Eye Hospital, Friedrich-Alexander-University Erlangen-Nürnberg (ISSN 2191-5008, CS-2011. ClinicalTrials.gov, Identifier: NCT00494923) — 10 normal subjects, 17 patients with ocular hypertension (OHT), 31 patients with preperimetric open-angle glaucoma (preOAG), 16 patients with normal tension glaucoma (NTG), and 16 patients with open-angle glaucoma (OAG) underwent confrontation visual field test using Bagolini striated glasses. Additionally, all subjects were examined by slit-lamp biomicroscopy, funduscopy, and Goldmann-tonometry. Subsequently, standard white-on-white perimetry (Octopus 500, G1 protocol, Interzeag, Schlieren, Switzerland), pachymetry for correction of intraocular pressure, and measurements of global retinal nerve fibre layer (RNFL) of the optic disc (Spectralis® OCT, Heidelberg Engineering, Heidelberg, Germany) were done. Standard perimetric parameters were used for classification of glaucoma: mean defect (MD) and corrected loss variance (CLV = standard deviation of MD). Perimetric visual field defect was defined as:

- MD greater than 2.8;
- three or more adjacent test points on the pattern deviation map with a probability of less than 5%;
- two or more adjacent test points on the pattern deviation map with a probability of less than 1%.

Preperimetric open-angle glaucoma showed an altered optic disc with normal white-on-white standard perimetry, whereas perimetric open-angle glaucoma had additional visual field defects. No secondary open-angle glaucoma was included. Demographic data of all subjects can be seen in Table 1. The tests were in agreement with the tenets of the Declaration of Helsinki and were approved by the Local Ethics Committee (3457). Informed consent was obtained from all subjects.

To perform the confrontation visual field test, Bagolini striated glasses and a light source (e.g. a ward round lamp) is needed. The patient has to fixate the light source, which should be covered by a mat sheet, in a distance of 50 cm, through the Bagolini glasses. If the patient is ametropic, the striated glasses have to be held directly in front of the patient's own eye glasses. The presented image consists of two diagonal crossing light stripes. Probands, testing their right eye, see a light stripe from the right down edge to the left superior edge and vis-à-vis (Fig. 1A and 1B). If patients show a normal binocularity, the two light stripes cross in the point of fixation (fovea). One of the light streams represents two quadrants of visual field until approximately 30° eccentricity. In this way two quadrants of each eye can be measured at once. By switching the Bagolini glasses the other way round, the remaining two quadrants of each eye can be analysed (Fig. 1).

To clarify whether normal binocularity is present, the patient is asked if he/she sees two diagonal

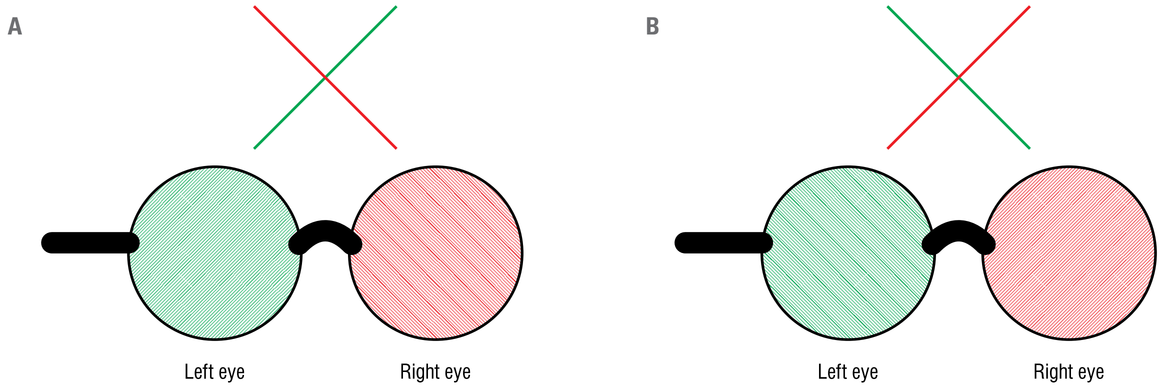

FIGURE 1. Schematic sketch of visual field test using Bagolini striated glasses. **A.** Visual effect of Bagolini striated glasses held upright; **B.** Visual effect of Bagolini striated glasses held reversed

Table 2. Bagolini test for all patients groups (normal, OHT, pre-OAG, NTG, and OAG): Amount of normal and pathological test results

Results	N (n = 10)	OHT (n = 17)	Pre-OAG (n = 31)	NTG (n = 16)	OAG (n = 16)
Normal	18 (100%)	25 (100%)	44 (96%)	6 (26%)	8 (27%)
Pathological	0	0	2 (4%)	17 (74%)	22 (73%)

N — number of patients; OHT — ocular hypertension; pre-OAG — preperimetric open-angle glaucoma; NTG — normal tension glaucoma; OAG — open-angle glaucoma

running light stripes, which cross at the light source. If the answer is yes, the crossing point can be treated as representative of the fovea. For declaration of only one stripe it has to be thought of as exclusion; this can be tested by short-duration covering of the leading eye. Subsequently the patient is asked about the four light stripes: Do the stripes have the same length? Are the stripes disconnected? Do the stripes show the same brightness? Patients with pathological test results see the stripes as disconnected, abbreviated, eased, or not at all.

RESULTS

Normals and patients with OHT showed exclusively normal test results. In the pre-OAG group normal Bagolini test results were received in 96% (Tab. 2), so the specificity is up to 98% for patients with normal visual field with a sensitivity of 73–80%.

Up to 74% of patients with NTG and 73% of OAGs showed pathological Bagolini test results. Absolute and relative results can be seen in Table 2.

Patients with visual field defects (NTG or OAG, MD > 2.8) showed altered Bagolini test results (Tab. 3). Localised visual field defects could be detected in 78% (NTG) and 80% (OAG) using Bagolini striated glasses (Tab. 4).

DISCUSSION

As worldwide disease, a screening method for glaucoma, which is quick and easy to perform, is of international interest especially in developing countries, where the financial ability of each patient is insufficient. This study introduces Bagolini striated glasses as a screening method for the detection of glaucomatous visual field defects.

A screening test should offer a sensitivity of 100%, but non-essentially a specificity of 100%. In this study, next to a specificity of 98%, a sensitivity of 73–80% was reached. Perimetric field defects can be detected if they are localised around the diagonals of the four quadrants (Fig. 2).

A general problem of visualisation of scotoma is the so-called filling-in phenomenon, which occurs for example in the Amsler-test or noise field campimetry [8]. However, Safran [9] stated that this filling-in phenomenon does not seem to play an important role in unidimensional testing like the use of one light stripe.

A modified version of our test, which is called the starlight test, was performed by Hirai et al. [10]. Testing glaucoma patients, this starlight test showed poorer results than the data from Humphrey 30-2 and Goldmann testing [10]. Interestingly, some patients mentioned irregularly broken stripes in areas that were shown to be normal by both Humphrey

Table 3. Patients with NTG and OAG: Mean defect (MD), corrected loss variance (CLV), and standard deviation (SD) of NTG and OAG, split by normal and pathological test results						
Results	NTG			OAG		
	MD [dB]	CLV [dB²]	SD [dB]	MD [dB]	CLV [dB²]	SD [dB]
Normal	2.2	1.5	1.2	3.6	2.6	1.6
Pathological	7.8	6.4	2.5	12.3	6.4	2.5

NTG — normal tension glaucomas; OAG — open-angle glaucomas

Table 4. Patients with NTG and OAG: Normal and pathological test results, split by diffuse and localised perimetric defects				
Results	NTG		OAG	
	Diffuse	Localised	Diffuse	Localised
Normal	2 (40%)	4 (22%)	3 (43%)	5 (20%)
Pathological	3 (60%)	14 (78%)	4 (57%)	20 (80%)

NTG — normal tension glaucomas; OAG — open-angle glaucomas

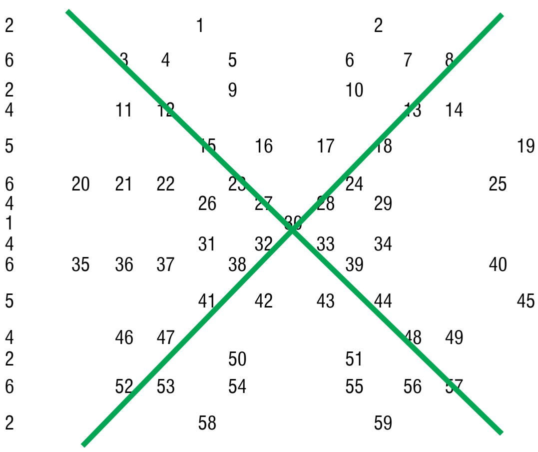

FIGURE 2. Octopus 500, G1 protocol testing spots (numbers), and two green lines, tested by Bagolini glasses (green stripes)

and Goldmann perimetry [10]. This difference could be due to the antithetic approach of the test set-ups. The common method of visual field testing, used by Humphrey and Goldmann perimetry, uses light spots that have to be recognised by the patient. These two tests are time consuming in clinical everyday life. Additionally, it is not easy for patients to focus on the centre. If there is any eye movement at the moment a test point is presented, a wrong point of the visual field is tested. Even if the patient corrects his eye position, the light can be seen and the point can recognised misleadingly as 'normal'. In our test the light itself does not need to be recognised but the absence of it. Following eye movements does not play such a critical role, because if the patient recognises a broken stripe, it occurs every time the patient fixes back to the crossing point of the stripes. Additionally, confrontation visual field test using Bagolini striated glasses is an easy and quick method, resulting in a decreased risk of eye movement.

Developing countries, in particular, could benefit from such an easy, quick, and affordable method to examine one essential function of the eye — the visual field. In these countries, such as India, even simple diagnostic techniques are often unavailable for most of the population [11]. For large parts of the population ophthalmic eye care facilities are absent or they have limited access [12]. There are no possibilities for population-based screening of glaucoma. Considering this fact, detection of visual field defects by a quick, easy, and cheap method is the recommended strategy [11]. Due to the financial situation, even in some residency programs routine ophthalmological examinations are performed by using a flashlight [13, 14]. Without use of a further device, the only way to detect visual field defects is by confrontation testing. The sensitivity of a confrontation test is about 37% [15]. Because this quick method, used in the present study, has a sensitivity of at least 73% and an affordable price, it represents a more effective way to diagnose glaucoma in countries with limited access to medical devices. Furthermore, the introduced method is easy to learn, so even non ophthalmologists are able to perform it. This is necessary because, especially in developing countries, ophthalmologists are rare [11]. Hence it would be helpful to have a possibility for all physicians to examine the visual field in such an easy and quick way. Also, for the patients, who are often not well educated, the test is easy to understand. Incorrect test results, due to misunderstanding, can be reduced to a minimum. Another advantage is that the test can be performed binocularly and also in immobile patients.

Some studies have underlined the need to develop effective glaucoma screening programs [16–18], but even in developed countries population-based screening methods of glaucoma are not seen to be cost-effective [19, 20] or have been shown to have evident benefits [21], but have not been established anywhere in the world [19].

Important factors of cost utility of an organised screening program are screening costs and specificity [22]. There is no single gold-standard test for glaucoma diagnosis [21–23]. It is always a synopsis of several examinations, which usually includes: best corrected visual acuity, slit-lamp examination, funduscopy, measurement of intraocular pressure, visual field tests (e.g. Goldmann, Humphrey, Octopus perimetry), structural imaging of optic disc (Optical Coherence Tomography), and stereo photography of the optic nerve head [23]. This amount of tests increases screening costs to inefficiency. However, screening costs are minimised by using Bagolini striated glasses for glaucoma screening, because the test is quick and therefore money saving, and even the recommended devices are cheap and are often already available in some facilities.

Most reviewed glaucoma screening tests have a specificity of approximately 85% or higher [19], which is lower than the specificity of 97.8% that we achieved with our method. Additionally, this factor, causing overdiagnosis and overtreatment, is also a relevant aspect. Furthermore, there are several pathological reasons for visual field defects other than glaucoma disease (e.g. cataract, tumour). Upon a pathological test result of Bagolini striated glasses, further examinations have to be added — an additional protective mechanism against overdiagnosing and overtreatment, associated with screening [21]. Confrontation visual field tests using Bagolini striated glasses can be seen as a preselective test to screen patients with an extremely high risk of glaucoma.

There are analogies of the presented method to the guaiac based faecal occult blood test (gFOBT), which is established in screening programs to detect colorectal cancer and early colorectal neoplasms. Like glaucoma disease, symptoms of colorectal cancer are rare and appear mostly in advanced stages of the disease. The sensitivity of gFOBT is relatively low for a screening test, at about 5.5–57.1% [24–26]. In accord with our test, a positive test result is not specific for the screened disease. In addition, a positive test result is also followed by further examinations to become certainty. Compared to the more sensitive alternatives, like rectoscopy and colonoscopy, the test is much quicker, cheaper, easier, and additionally noninvasive. Therefore, it is, despite low sensitivity and being non-specific, an established part of colorectal cancer screening.

Diagnosing glaucoma is not easy. A variety of examinations and experts are needed to evaluate the results. Additionally, diagnostic criteria depend on the subjectivity of the examiner [12]. Instead the present test set-up is more objective because a positive result is defined clearly and is not up to the opinion of the examiner.

In developed countries about half of patients with glaucoma are not diagnosed [19, 27–30]. Due to slow progression and preserved visual acuity for a long period, many glaucoma patients do not realise symptoms until advanced stages or even blindness of one eye [20], where the potential for treatment success is limited. Confrontation test using Bagolini striated glasses, a cost-efficient and time saving method, offers the possibility to detect more glaucoma patients prior to this advanced stage of disease, slowing down progression before psychological strain begins.

CONCLUSIONS

Confrontation visual field test using Bagolini striated glasses seems to be suitable for detection of glaucomatous visual field defects, especially for use in developing countries with limited access of patients to medical examinations and treatments, where it offers an improvement in ophthalmological screening methods.

Conflict of interest and source of funding

None declared.

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