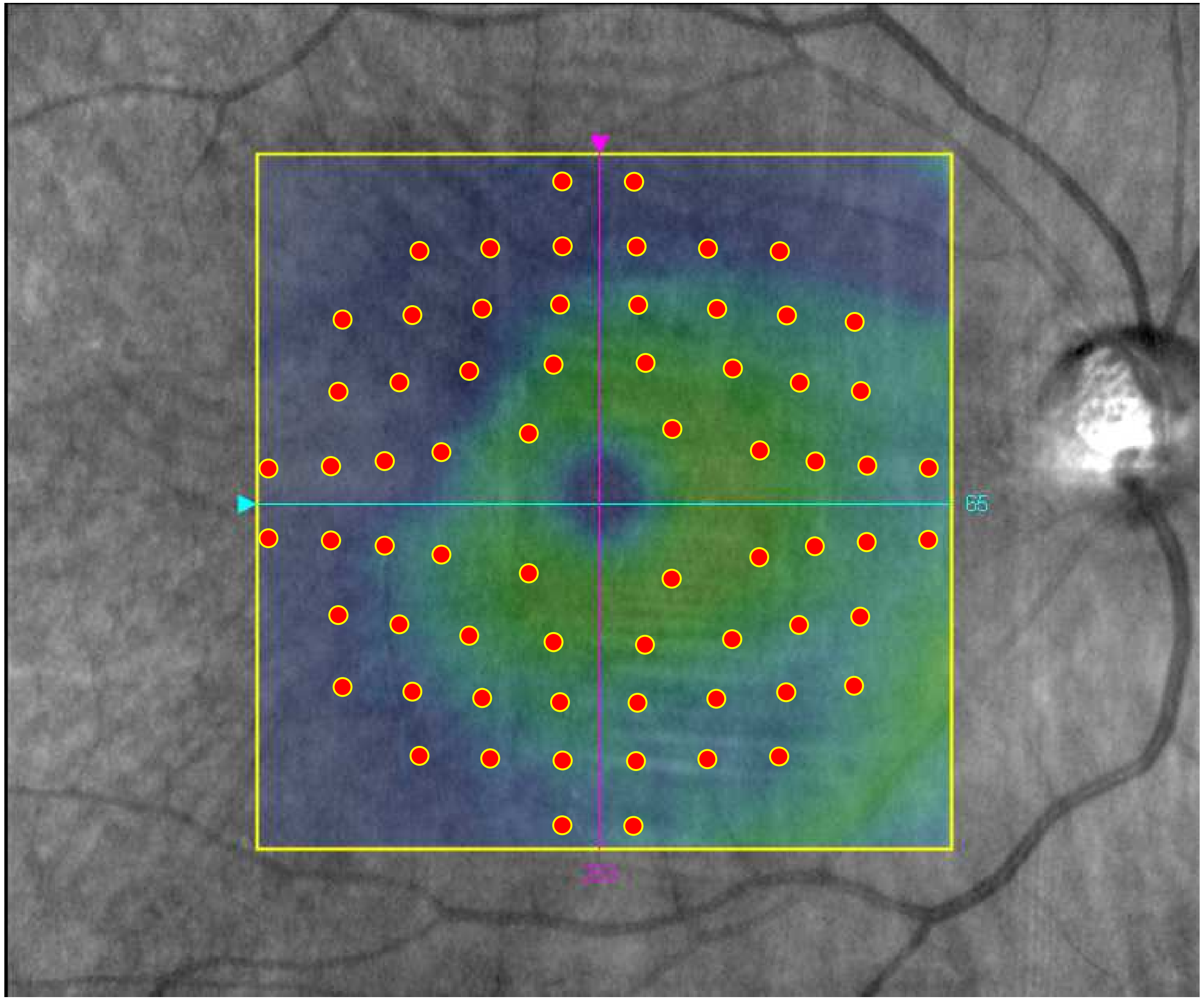
OCT-HFA correlation

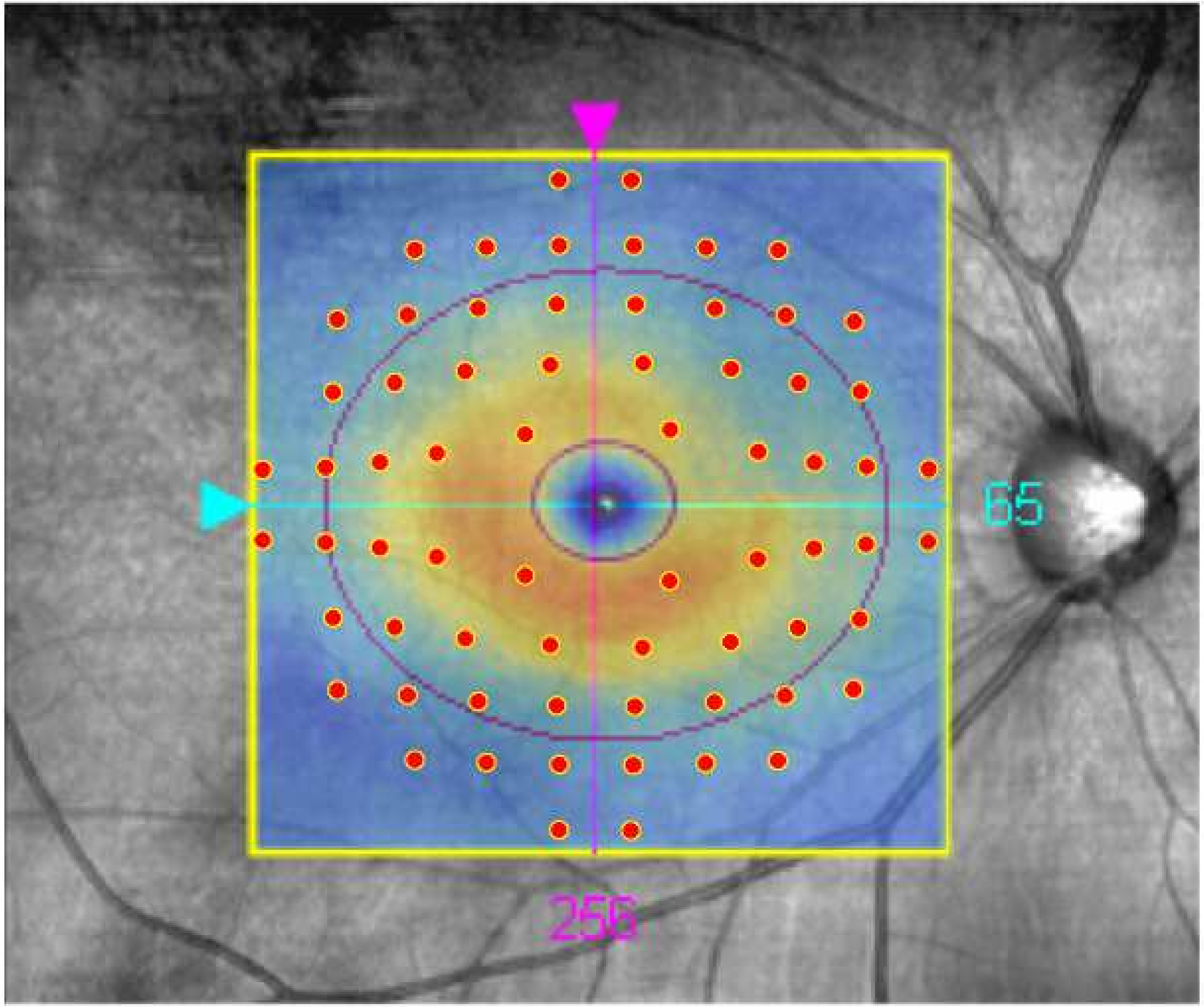
Overlay of OCT macular scans with HFA VF tests

CZ Meditec Inc, Ltd., Japan

HFA 10-2 test grid overlayed on OCT macular scan



HFA 10-2 test grid overlayed on GC+IPL thickness



General tasks of correlating HFA & OCT results

Image of OCT
(GCA thickness & deviation plot)

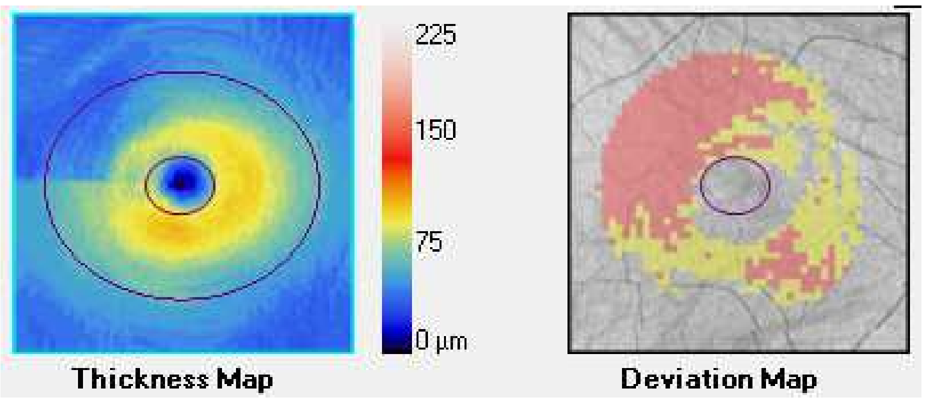
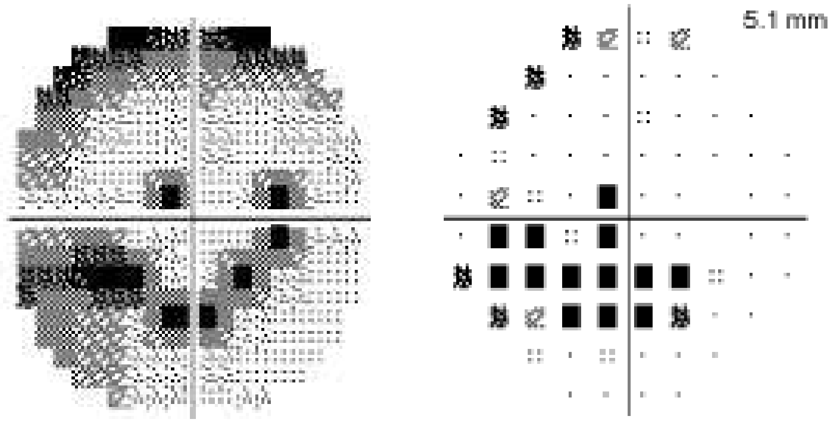
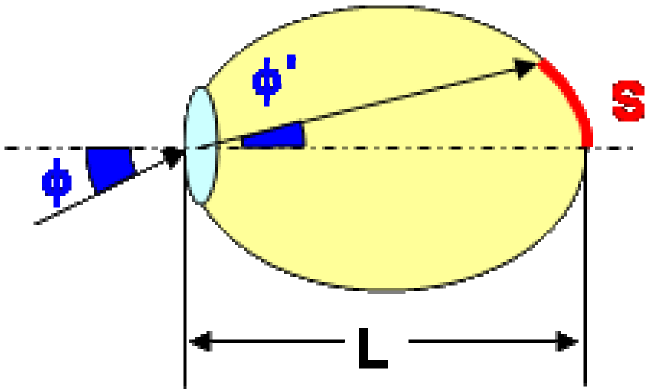


Image of HFA
(sensitivity & pattern deviation)

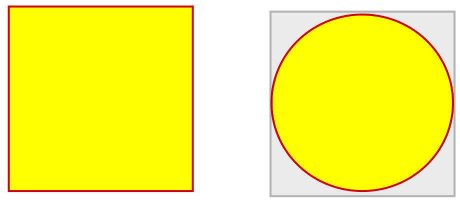


* Physical registration of OCT and HFA coordinate system (up-down flip)
* Choice of comparable properties (e.g. probability maps)
* Consideration of GC displacement of photoreceptor positions (GC comparison)
* Consideration of RNFL inhomogeneous distribution (RNFL comparisons)

Relationship “HFA angular field of view” & “OCT scan area”



Assumed Index of refraction: 1.3367



Length of Eye L	FoV-Angle	Retinal length S	Scan side	inside FoV
22 mm	10 Degree	2.9 mm	6 mm	± 10.4 Degree
23 mm	10 Degree	3.0 mm	6 mm	± 10.0 Degree
24 mm	10 Degree	3.1 mm	6 mm	± 9.6 Degree
25 mm	10 Degree	3.3 mm	6 mm	± 9.2 Degree
26 mm	10 Degree	3.4 mm	6 mm	± 8.8 Degree

CIRRUS assumption (n=1.3364):

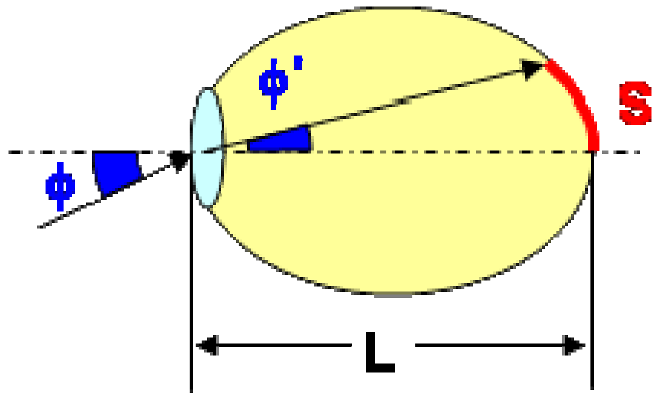
22 mm	10 Degree	2.86 mm	6 mm	± 10.5 Degree

Relationship “HFA angular field of view” & “OCT scan area”

Note:

An OCT scan subtends the same external FOV, but depending on the physical size of the eye, the retinal area covered varies.

The VF overlay, however, remains identical !



Presuming, that Myopia/Hyperopia stems only from a change in size of the eye (thus ignoring effects of the cornea and lens), one can approximately calculate the elongation and thus scaling of the OCT scan depending on the refractive error:

⇨ 1 D ≈ 0.4 - 0.5 mm length change eye

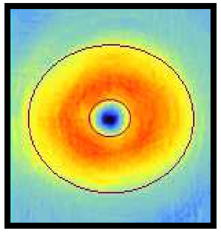
≈ 0.09 – 0.13 mm length change of 6 mm - OCT scan

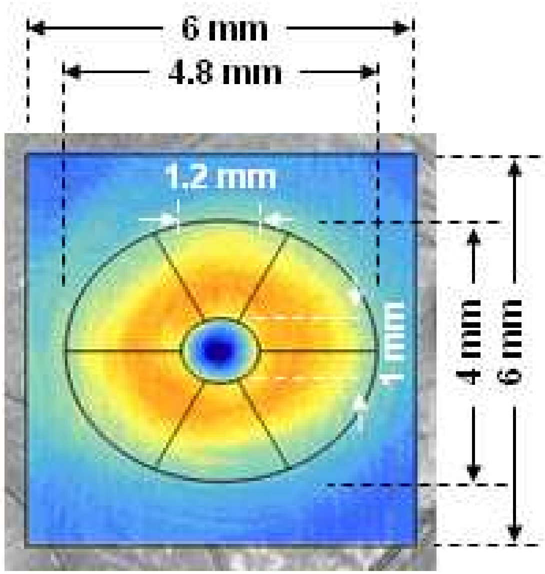
dD	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
dL	5.3	4.7	4.1	3.5	3.0	2.4	1.9	1.4	0.9	0.5	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-2.3	-2.7	-3.0	-3.3	-3.7
OCT	7.3	7.2	7.0	6.9	6.7	6.6	6.5	6.3	6.2	6.1	6.0	5.9	5.8	5.7	5.6	5.5	5.4	5.3	5.3	5.2	5.1
dOCT	1.3	1.2	1.0	0.9	0.7	0.6	0.5	0.3	0.2	0.1	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.7	-0.8	-0.9

Assumed Index of refraction: 1.3367

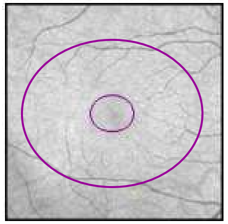
CIRRUS Ganglion Cell area of analysis:

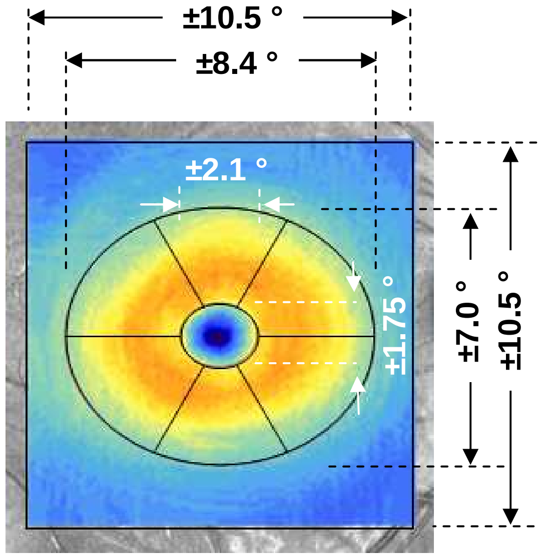
Distribution of Ganglion Cells:





Adopted Elliptical Area of Analysis:

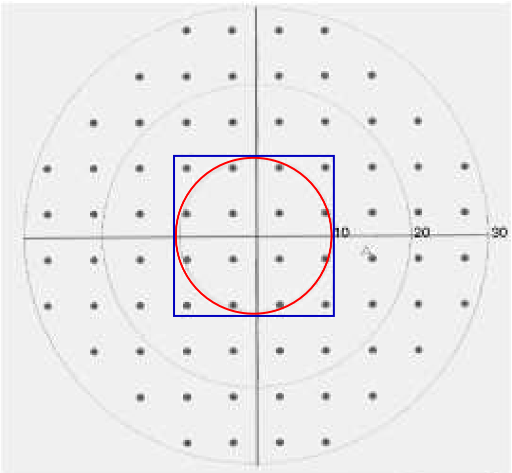




Careful: do not mix up area of analysis size in degrees with location of VF points !!

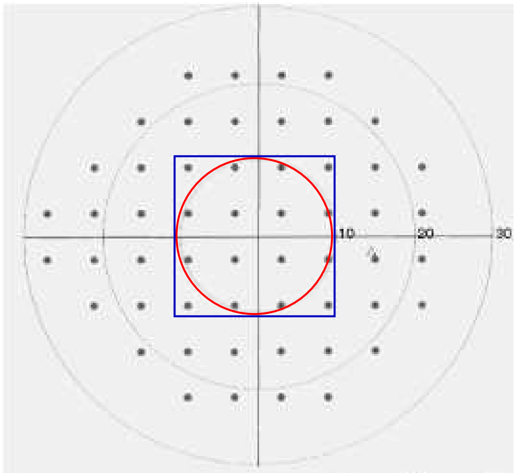
HFA test grids (± 10°) & OCT Scan Area (6x6 mm) (without consideration of GC displacement)

30 - 2



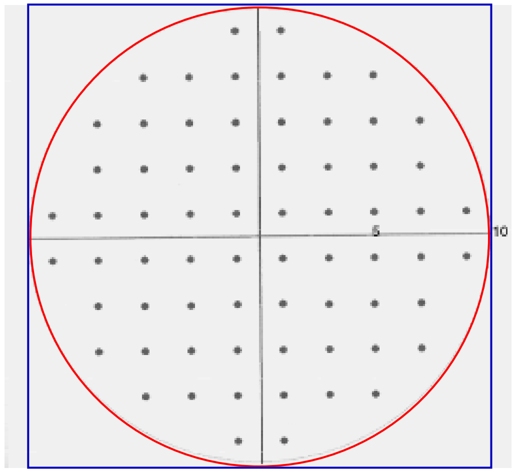
4 central, 12 edge test spots

24 - 2



4 central, 12 edge test spots

10 - 2

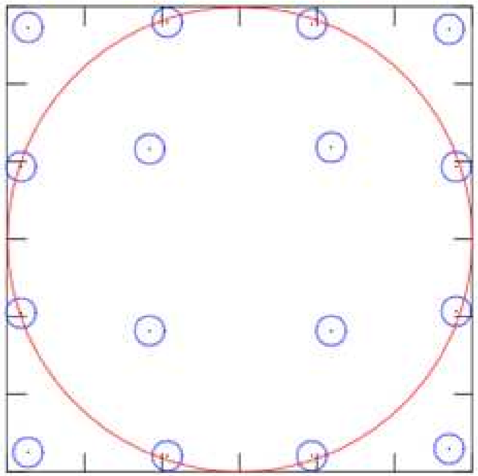


68 central test spots

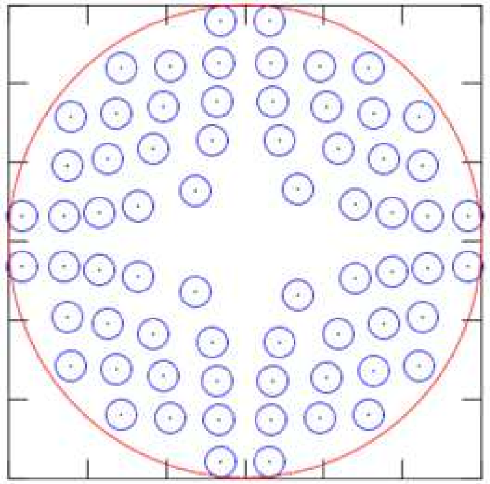
- only the 10-2 test pattern provides sufficiently many test spots within the OCT scan area to enable performing a spatially resolved correlation analysis
- the situation becomes even more critical when taking the physiological dis-placement of the Ganglion cells from their respective photoreceptors

HFA test grids (± 10°) & OCT Scan Area (6x6 mm) (with consideration of GC displacement)

24 - 2 / 30 - 2



10 - 2

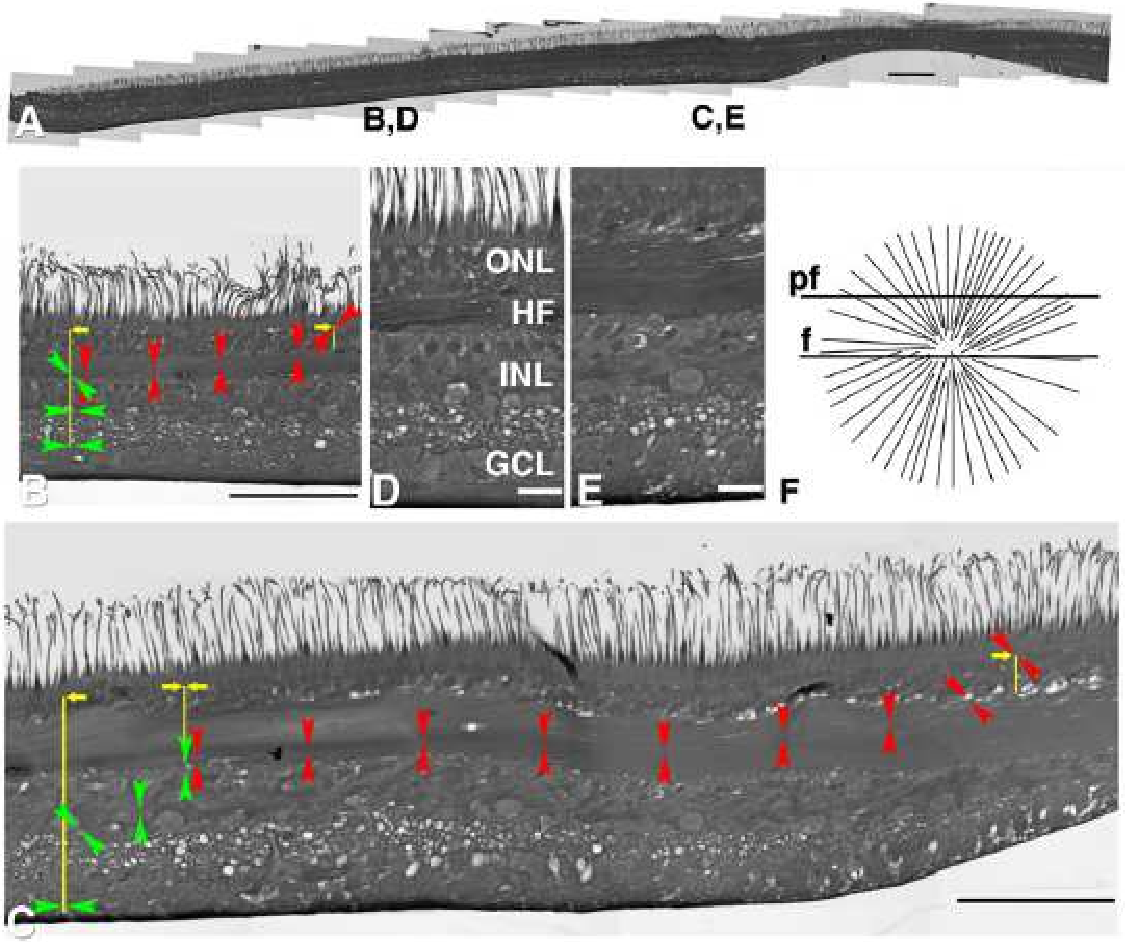


- Mapping the photoreceptor positions to their respective Ganglion cells, the HFA test grid becomes distorted
- The calculation illustrated has restrictions in applicability due to the following reasons:
  - based on mean data of only six patients [4]. Individual variance exists.
  - scaling depends on size of individual eye
  - horizontal data [4] extended to 2D map
  (principle of continuity and 24% reduction for vertical meridian)

Drasdo et al [4] results

Drasdo et al [4] results: histological measurements

(Figure 1 and text from [4])

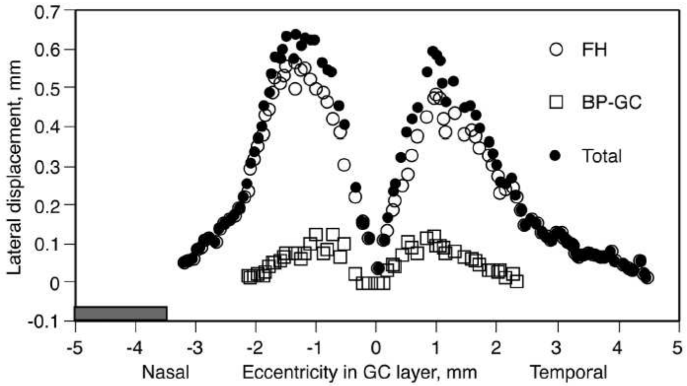


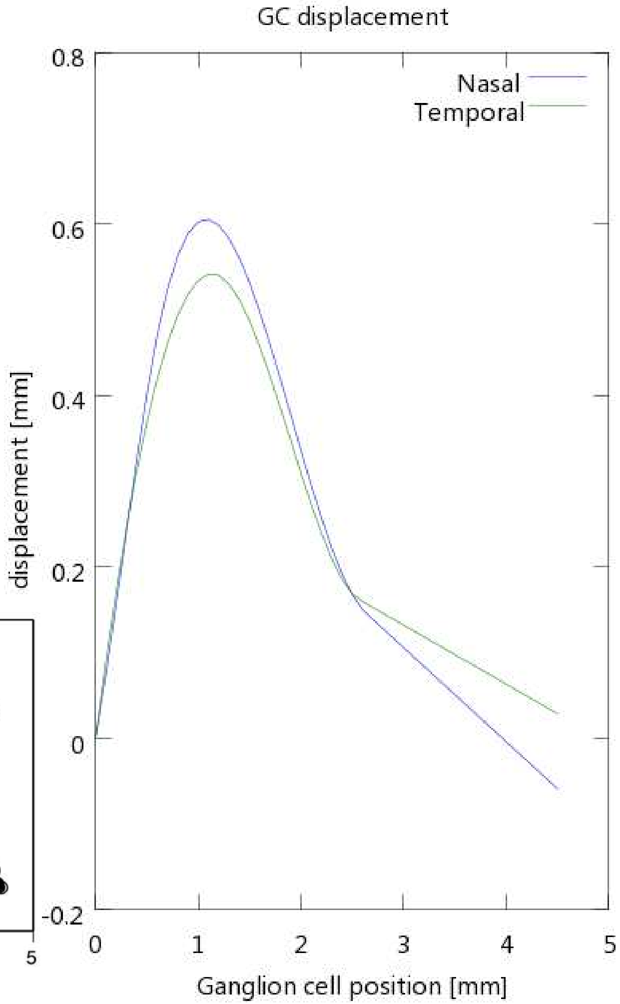
Histological section, showing the receptoral and post-receptoral components of GC displacement. Glycol methacrylate section, stained methylene blue - azure II, includes the fovea and nasal parafovea from an 82 yr old male (second donor listed in Table 3). **A.** Low magnification view created by photomontage of multiple higher magnification images. Sites illustrated in panels B,D and C,E are indicated. Bar, located at fovea, 200 µm. **B.** Site at 1.87 mm eccentricity in the layer of inner segments. Henle fiber length (as traced through zone delimited by red arrowheads) is 0.21 mm. Post-receptoral replacement (as traced through zone delimited by green arrowheads) is zero. The two ends of the displacements were projected onto the external limiting membrane (yellow lines), and lengths were measured along this membrane between the yellow arrows. Bar, 100 µm. **C.** Site at 0.52 mm eccentricity in the layer of inner segments. Henle fiber is 0.52 mm. Post-receptoral replacement is 0.073 mm, for a total of 0.595 mm. Bar, 100 µm. **D, E.** Detail of sites shown in B, C, respectively. Contrast in Henle fiber layer is selectively enhanced for illustrative clarity. ONL, outer nuclear layer; HF, Henle fibers; INL, inner nuclear layer; GCL, ganglion cell layer. Inner segment layer is just barely visible at top of panel E. Bars, 20 µm. **F.** Schematic of Henle fiber layer, viewed from vitreal aspect. The appearance of Henle fibers at section levels pf (parafovea) and f (foveal center) are shown.

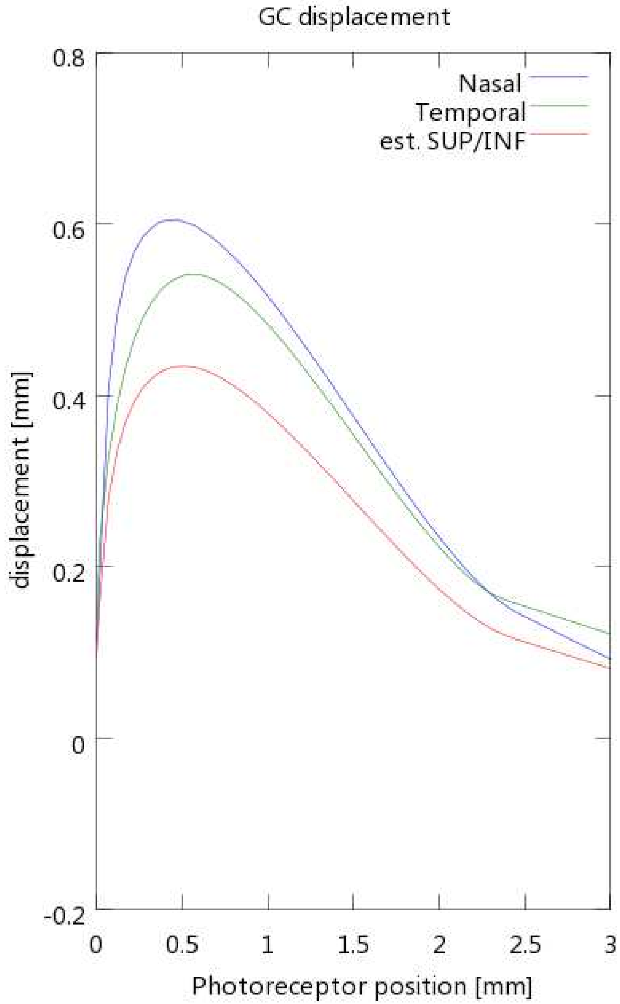
Drasdo et al [4] results:

GC displacement from respective photoreceptors based on the measurement of length of Henle fibers in six eyes. Density model predicts even larger displacements.

Figure 2 [4]:





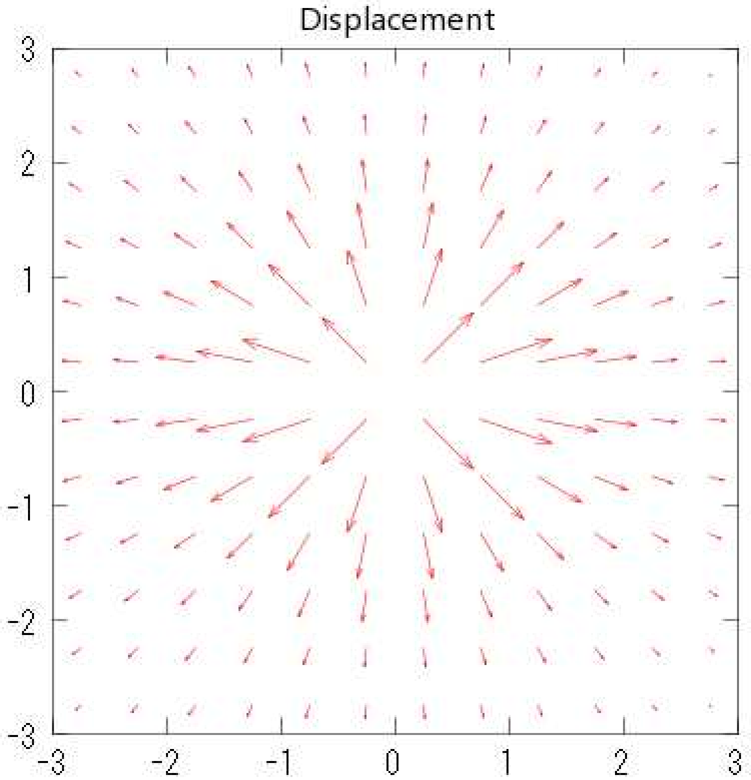


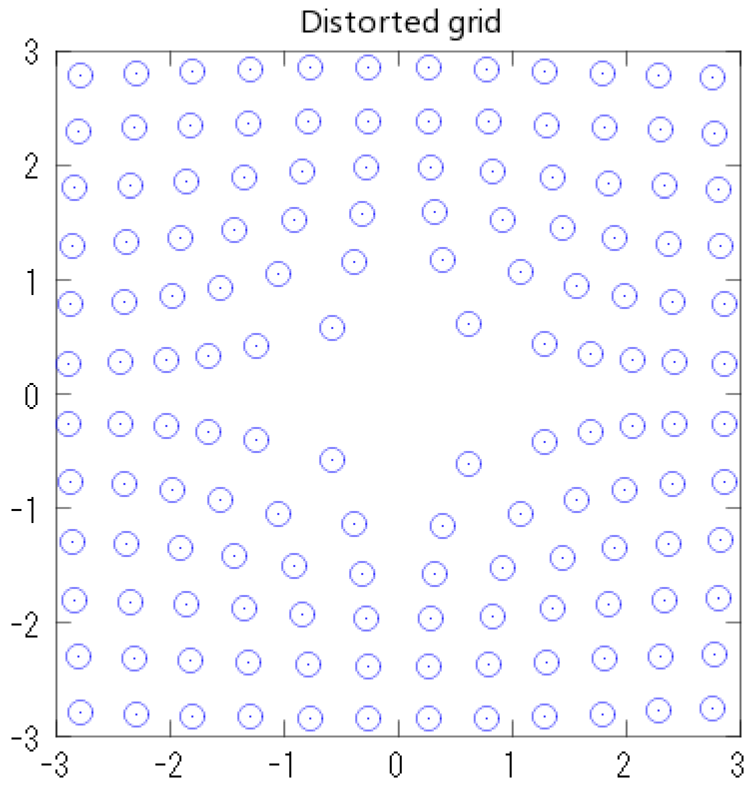
Drasdo et al [4] results:

2D Displacement field generated according to [4] within the typical 6 x 6 mm macular scan

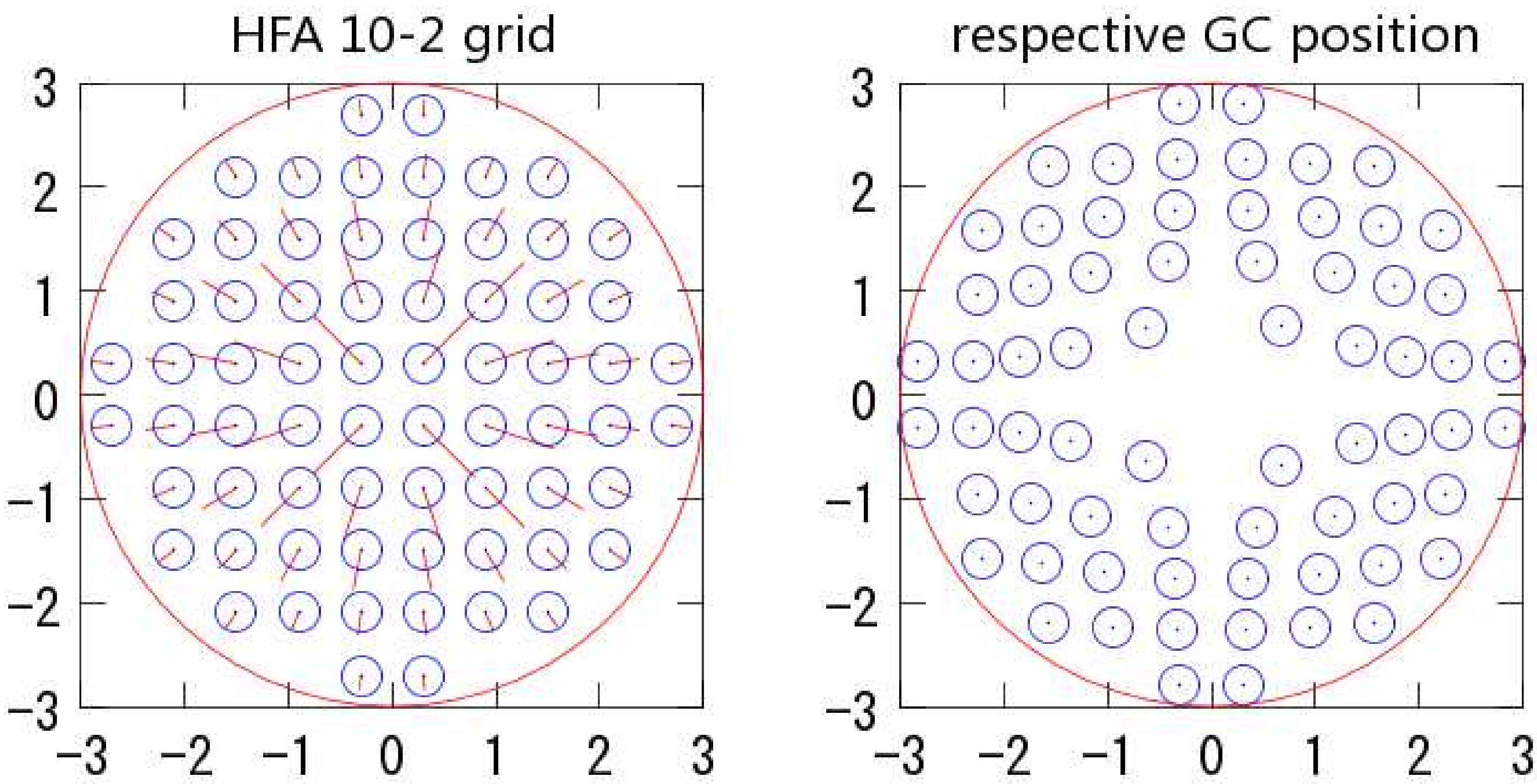
Assumptions:

- Mean values of experimental results [4] used for horizontal meridian
- 24% downscaled displacement at vertical meridian
- continuous variation based on elliptical equation

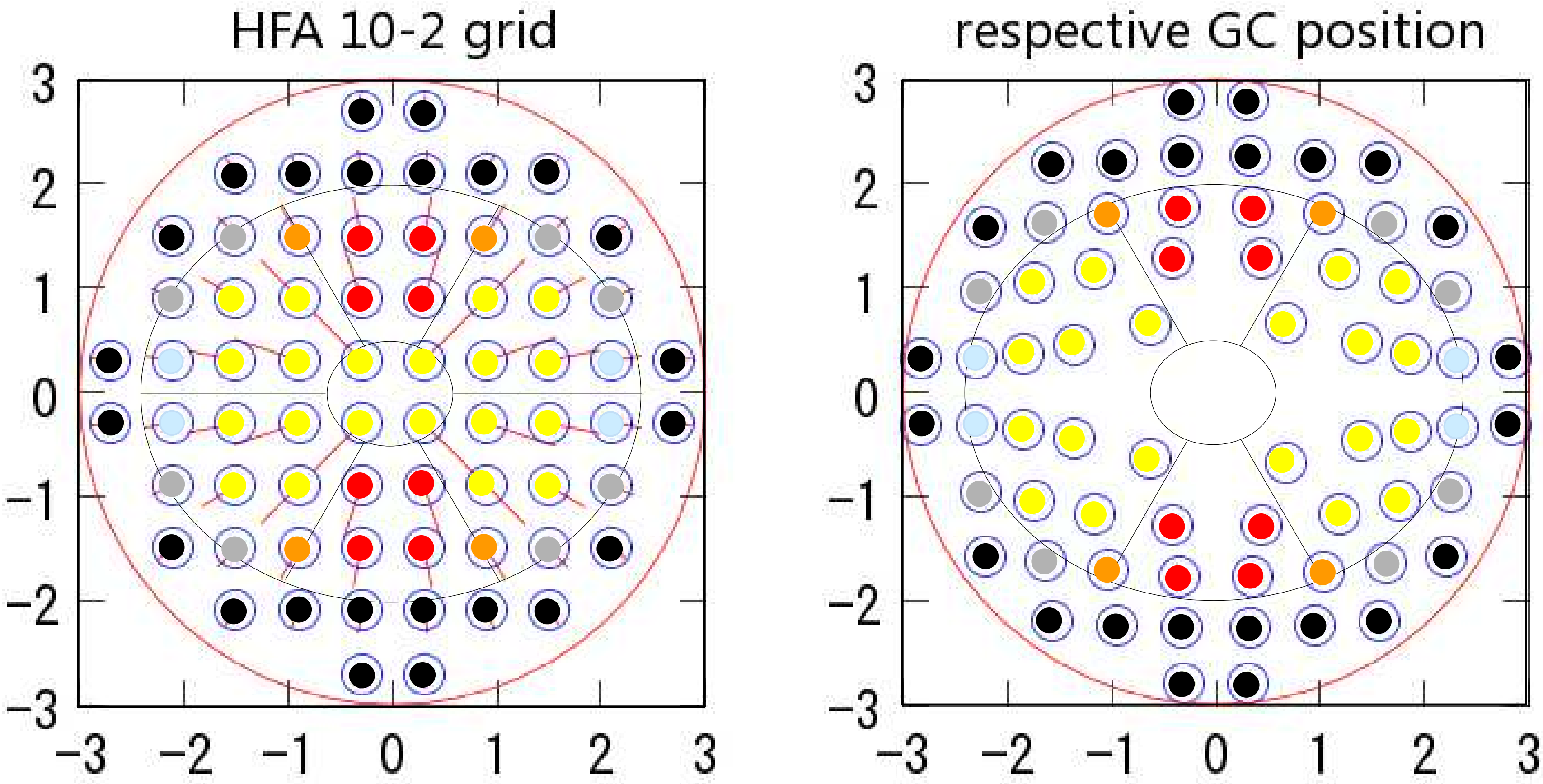




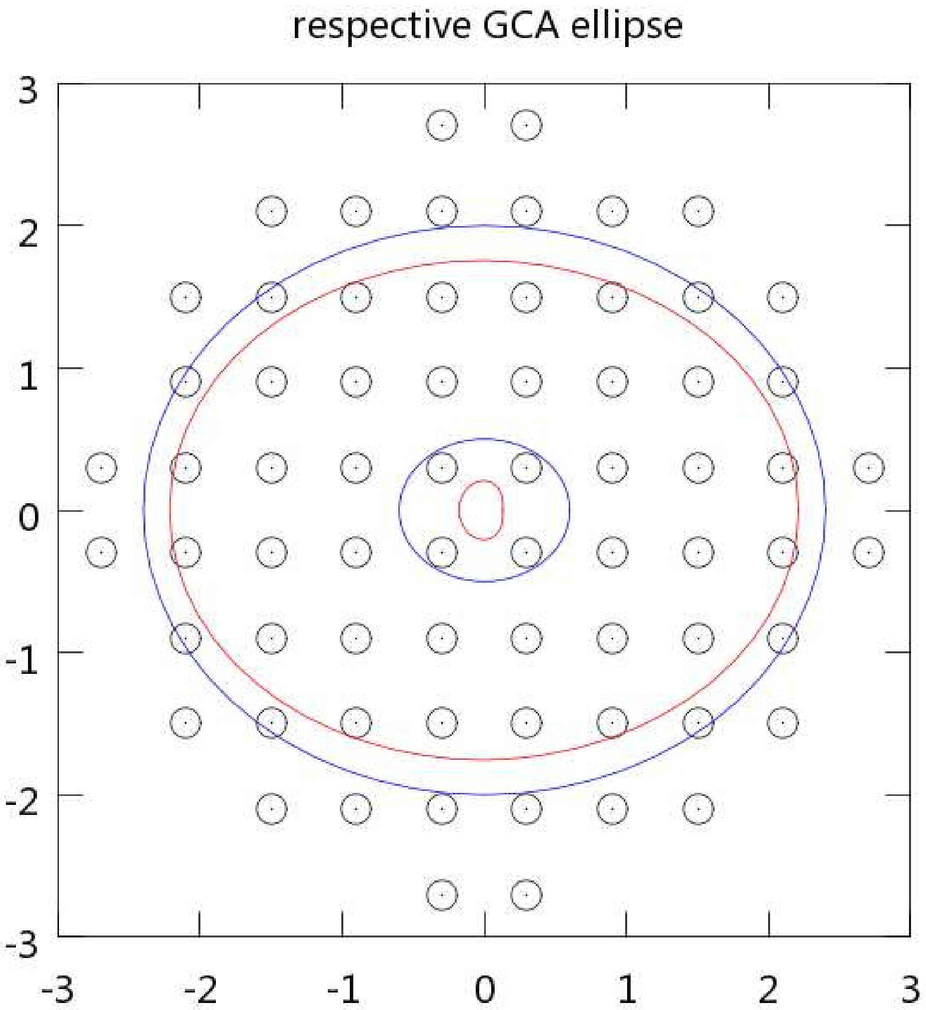
Drasdo et al [4] results applied to 10-2 HF test pattern



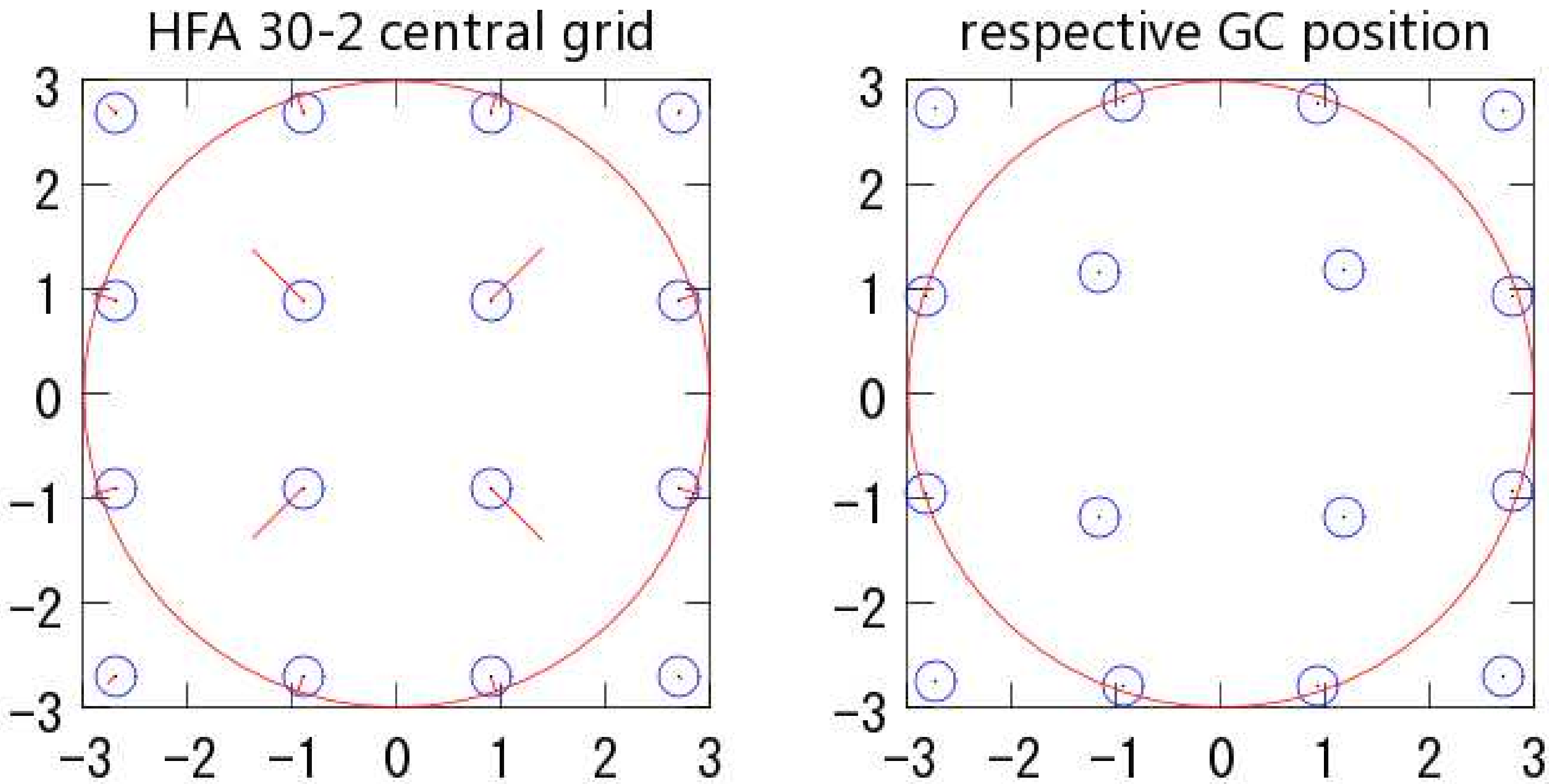
Overlay 10-2 HF test pattern & Ganglion Cell Analysis



Overlay of Ganglion Cell Area onto HFA 10-2 test locations



Drasdo et al [4] results applied to 24-2/30-2 HFA test pattern (only within the macular scan area)



References

References

[1]	Ferreras et al	Mapping Standard Automated perimetry to the Peripapillary Retinal Nerve Fiber Layer in Glaucoma (Inv. Ophth. & Vis. Sci., July 2008, Vol 49, No 7)
[2]	Hood, Raza	Method for comparing visual field defects to local RNFL and RGC damage seen on frequency domain OCT in patients with glaucoma (Biomed. Opt. Express, May 1, 2011, Vol 2, No 5)
[3]	Zhang et al	Deriving visual field loss based upon OCT of inner retinal thicknesses of the macula (Biomed. Opt. Express, June 1, 2011, Vol 2, No 6)
[4]	Drasdo et al	The Length of Henle Fibers in the Human Retina and a Model of Ganglion Receptive Field Density in the Visual Field (Vision Res., Oct. 2007, Vol 47(22), p. 2901 ff.)

Retinal Ganglion Cell Layer Thickness and Local Visual Field Sensitivity in Glaucoma

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Objective To compare loss in sensitivity measured using standard automated perimetry (SAP) with local retinal ganglion cell layer (RGC) thickness measured using frequency-domain optical coherence tomography in the macula of patients with glaucoma.

Methods To compare corresponding locations of RGC thickness with total deviation (TD) of 10-2 SAP for 14 patients with glaucoma and 19 controls, an experienced operator hand-corrected automatic segmentation of the combined RGC and inner plexiform layer (RGC+IPL) of 128 horizontal B-scans. To account for displacement of the RGC bodies around the fovea, the location of the SAP est points was adjusted to correspond to the location of the RGC bodies rather than to the photoreceptors, based on published histological findings. For analysis, RGC+IPL thickness vs SAP (TD) data were grouped into 5 eccentricities, from 3.4° to 9.7° radius on the retina with respect to the fovea.

Results The RGC+IPL thickness correlated well with SAP loss within approximately 7.2° of the fovea (Spearman = 0.71-0.74). Agreement was worse (0.53-0.65) beyond 7.2°, where the normal RGC layer is relatively thin. A linear model relating RGC+IPL thickness to linear SAP loss provided a reasonable fit for eccentricities within 7.2°.

Conclusion In the central 7.2°, local RGC+IPL thickness correlated well with local sensitivity loss in glaucoma when the data were adjusted for RGC displacement.