Analysis of visual fields: history, advances and importance in the management of glaucoma

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Most people are familiar with the assessment of visual acuities, in which a patient's ability to read and recognise distant objects is measured by a standardised, objective method, such as a Snellen chart. Visual acuity is commonly measured by optometrists to provide people with an eyeglass prescription for refractive errors. However, visual acuity only describes the most acute vision of the central macula of our eyes. There are various ophthalmological and neurological diseases that may affect the field of vision, and yet patients with such diseases can perform well in tests of visual acuity. The visual field refers to how wide of an area one's eye can see when one focuses on a central point. Visual field testing is one method that clinicians and ophthalmologists use to measure how much vision one has in either eye and how much vision loss may have occurred over time.[1]

Evaluation of peripheral visual field was first performed more than 2000 years ago, whereas quantitative measurement of the visual field has been utilised for around 200 years. One of the first accounts of peripheral visual field evaluation was by Hippocrates, from around the late fifth century BC, when he described hemianopia. A further attempt to map a patient's visual field defect was made by Ptolemy in 150 BC. These documented early evaluations of the visual field were mostly qualitative, and it was not until 1856 when Albrecht von Graefe developed quantitative visual field measurements, where he presented visual field loss that was characteristic of glaucoma. von Graefe also published examples of visual field losses associated with many other ophthalmic or neurological diseases.

Jannik Bjerrum popularised perimetry (ie, testing of visual field) using a tangent screen with a standardised target size and background illumination. One of the most important contributions to modern perimetry was the work of Hans Goldmann in 1945. He developed a hemispherical bowl perimeter that provided a uniform background illumination and a moving optical projection system that could superimpose stimuli on the background. Static and kinetic perimetry can be performed by using the Goldmann perimeter with a variety of targets of varying sizes, luminance, and colour characteristics. Goldmann's work also further described evaluation of normal controls and patients with glaucoma and other diseases affecting the visual pathways.

Friedmann created the first central field analyser model in 1966, which contained a patient chin and head rest and a source of illumination for the stimulus patterns, with a total of 46 stimuli. The donated Friedmann Visual Field Analyser Mark II is a model used in the 1970s, with improvements that included 99 stimuli and more automation (Fig). To perform the visual field assessment, the patient rested his or her head on the chin and head rest. Each eye was tested individually, with the patient instructed to look at a central fixation point in the machine as stimuli were generated automatically; a technician then manually recorded the results on a chart printout provided by Friedmann.

In the early 1970s, Drs John Lynn and George Tate developed one of the first automated perimeters, although Dr Franz Fankhauser is widely considered the foremost expert in this field who produced and popularised the first automated perimeter known as the Octopus. Many other automated or semi-automated perimetry devices followed, including the Fieldmaster, DICON, Humphrey Field Analyzer, and Easyfield (Oculus).[2]

Clinicians and scientists are working to refine the test for the patient to detect small targets on a uniform background, so as to quantitatively evaluate and document the functional status of the peripheral field of view for diagnosis and follow-up of many ophthalmological or neurological diseases.

Some common clinical conditions that require visual field assessment are listed as follows:

- Glaucoma
- Various retinal diseases (eg, retinal vascular occlusion secondary to common conditions such as hypertension, diabetes mellitus, and retinitis pigmentosa)
- Multiple sclerosis
- Thyroid eye disease
- Optic nerve diseases (eg, optic neuritis, anterior ischemia optic neuropathy)
- Central nervous system tumours (such as a brain tumour that may be pressing on the visual pathway of the brain, eg, pituitary tumour)
- Central nervous system vascular diseases (eg, stroke)
- Long-term use of certain medications (eg, hydroxychloroquine)
- Ptosis, where assessment of a visual field defect is required

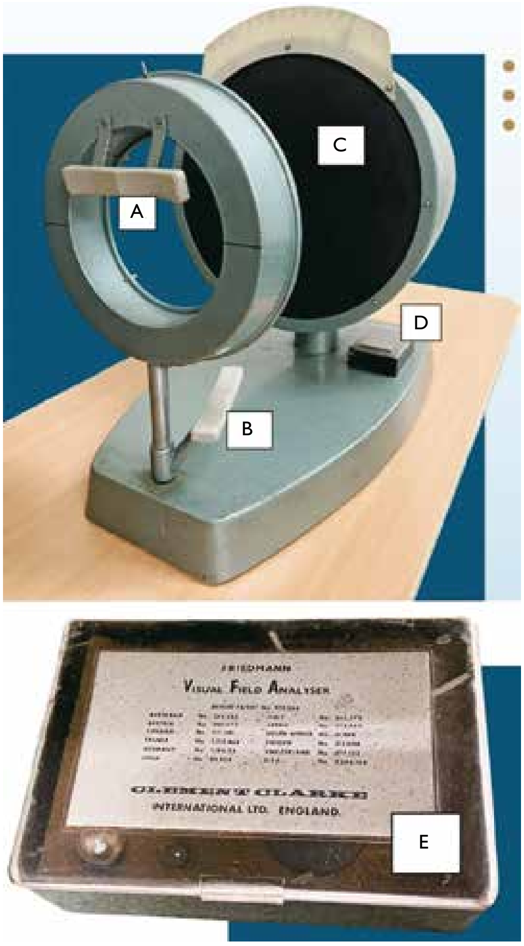

FIG. Friedmann Visual Field Analyser Mark II donated by Dr Patrick Tong: (A) head rest; (B) chin rest for the patient, which could be rotated out when in use; (C) visual field analyser that included 99 stimuli and was automated; (D) plate display of patent number, with an enlarged image in (E)

More recently in the development of automated visual field testing, advances have been made to make these tests and procedures more standardised, automated, accurate, precise, efficient, quantitative, repeatable, statistically reliable, and easy to use. There has been further software development over the years for the analysis of glaucoma progression—the most prevalent and important long-term blinding eye disease.

The changes in visual field or progression of defects caused by chronic glaucoma are very subtle. Together with the fact that individual test result reliability relies heavily on physical status and consistent performance of the patient, visual field testing continues to be perceived by many patients as one of the most demanding tests.

Clinicians now use standard automated perimetry for the diagnosis and management of glaucoma throughout the world. Various testing paradigms and analytic methods have been developed to simplify the diagnosis of glaucoma and the interpretation of its progression. Glaucoma detection and progression analyses are also incorporating more information and will be improved further as deep-learning strategies are applied.

With advancing technology, besides the use of visual field testing for monitoring the functional changes of the optic nerve in patients with glaucoma, ophthalmologists also closely monitor the structure of the optic nerve by means of structural scanning using optical coherence tomography. Furthermore, perimetric and structural testing will likely become more closely intertwined as testing platforms and progression analysis incorporate these measures.[3]

With an ageing population, glaucoma has become the most important and prevalent chronic blinding eye disease in Hong Kong. Additionally, with the increasing prevalence of normal-tension glaucoma (patients with glaucoma who do not have high eye pressure), which constitutes up to 30% of all glaucoma cases, monitoring requires ever more detail and cannot rely solely on eye-pressure monitoring.

Many of these patients require systemic investigations, which include blood tests for common cardiovascular risk factors, imaging of the brain in suspicious cases, and sleep study. There are many reports of a higher risk of glaucoma among patients with sleep apnoea, and a higher prevalence of sleep apnoea in patients with glaucoma. This is especially true for patients with normal-tension glaucoma. In this group, treatment of the sleep apnoea will help to stop the deterioration and further loss of optic nerve fibres and visual field.[4-6]

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