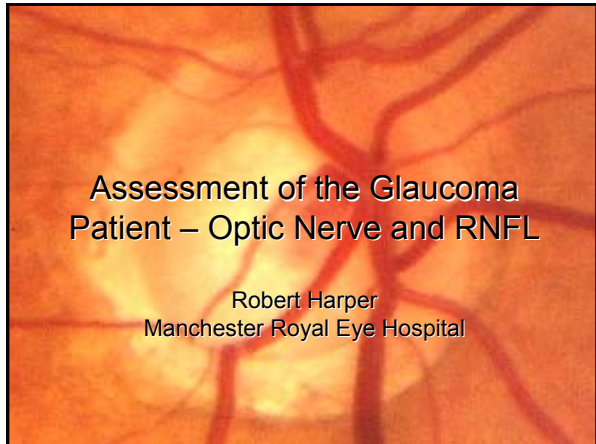



Assessment of the Glaucoma Patient – Optic Nerve and RNFL

Robert Harper
Manchester Royal Eye Hospital



Introduction

- Glaucoma is a group of diseases characterised by retinal ganglion cell dysfunction and death
- Detection of glaucoma and its progression are based on identification of abnormalities or changes in the optic nerve head (ONH) or the retinal nerve fibre layer (RNFL), either functional or structural



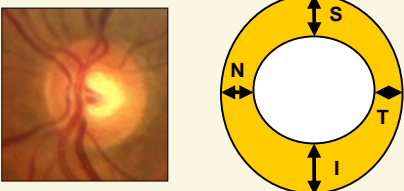
First POAG endpoint (OHTS)

Endpoint	Medication Group (%)	Observation Group
Visual Field <i>(3 HVFAs: GHT/CPSD)</i>	41.7%	32.6%
Optic Disc <i>(masked readers)</i>	50%	57.3%
Both <i>(concurrent)</i>	8.3%	10.1%

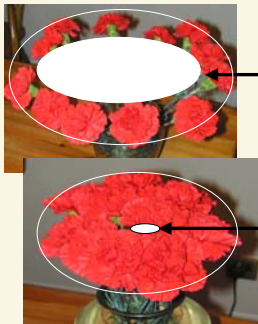
Kass et al. Ocular Hypertension Treatment Study. Arch Ophthalmol 2002; 120:701-13

The 'normal' optic disc

- Neural rim
- Physiological cup
- White physiological scleral rim (Elschnig)
- Yellow-white 'sieve-like' appearance of lamina cribrosa
- Rim width configuration



Optic disc size and cupping




1.2 million nerve fibres passing through a large scleral opening gives a large cup

1.2 million nerve fibres passing through a small scleral opening gives a small cup

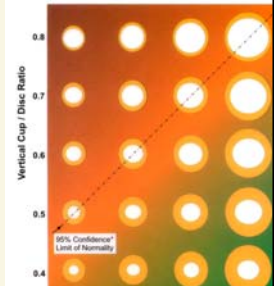
C/D ratio & disc diameter

BIO lens magnification factors

Superfield ~1.5
90D ~1.4
78D ~1.1
66D ~1.0



Superfield	Disc Diameter mm			
	1.2	1.5	1.8	2.2
WD	0.8	1.0	1.2	1.5
78D	1.1	1.4	1.6	2.0

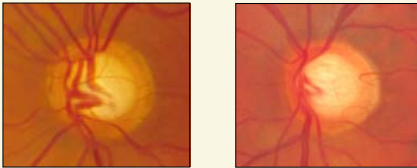


Vertical Cup / Disc Ratio

95% Confidence Limit of Normality

Optic disc assessment difficulties

- Sensitivity and specificity
 - Competence/experience
 - Method/technique
- Observer variability
- Technology not applicable to all

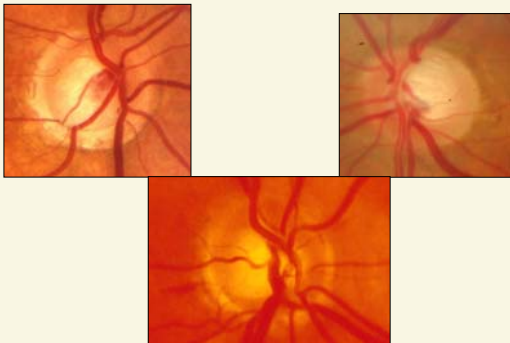


Optic disc changes in glaucoma

- Enlargement of the optic cup
- Loss of disc rim (neural tissue)
- Vascular changes
- Increased pallor (late)
- Peripapillary atrophy
- RNFL changes



Neural rim loss



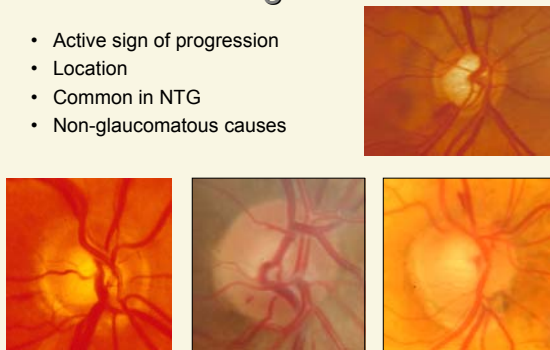
Vascular changes

- Vessel configuration
 - Nasalization
 - Bayonetting
 - Flyover/overpass
 - Circumlinear beading
- Calibre of vessels
- Collateral vessels
- Haemorrhage*



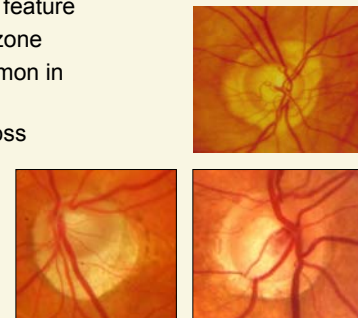
Disc haemorrhages

- Active sign of progression
- Location
- Common in NTG
- Non-glaucomatous causes

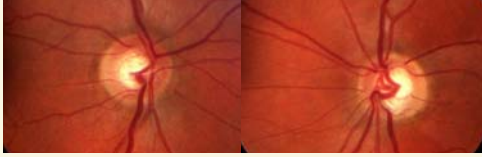


Peri-papillary atrophy

- 'Second order' feature
- α -zone and β -zone
- β -zone uncommon in normals
- NRR and VF loss



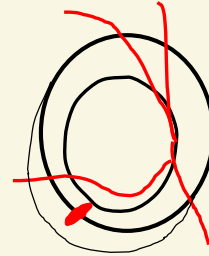
Look for asymmetry



Recording your assessment: 'Low tech'

CDR ~0.70

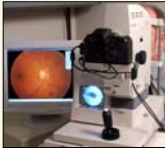
S>I rim



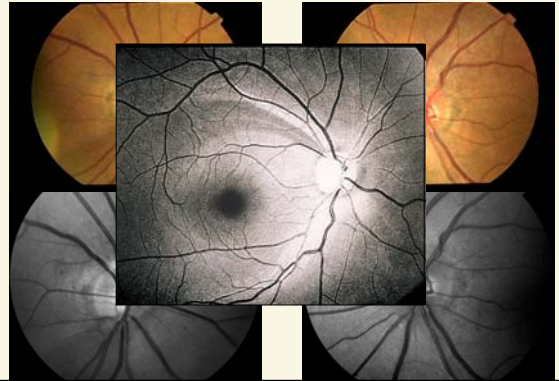
1.8mm
Volk 60D

Optic Disc Photography

- High resolution digital imaging of the optic disc and RNFL
 - Quantification possible



Photography of RNFL



Optic nerve head imaging systems

- Heidelberg Retina Tomograph (HRT)
- Scanning Laser Polarimetry - GDx VCC
- Optical Coherence Tomography (OCT)

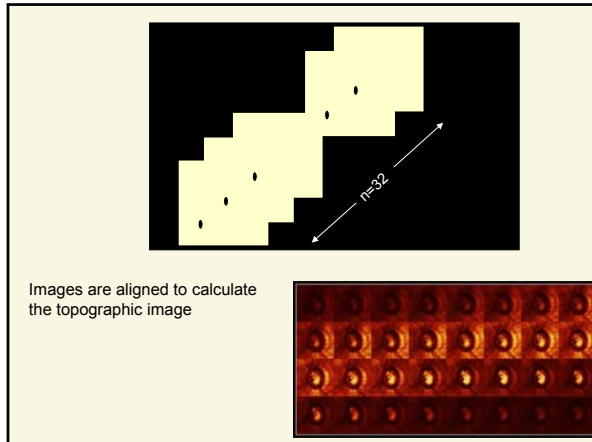


Heidelberg instrument

- Confocal scanning laser ophthalmoscope (Mk I, II and III)
- Multiple 2D scans – OD sections
- Field size 10x10, 15x15
- He-Ne Laser 670nm



www.HeidelbergEngineering.com



Images are aligned to calculate the topographic image

Reflection Image

Moorfields Regression Analysis carried out on each sector, compared to a normative database

Based on linear regression analysis between the disc area and the log of the neuro-retinal rim

Tick – within the normal 95%
 X – p value below 0.1%
 ! – borderline – p value less than 5%

Image quality is expressed in terms of the average standard deviation and should be as low as possible. A Standard Deviation of 50µm or higher indicates you should use the data with caution.

Retinal Nerve Fibre Layer Profile Graph
 TSNIT Plot

Height profile along the contour line
 Healthy eyes – double hump appearance
 Normal range superimposed
 Green normal 95% range

Image quality is expressed in terms of the average standard deviation and should be as low as possible. A Standard Deviation of 50µm or higher indicates you should use the data with caution.

Glaucoma Probability Score (GPS)

5 parameters

1. Cup size
2. Cup depth
3. Rim steepness
4. Horizontal retinal nerve fibre layer curvature
5. Vertical retinal nerve fibre layer curvature

Geometric model to describe shape of optic disc/peri-papillary retina globally and locally using 5 parameters

Doesn't depend on contour line or reference plane – therefore operator independent

GDx/GDxVCC

- Scanning Laser Polarimeter (SLP)
- RNFL is birefringent
 - Changes state of polarization of light beam
- RNFL thickness estimated by comparing states of polarization of incident and reflected beams
- Cornea and lens also birefringent
 - Variable corneal compensation

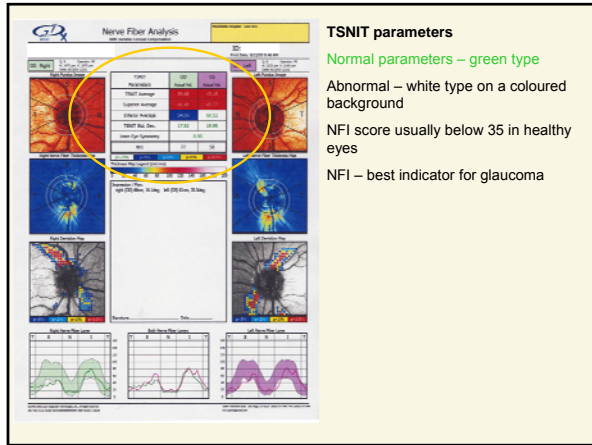
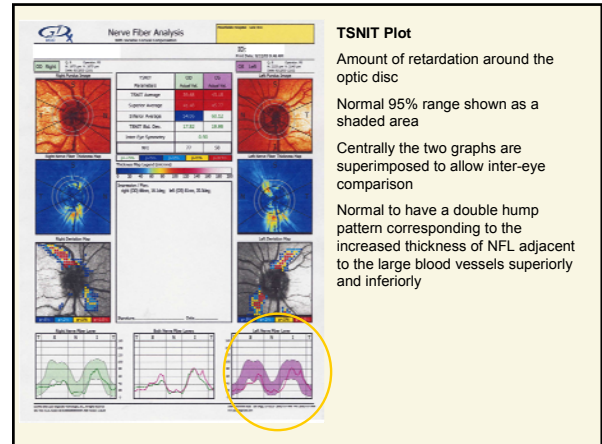
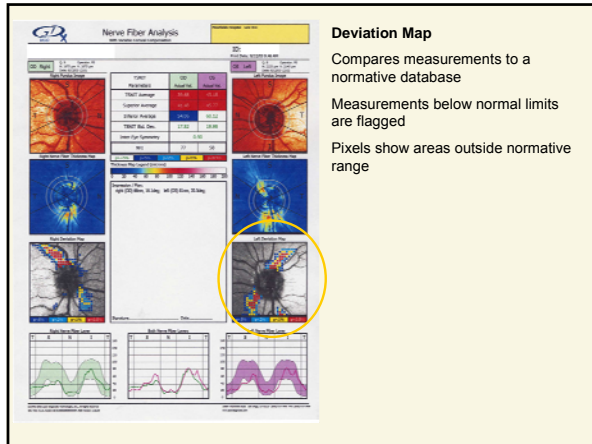
www.meditec.zeiss.com/gdxvcc

Retardation Image – Nerve Fibre Thickness Map

Measurements of retardation in a 20 x 20 field of view

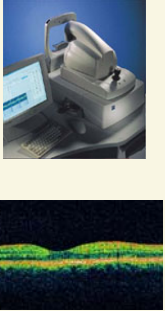
Warm colours – thicker
 Cool colours – thinner

Normal eyes large amounts of retardation adjacent to the thick blood vessels superiorly and inferiorly



Optical Coherence Tomography (OCT)


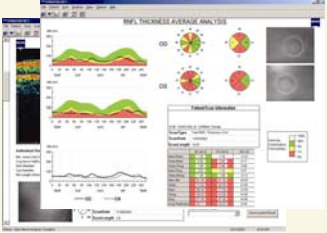
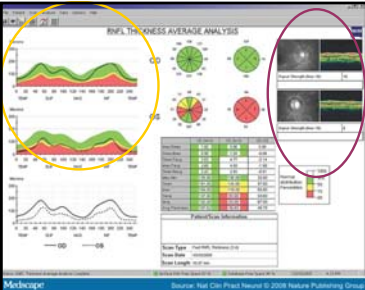
- OCT described by Huang in 1991
- Potential use in glaucoma, retinal and macular disease for >10 yrs
- Near infra-red laser with high resolution cross sectional *in vivo* imaging (~10µm)
- Super-luminescent diode – measurement and reference beams
- Low coherence interferometry – delay times of reflected rays from different retinal layers are measured by comparison with the reference beam
- Time sequence of impulses corresponds to space sequence of retinal structures



www.meditec.zeiss.com

OCT imaging

- Radial OCT sections through the disc and peripapillary region taken at equally spaced orientations

Colour coded linear cross section of tissue

Thickness Chart Right and Left – TSNIT Plot

Displayed over coloured bands corresponding to normative database

Normal eyes have double hump pattern – look for loss of this pattern

Average RNFL height 100 – 120 microns

Early glaucoma usually less than 80 microns

End stage glaucoma – usually 40-50 microns

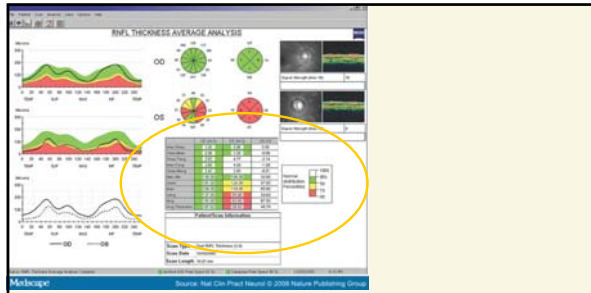


Table of Parameters

Colour coded to indicate deviation from normative database
 Normal Smax and Imax usually greater than 125 microns
 Inter eye asymmetry also examined
 Loss of the inferior RNFL has been found to be more sensitive for detecting glaucoma

Glaucoma imaging study conclusion

- Poor agreement for glaucoma detection between HFA, HRT and GDx.
- Techniques are amenable for clinical use
- No single examination has sufficient diagnostic precision to be used in isolation
 - ~45%-60% sensitivity at 95% specificity
- Techniques are not universally applicable
 - 80% HRT, 88% GDx
- Neither HRT nor GDx can replace the need for visual fields

Kwartz AJ, Henson DB, Harper RA, Spencer AF and McLeod D.
 The effectiveness of the Heidelberg Retina Tomograph and laser diagnostic scanning system (GDx) in detecting and monitoring glaucoma.
Health Technol Asst 2005; **9** (46): 1-132.

Acknowledgement

- Janice Brady, Glaucoma Fellow, MREH
- Amanda Harding, OLGA, MREH