Shining a new light on the macula: its emerging role in glaucoma

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Traditional Glaucoma Evaluation

- Clinical assessment of optic nerve
  - Now often includes OCT-RNFL measurement
- Threshold visual field testing
Recently, however, attention has been focused on the macula.

But....didn’t we learn that the macular region is spared until later-stages of glaucoma?
Accumulating evidence indicates that both structural & functional macular involvement is present throughout the spectrum of glaucoma.

1. Macular compromise is associated with central visual field loss and central vision loss is closely related to QOL
2. OCT technology permits fast, precise, reproducible measurement of the macula
3. Current 24-2 pattern poorly samples central field
Structural Evidence: diagnostic precision

- Many studies have shown that partial/inner macular thickness parameters carry similar diagnostic capability compared to RNFL thickness parameters

- Full-thickness macular parameters generally underperform vs RNFL with one exception
  - Macular thickness asymmetry parameters compare favorably with RNFL diagnostic capability
Visual Dysfunction Evidence

Acquired B-Y color vision defects occur in early glaucomatous process -- likely represents macular ganglion cell dysfunction

Visual adaptation to changing contrast is altered in glaucoma

Lek JJ, Vingrys JJ, McKendrick AM Rapid Contrast Adaptation in Glaucoma and Aging. IOVS 2014
Recent studies also report that isolated central visual field loss is common in early glaucoma, particularly when 10-2 visual fields are utilized.

Hood et al. Early glaucoma involves both deep local, and shallow widespread, retinal nerve fiber damage of the macular region. IOVS 2013.
Hood et al. Initial arcuate defects within the central 10 degrees in glaucoma. IOVS 2011.
Macula involved in all stages of glaucoma

–Central visual field loss is more commonly found on **10-2** pattern compared to 24-2 pattern

Sampling of the central 10 degrees is only accomplished with the inner 4 points on 24-2

Macula involved in all stages of glaucoma

So why might the macula be involved in early glaucoma?

The macula contains 50-60% of all retinal ganglion cells.

The central 8 degrees contains one third of all ganglion cells.

Macular structure and central visual function are better correlated than RNFL thickness and 24-2 visual function.

Hood et al. Glaucomatous damage of the macula. PRER 2013.
Central visual field loss has distinctive patterns.

Superior defects are more common and are usually closer to fixation.

Hood et al. Initial arcuate defects within the central 10 degrees in glaucoma. IOVS 2011.


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Visual Dysfunction Evidence

Examples of 10-2 visual field loss

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Macular Vulnerability Zone

Summary of evidence

–So, the evidence is strong that the macula and central visual field is involved in early glaucoma

Now what?
So should we implement MT as part of our clinical workup?

Questions to resolve

1. Is MT advantageous for diagnosis?

2. Can MT be used to identify progression?

3. Does MT provide unique value for risk assessment?
Is macular thickness useful for diagnosis?

- Macular thickness asymmetry: Yes
- Ganglion cell complex: Yes
- GC-IPL (Ganglion cell analysis): Yes
- Total Macular Thickness: No

Diagnostic capability of MT and RNFL asymmetry parameters

83% sensitivity
95% specificity
Using threshold Value of 5um

50 early POAG Versus 50 Normal

Inter-eye global MT difference; AUC=0.913
Global RNFL thickness (lowest eye); AUC=0.937
Inter-eye difference RNFL; AUC=0.921
Intra-eye MT difference (high eye); AUC=0.860

Sullivan-Mee et al. AJO 2013
The **Ganglion Cell Complex (GCC)** measures the thickness of the 3-innermost retinal layers that are preferentially affected in glaucoma.

**Ganglion Cell Complex (GCC)**

- **Axons** = nerve fiber layer (NFL)
- **Body** = ganglion cell layer (GCL)
- **Dendrites** = inner plexiform layer (IPL)
GCC strategy
Ganglion Cell analysis strategy
Structure/Function analysis with GCC
Summary....macular thickness for diagnosis

• **MT Advantages:**
  – Better reproducibility than RNFL parameters
  – Less anatomic variability
  – Better correlation with symptoms
  – Better structure/function correlation

• **MT disadvantages**
  – Samples only 50% of RGC’s
  – Similar diagnostic capability to RNFL

MT provides strong complementary value.... But it doesn’t replace RNFL
Few studies have investigated the use of macular thickness for identifying progression?

• **MT Advantages:**
  – Better reproducibility than RNFL parameters
  – Less anatomic variability

• **MT disadvantages**
  – Samples only 50% of RGC’s
  – Supporting evidence sparse at present

MT has great potential to aid identification of glaucoma progression but is not yet proven
May identify underestimated field loss on 24-2
May predict central field compromise
Summary... macular thickness for risk assessment

- **MT Advantages:**
  - Strong structure/function relationship
  - Less anatomic variability

- **MT disadvantages**
  - Predictive value not yet proven

**MT findings have power to influence treatment aggressiveness**
What about 10-2 VF testing...
So.....is 10-2 useful for glaucoma management?

- **10-2 Advantages:**
  - Better sampling of central field than 24-2
So......is 10-2 useful for glaucoma management?

• **10-2 Advantages:**
  – Faster /easier test to perform than 24-2
  – Good structure/fxn relationship with MT
So......is 10-2 useful for glaucoma management?

• **10-2 may detect progression better than 24-2 in patients with paracentral visual field loss**
Summary for 10-2 Visual field testing

• **10-2 Advantages:**
  – Better sampling of central field than 24-2
  – Faster /easier test to perform than 24-2
  – Good structure/fxn relationship with MT
  – May detect progression better than 24-2 in patients with central visual field loss

• **10-2 disadvantages**
  – Logistics: when and how often to use
  – No commercially available progression software

10-2 provides unique information that can be very valuable for glaucoma
Recommendations for when to use 10-2

- Pre-perimetric glaucoma
- Normal-tension glaucoma
- Presence of disc heme
- RNFL measures that are globally or focally reduced
- Routinely after rate of glaucoma progression determined
- Visually symptomatic patients
CONCLUSION

• Macular structure and central visual function have convincingly been shown to be involved in ALL STAGES of glaucoma.

• Employment of structural and functional methods to assess macular involvement in glaucoma currently provides valuable and unique data that can improve care and management of patients with glaucoma.