ORIGINAL PAPER
DOI: 10.5603/OJ.2022.0006

Utility of the ganglion cell complex thickness map in glaucoma: the presence of raphe sign

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ABSTRACT

Macular ganglion cell complex (GCC) thickness map is a functional ancillary test to detect early structural changes in glaucomatous optic neuropathy (GON). The temporal raphe sign is present in almost all patients with narrow retinal nerve fiber layer (RNFL) defect, especially when there is a small angular distance between the fovea and the RNFL defect. A case series of patients with GCC thickness map and a positive temporal raphe sign is presented.

KEY WORDS: glaucoma; retinal nerve fiber defects; cup/disc ratio; optical coherence tomography

Ophthalmol J 2022; Vol. 7, 35–41

INTRODUCTION

Glaucoma is the leading cause of visual impairment worldwide, affecting more than 70 million people [1]. This neuropathy is characterized by optic disc cupping and thinning of the peripapillary retinal nerve fiber layer and as a result, axonal and secondary retinal ganglion cell loss. One of the earliest signs of glaucoma are retinal nerve fiber layer (RNFL) defects [2]. A detailed clinical history and clinical examination help confirm the presence of glaucomatous optic neuropathy (GON). Visual field defects are highly correlated with macular GCC analysis, which is centered over the fovea.

Typically, there is a progressive retinal ganglion cell (RGC) axonal thinning in glaucoma. There is a body of evidence that having glaucomatous damage implicates macular involvement, even in the early stages of glaucoma [6, 7].

The GCC thickness map uses sector-based color code classification to detect early structural changes. A useful finding for the detection of a glaucomatous change is a step-like configuration of the ganglion cell-inner plexiform layer (GCIPL) in the horizontal raphe due to the difference in thicknesses between the inferior and superior hemispheres. This step-like configuration is called the temporal raphe sign. Usually, this sign has a good concordance with a localized RNFL defect. A case series of patients with GCC thickness map and a positive temporal raphe sign are presented.

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CASES PRESENTATION

The patients with a diagnosis of glaucoma were examined in GSR Medical Center, Collective Innovations Colombia, in Cali, Cauca Valley, Colombia. The morphometric parameters of the optic disc, GCC, and RNFL thickness were measured using ZEISS CIRRUS™ HD-OCT Model 5000 optical coherence tomography (Carl Zeiss Inc., Dublin, CA, USA).

Case 1

A female patient with an 8-year history of primary open-angle glaucoma (POAG), treated with latanoprost 0.005% (1 drop at night). Visual acuity in the right eye (RE) was 20/40, in the left eye (LE) — 20/40. Slit-lamp examination revealed mild cataracts in both eyes; intraocular pressure (IOP) was 14 mm Hg in RE and 13 mm Hg in LE. Fundus examination showed: RE — cup/disc (C/D) ratio 0.6 with inferior rim thinning, LE — C/D ratio 0.7 (Fig. 1).

Case 2

A female patient with a diagnosis of POAG, **actually [currently?]** treated with dorzolamide 2%/timolol 0.5% (2 times per day). Visual acuity in RE was 20/25 and in LE — 20/25. Anterior segment exam was normal in both eyes, IOP in RE was 11, and in LE was 13. Fundus examination showed in RE a C/D ratio of 0.7 with inferior rim thinning, and in LE a C/D ratio was 0.6 (Fig. 2).

Case 3

African descendant male patient diagnosed with POAG, treated with travoprost 0.004% (1 drop at night). Visual acuity in both eyes was 20/20. Anterior segment evaluation was normal, IOP was 17 mm Hg in RE and 18 mm Hg in LE. Posterior pole examination showed a C/D ratio in RE 0.2 and in LE — 0.2 (Fig. 3).

Case 4

A female patient with a history of POAG, treated with latanoprost 0.005% (1 drop at night). Visual acuity in both eyes was 20/25. Anterior segment exam revealed a centered intraocular lens, IOP was 12 mm Hg in RE and 11 mm Hg in LE. Fundus examination showed a C/D ratio in RE 0.7 with inferior rim thinning and in LE a C/D ratio was 0.8 (Fig. 4).

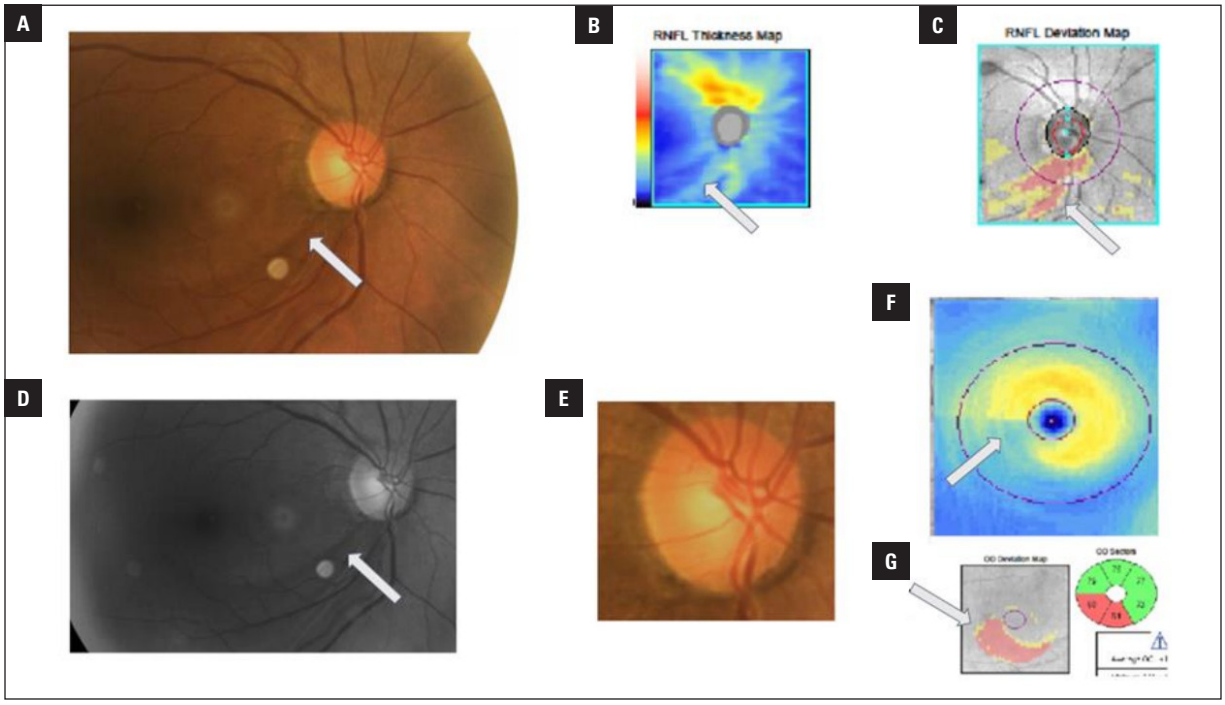

FIGURE 1. **A.** Right eye (RE) optic nerve color image showing inferior retinal nerve fiber layer (RNFL) defect (white arrow); **B.** RNFL defect thickness map indicating inferior RNFL defect (white arrow); **C.** RNFL defect deviation map showing inferior RNFL defect; **D.** RE red-free image showing inferior RNFL defect (white arrow); **E.** First plane, RE normal C/D ratio; **F.** Ganglion cell complex (GCC) thickness map indicating temporal positive raphe sign (respects horizontal midline); **G.** GCC deviation map and sectors showing thinning of the inferior sectors

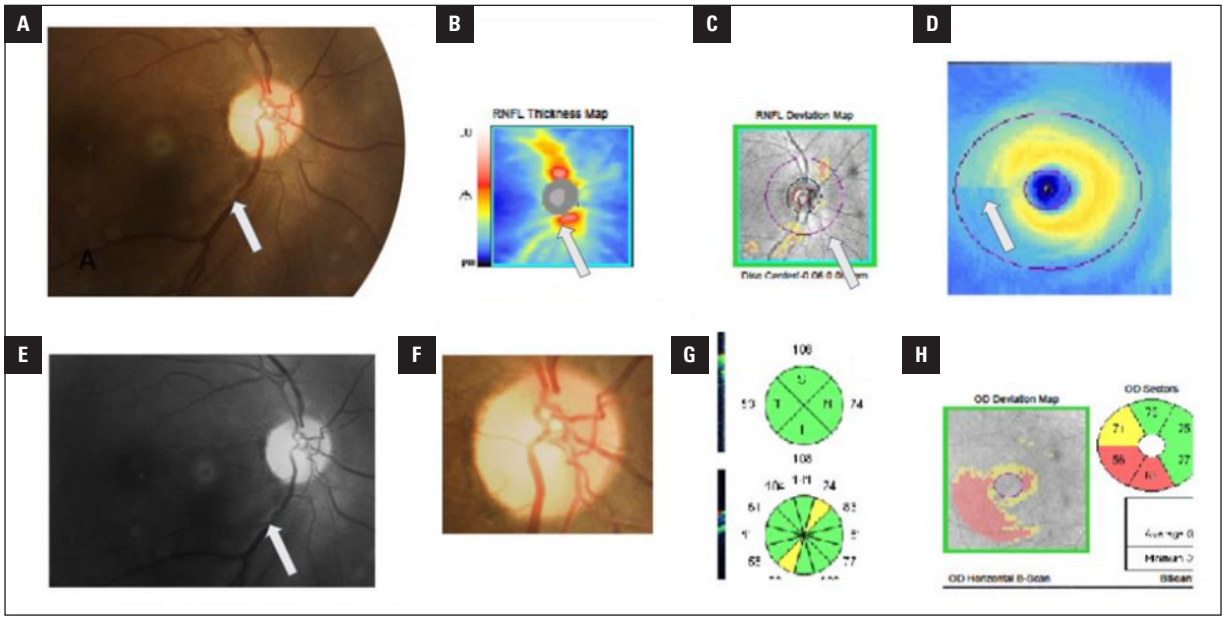

FIGURE 2. **A.** Right eye (RE) red color image showing inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** RNFL thickness map showing inferior RNFL defect (white line); **C.** RNFL deviation map showing inferior thinning; **D.** Ganglion cell complex (GCC) thickness map indicating positive temporal raphe sign; **E.** Right eye red free optic nerve image showing inferior RNFL defect; **F.** First plane right optic nerve with a normal C/D ratio; **G.** RNFL meridians indicating inferior thinning; **H.** GCC deviation map and meridians showing inferior thinning

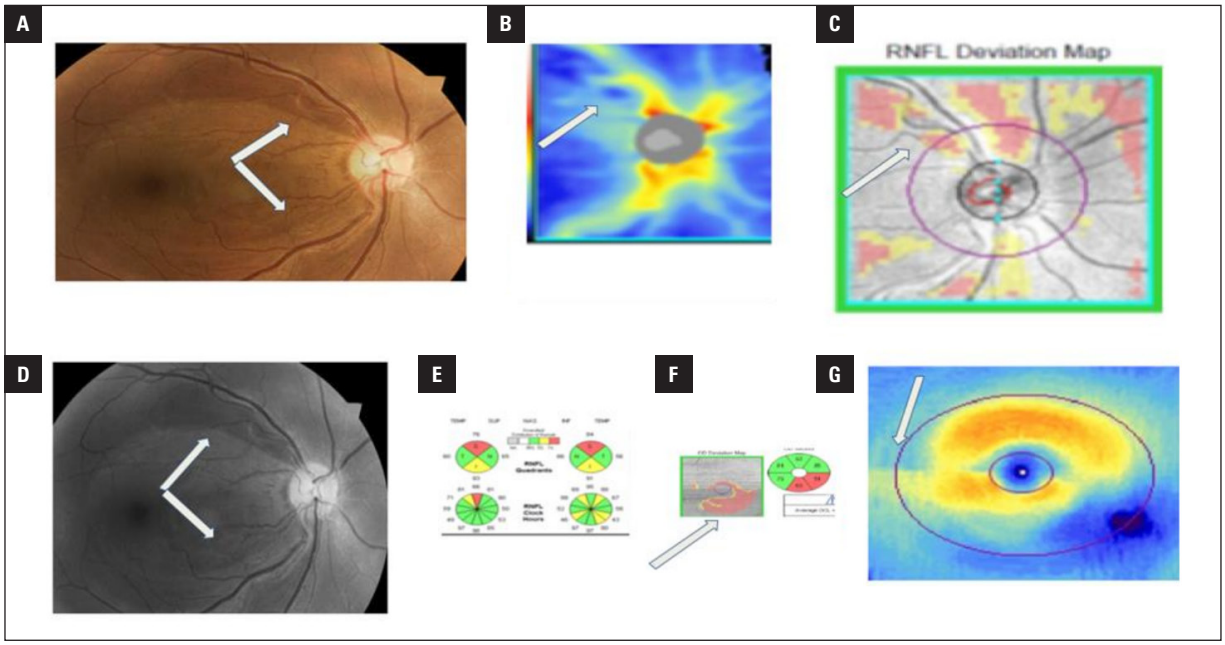

FIGURE 3. **A.** Right eye (RE) red color image indicating a superior and inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** RNFL thickness map showing superior diffuse RNFL defect (white line); **C.** RNFL deviation map showing superior thinning; **D.** RE red-free optic nerve image showing superior and inferior RNFL defect; **E.** RNFL meridians showing superior thinning; **F.** Ganglion cell complex (GCC) deviation map and meridians indicating inferior thinning; **G.** GCC thickness map indicating temporal raphe positive sign

Case 5

A female patient with a history of POAG, treated with latanoprost 0.005% (1 drop at night). Visual acuity in RE was 20/30 and in LE — 20/30. Anterior segment exam revealed mild nuclear sclerosis, IOP was 10 mm Hg in RE and 11 mm Hg in LE.

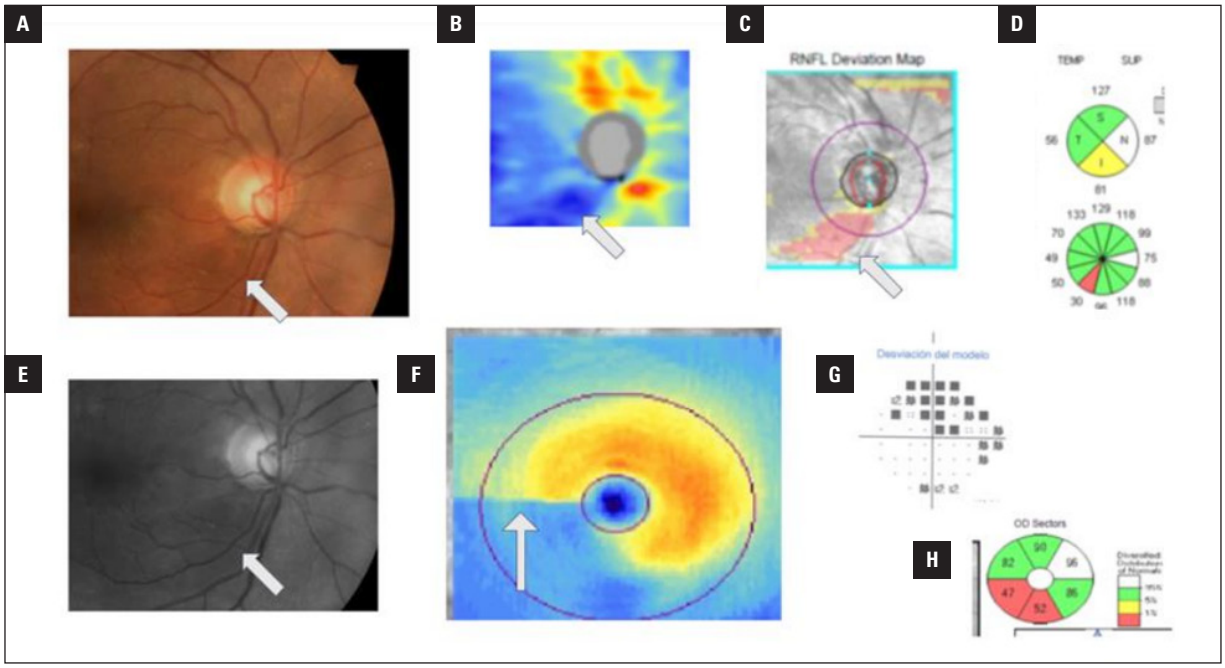

FIGURE 4. **A.** Right eye (RE) red color image showing inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** RNFL thickness map showing inferior RNFL defect (white line); **C.** RNFL deviation map showing inferior thinning; **D.** RNFL meridians showing inferior thinning; **E.** RE red-free optic nerve image indicating inferior RNFL defect; **F.** Ganglion cell complex (GCC) thickness map showing temporal raphe positive sign; **G.** Visual field showing superior arcuate defect; **H.** GCC sectors meridians showing inferior thinning

Fundus examination showed a cup/disc ratio in RE 0.8 with inferior and superior rim thinning, and in the LE a cup/disc ratio was 0.6 (Fig. 5).

Case 6

A male patient with a history of POAG, treated with dorzolamide 2%/timolol 0.5% (2 times per day) and latanoprost 0.005% (1 drop at night). Visual acuity in both eyes was 20/25. Slit-lamp examination was normal, IOP was 13 mm Hg in RE and 12 mm Hg_in LE. Fundus examination showed a C/D ratio in RE 0.8 with an inferior notch and in LE a cup/disc ratio was 0.8 with an inferior notch (Fig. 6).

Case 7

A patient with a history of POAG, treated with dorzolamide 2%/timolol 0.5% (2 times per day). Visual acuity was 20/25 in both eyes. Slit-lamp examination was normal, IOP was 12 mm Hg in RE and 11 mm Hg in LE. Fundus examination showed a C/D ratio in RE 0.5 and in LE 0.8 with inferior rim thinning (Fig. 7).

Case 8

A female patient with a history of POAG, treated with latanoprost 0.005% (1 drop at night). Visual acuity was 20/25 in both eyes. Anterior segment exam was normal, IOP was 12 mm Hg in RE and 11 mm Hg in LE. Fundus examination showed a C/D ratio in the RE 0.6 with inferior rim thinning and in LE a C/D ratio was 0.6 with inferior rim thinning (Fig. 8).

DISCUSSION

Optical coherence tomography (OCT) is a non-invasive optical technique that allows in vivo cross-sectional imaging of the optic nerve head (ONH) and the retina [3]. Cross-sectional images (B-scans) are created through longitudinal scans that can be analyzed quantitatively to measure the thickness of the retinal macular layers [4].

Hwang et al. [5] included 131 patients in a cross-sectional study with early glaucoma (mean deviation > 6.0 dB) and 132 matched healthy patients. Macular GCA images were obtained using Cirrus high-definition optical coherence tomography (HD-OCT). Red-free fundus photographs were used to analyze the location, angular distance, and width of the circumpapillary retinal nerve fiber layer (RNFL). Among the 131 patients with glaucoma, 115 (87.8%), 105 (80.2%), and 104 (79.4%) showed structural abnormalities in the GCA, devia-

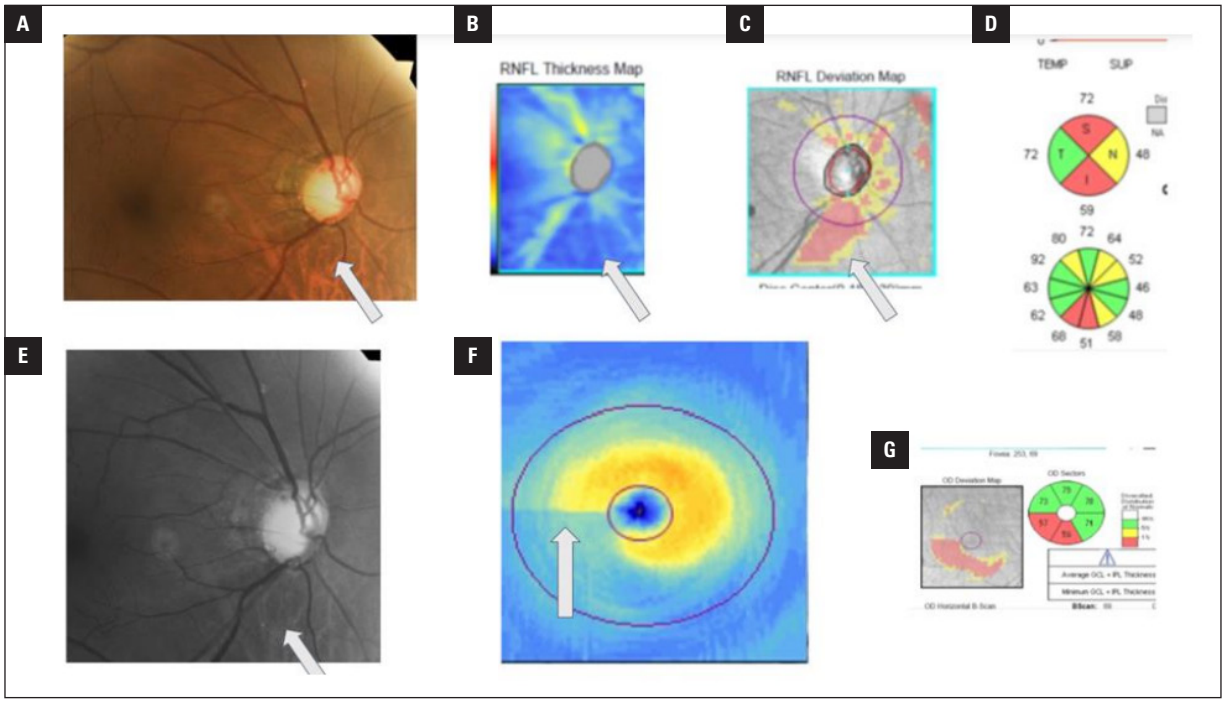

FIGURE 5. **A.** Right eye (RE) red color image showing inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** RNFL thickness map indicating inferior RNFL defect (white line); **C.** RNFL deviation map showing inferior thinning; **D.** RNFL meridians showing inferior thinning; **E.** RE red-free optic nerve image indicating inferior RNFL defect; **F.** Ganglion cell complex (GCC) thickness map showing temporal raphe positive sign; **G.** Visual field showing superior arcuate defect; **H.** GCC thickness and sector meridians showing inferior thinning

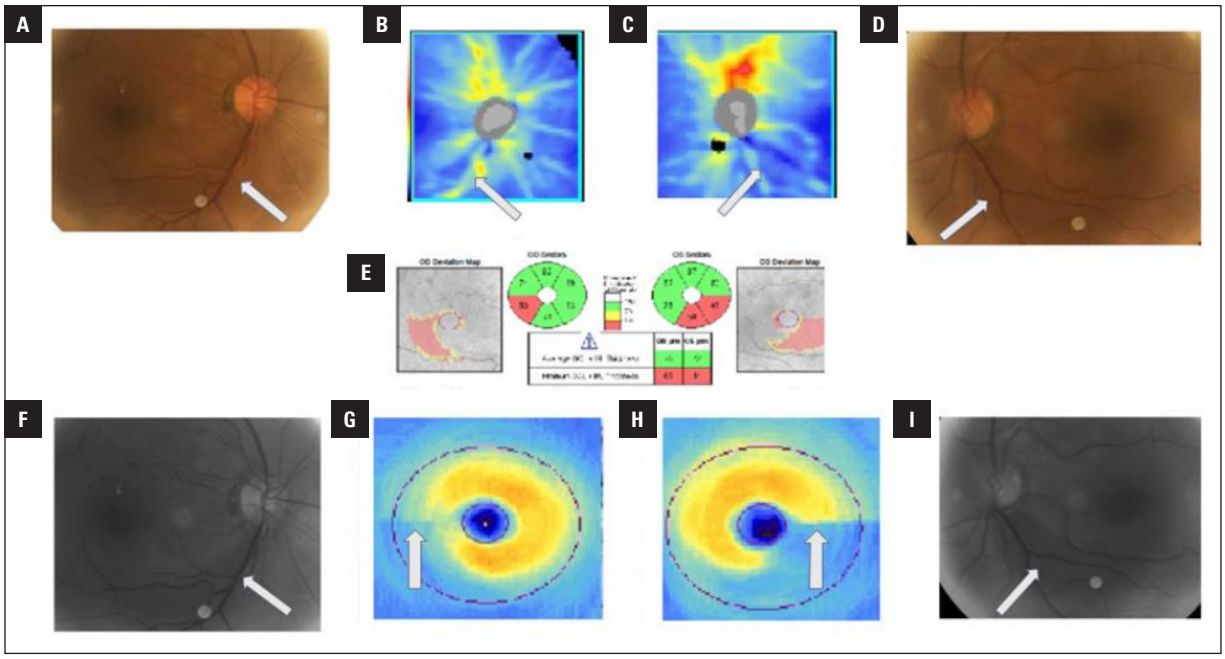

FIGURE 6. **A.** Right eye (RE) red color image indicating inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** RNFL meridian map indicating inferior thinning; **C.** Left eye (LE) red color image indicating inferior RNFL defect (white line); **D.** Ganglion cell complex (GCC) deviation and meridians indicating inferior thinning; **E.** RE red-free optic nerve image indicating inferior RNFL defect; **F.** Right GCC thickness map indicating temporal raphe positive sign; **G.** Right GCC thickness map indicating temporal raphe positive sign; **H.** RE red-free optic nerve image showing inferior RNFL defect

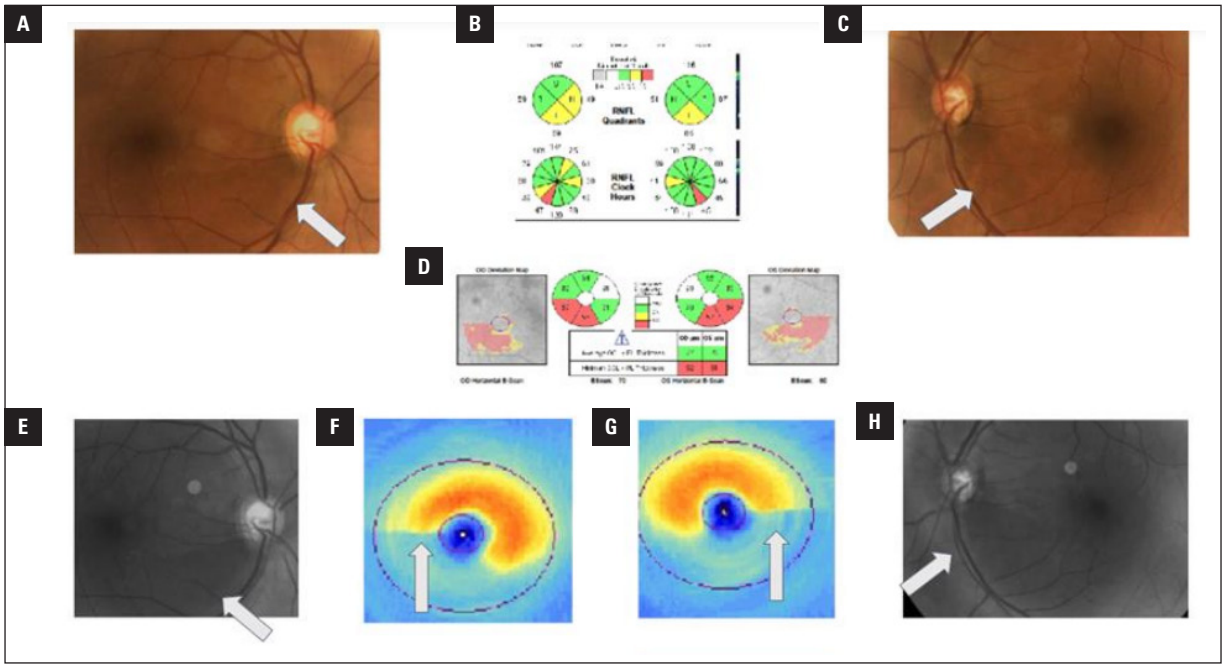

FIGURE 7. **A.** Right eye (RE) red color image indicating inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** RE RNFL thickness map indicating inferior thinning; **C.** Left eye (LE) RNFL thickness map indicating inferior thinning; **D.** LE red color image indicating inferior RNFL defect (white line); **E.** Ganglion cell complex (GCC) deviation and meridians indicating inferior thinning; **F.** RE red-free optic nerve image showing inferior RNFL defect; **G.** Right GCC thickness map indicating temporal raphe positive sign; **H.** Left GCC thickness map indicating temporal raphe positive sign; **I.** LE red-free optic nerve image indicating inferior RNFL defect

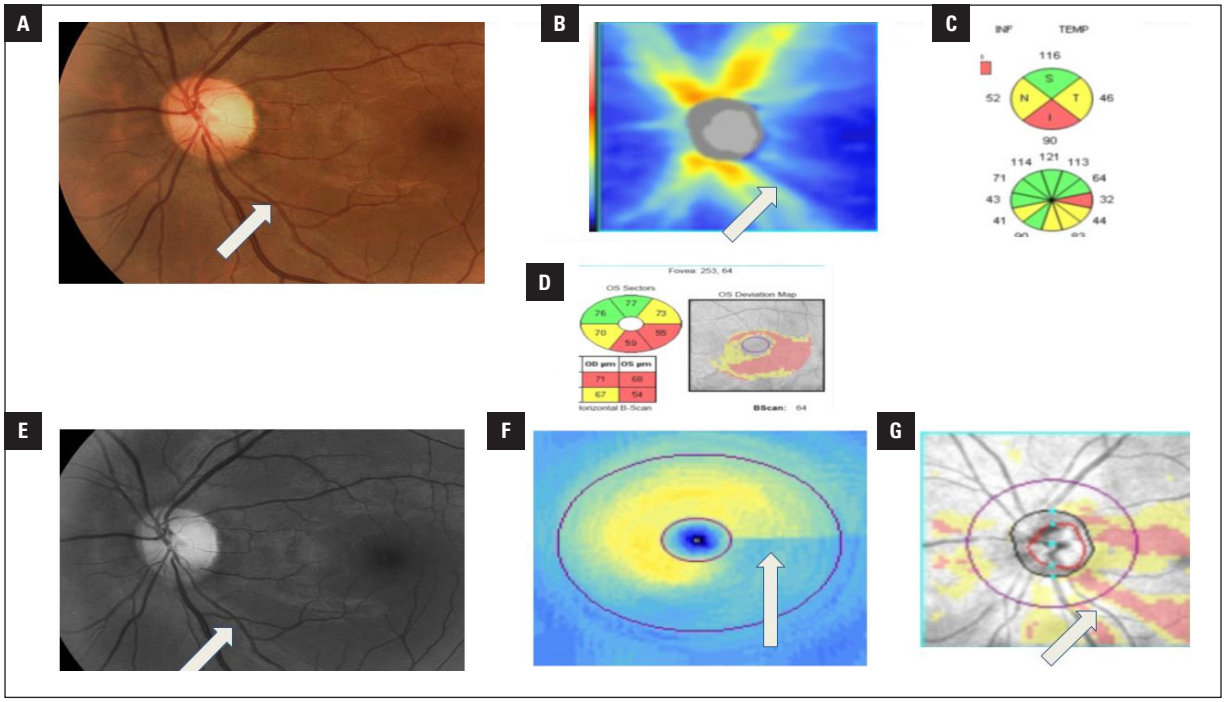

FIGURE 8. **A.** Left eye (LE) red color image indicating inferior retinal nerve fiber layer (RNFL) defect (white line); **B.** LE RNFL thickness map indicating inferior thinning; **C.** LE RNFL meridian map showing inferior thinning. LE red color image indicating inferior RNFL defect (white line); **D.** Ganglion cell complex (GCC) deviation and meridians indicating inferior thinning; **E.** LE red-free optic nerve image indicating inferior RNFL defect; **F.** Left GCC thickness map showing temporal raphe positive sign; **G.** LE RNFL deviation map showing inferior thinning

tion, sector, and thickness maps, respectively. Glaucomatous eyes with the greater angular distance between the fovea and the RNFL defect and narrower width of the RNFL defect had normal findings in the GCA maps.

Temporal RNFL enters into the superotemporal and inferotemporal aspects of the optic disc. Glaucomatous structural damage corresponding to the anatomic distribution of the RNFL is often asymmetric across the horizontal meridian because of the superior/inferior segregation [6]. Lee et al. [7] studied a total of 175 eyes of 175 patients with macular ganglion cell inner plexiform layer (mGCIPL) thinning on Cirrus (Carl Zeiss Meditec, Dublin, CA) HD-OCT. 67 eyes with GON and 73 eyes with nonglaucomatous optic neuropathy (NGON) were enrolled. A positive temporal raphe sign was defined in mGCIPL thickness maps when there was a straight line longer than one-half of the length between the inner and outer annulus in the elliptical temporal area. The temporal raphe sign was observed in 61 of 67 GON eyes (91.0%), but in only 21 of 73 NGON eyes (28.8%) ($p < 0.001$; chi-square test).

CONCLUSIONS

In this case series, we demonstrated the excellent performance of the macular GCC thickness map in detecting changes secondary to GON. The temporal raphe sign is a frequent finding among patients with GON, especially when they present with narrow and located RNFL defect, and the angular distance between fovea and RNFL defect is small.

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