# Multicolor imaging for retinal nerve fiber layer defect in glaucoma

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Glaucoma is a progressive optic neuropathy associated with irreversible loss of retinal ganglion cells (RGC). This emblematic localized retinal nerve fiber layer defect (RNFLD) can be the earliest sign to detect the ongoing glaucomatous damage. Slitlamp biomicroscopy [90D & 78D], colour and redfree fundus photography, OCT & HRT are used conventionally for early detection of RNFLD. Multicolour Imaging (MCI) is a new non-invasive retinal imaging modality available in Spectralis platform which simultaneously acquires three reflectance images of the retina using three individual lasers producing a composite image thereby allowing analysis of changes at various levels within the retina. MCI provides sharper image, enables imaging through small pupil and hazy media. Current report describes 2 cases where in MCI proved superior to CFP and conventional redfree photograph in delineating area of RNFLD. This is the first report of MCI in RNFL imaging. The present report highlights the role of MCI in detection of RNFLD.

**Key words:** Glaucoma, multicolor imaging, retinal nerve fiber layer defect

Glaucoma is a progressive optic neuropathy associated with irreversible loss of retinal ganglion cells (RGCs). Death of axons arising from RGCs gives rise to nerve fiber layer defect on its course to the optic nerve head (ONH). The concentric arrangement of the retinal nerve fibers in arrangement of bundles gives rise to the wedge-shaped defect.[1] This emblematic localized retinal nerve fiber layer defect (RNFLD) can be the earliest sign to detect the ongoing glaucomatous damage and its association to the ONH morphological change along with corresponding visual field changes has been long proven.[2,3] Slit-lamp biomicroscopy (90 D and 78 D), disc color photography, red-free photography, multimodal imaging, i.e., optical coherence tomography (OCT), and Heidelberg retina tomography are used for early detection of RNFLD.[4] Multicolor imaging (MCI) is a new noninvasive retinal imaging modality available in Spectralis platform (Heidelberg Engineering, Heidelberg, Germany).[5] It simultaneously acquires three reflectance images of the retina using three individual lasers producing a composite image, thereby allowing analysis of changes at various levels within the retina. Utility of MCI has been described in various disorders such as epiretinal membrane, age-related macular degeneration, and ONH edema.[6-8] MCI signatures of RNFLD are yet to be described. The present report highlights the role of MCI in the detection of RNFLD in patients with glaucoma.

**Access this article online**

Quick Response Code:

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_30_18

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Manuscript received: 02.03.18; Revision accepted: 06.05.18

## Case Reports

### Case report 1

A 38-year-old female presented with a complaint of diminution of vision and eye strain for 1 year. She was diagnosed elsewhere to have glaucoma and was started on prostaglandin analogs (tafluprost once daily dosage). Family history of glaucoma in mother was positive. Best-corrected visual acuity (BCVA) both eyes (OU) was 20/20 N6. Anterior segment examination was unremarkable. The intraocular pressure was 12 mmHg in OU with central corneal thickness (CCT) of 516 µ and 523 µ in the right and left eye, respectively. The gonioscopic examination revealed open angles in OU. Slit-lamp biomicroscopy in OU revealed glaucomatous cupping. Right

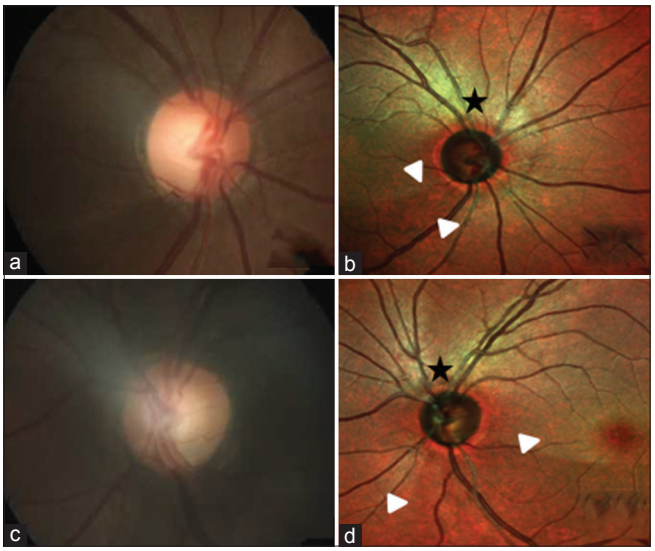


**Figure 1:** Color fundus photograph (a and c) of the right and left eye shows retinal nerve fiber layer thinning inferotemporal to disc (arrowheads) which is seen better on multicolor composite image (b and d) as a wedge defect (arrowheads) with loss of greenish hue inferiorly in contrast to greenish hue emanating from intact retinal nerve fiber layer superiorly (black asterisk)

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**Cite this article as:** Basu T, Shah D, Das D, Saurabh K, Roy R. Multicolor imaging for retinal nerve fiber layer defect in glaucoma. Indian J Ophthalmol 2018;66:1345-9.

eye had a vertical cup-disc ratio (VCDR) of 0.6:1 with inferior rim notch with accompanying wedge-shaped RNFLD and left eye had VCDR 0.7:1 with inferior rim loss and accompanying wedge-shaped RNFLD. Rest of the retina was within normal limit.

Color fundus photography (CFP) was performed with FF 450 Plus Fundus Camera (Carl Zeiss Meditec, Germany). CFP of disc (20°) and red-free disc photograph (30°) were taken to document the disc and RNFL changes. CFP [Fig. 1a and c] and red-free photograph [Fig. 2a and b] showed a wedge-shaped area of RNFLD inferotemporal to disc in OU. The Humphrey Visual field test (24-2) revealed a corresponding superior arcuate defect in both the eyes [Fig. 3]. MCI was obtained using the Spectralis SD-OCT (Heidelberg Engineering). MCI highlighted the RNFLD as a wedge defect inferotemporal to the disc with loss of greenish hue inferiorly in contrast to greenish hue emanating from intact RNFL superiorly [Fig. 1b and d]. The RNFLD is better seen on green reflectance (GR) [Fig. 2c and d] and blue reflectance (BR) images [Fig. 2e and f] as compared to conventional red-free photograph and appear as a hyporeflectant wedge inferotemporal to disc in OU. Infrared reflectance (IR) image, which conveys information from deeper retinal pigment epithelium level, shows no abnormality [Fig. 2g and h]. The patient was advised to continue with the same antiglaucoma medication and 6 monthly follow-up.

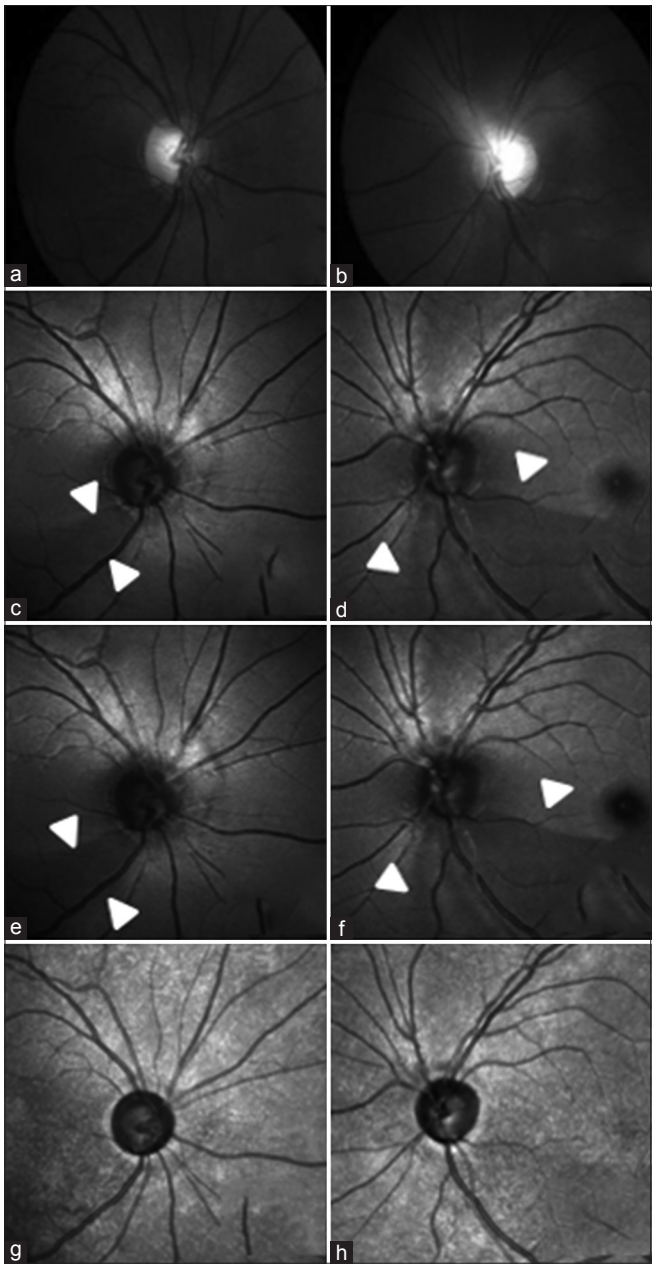


**Figure 2:** Red-free fundus photograph (a and b) of the right and left eye shows retinal nerve fiber layer wedge defect inferotemporal to disc (arrowheads) which is better seen on green (c and d) and blue (e and f) reflectance as a hyporeflectant wedge (arrowheads) and no abnormality on infrared reflectance (g and h)

### Case report 2

A 60-year-old male presented with a complaint of diminution of vision and eye strain for 1 year. BCVA OU was 20/30 N6. Anterior segment examination was unremarkable. The intraocular pressure was 12 and 14 mmHg and the CCT was 496 μ and 504 μ in the right and left eyes, respectively. The gonioscopic examination revealed open angles in OU. Slit-lamp biomicroscopy revealed normal disc in the right eye with VCDR of 0.3:1 with healthy neuroretinal rim and left eye had VCDR 0.9:1 with bipolar rim thinning and accompanying wedge-shaped RNFLD. Rest of the retina was within normal limit.

CFP [Fig. 4a] and red-free photograph [Fig. 5a] right eye appeared normal, left eye [Figs. 4c and 5b] showed wedge-shaped area of RNFLD superotemporal and inferotemporal to disc in the left eye. The Humphrey Visual field test (30-2) revealed few paracentral scotomas in the right eye and a biarcuate defect corresponding to RNFLD in the left eye [Fig. 6a and b].

MCI image of the right eye [Fig. 4b] and reflectance images [Fig. 5c, e, and g] appeared normal; MCI left eye emphasized the RNFLD as a wedge defect superotemporal and inferotemporal to the disc with loss of greenish shade inferiorly in contrast to greenish hue emanating from intact RNFL in the other eye [Fig. 4b and d]. In this case also, the RNFLD is better seen on GR [Fig. 5d] and BR images [Fig. 5f] as compared to conventional red-free photograph and appear as a hyporeflectant wedge inferotemporal to disc in the left eye with silent infrared reflectance [Fig. 5h].

On the basis of these findings, normal tension glaucoma was diagnosed and patient was started on antiglaucoma medication.

## Discussion

Wedge-shaped RNFLD is an important finding in the early diagnosis and prognosis of the glaucoma patients. Multiple experimental studies have shown that axons of RGCs get inserted into the ONH in a bundle which is organized in a concentric. Hoyt *et al*. have described the normal retinal fiber as fine white striations tracing back to ONH with the maximum thickness being near the ONH.[3] Wearing away of the retinal nerve fiber appeared as dark slits along the conduit of the axonal bundles of RGC.

Fitzgibbon has shown that retinal axons are noted to be fairly parallel to each other in their course to the ONH with minimal lateral overlapping, thus giving rise to distinct wedge-shaped defect near the superior or the inferior pole.[9]

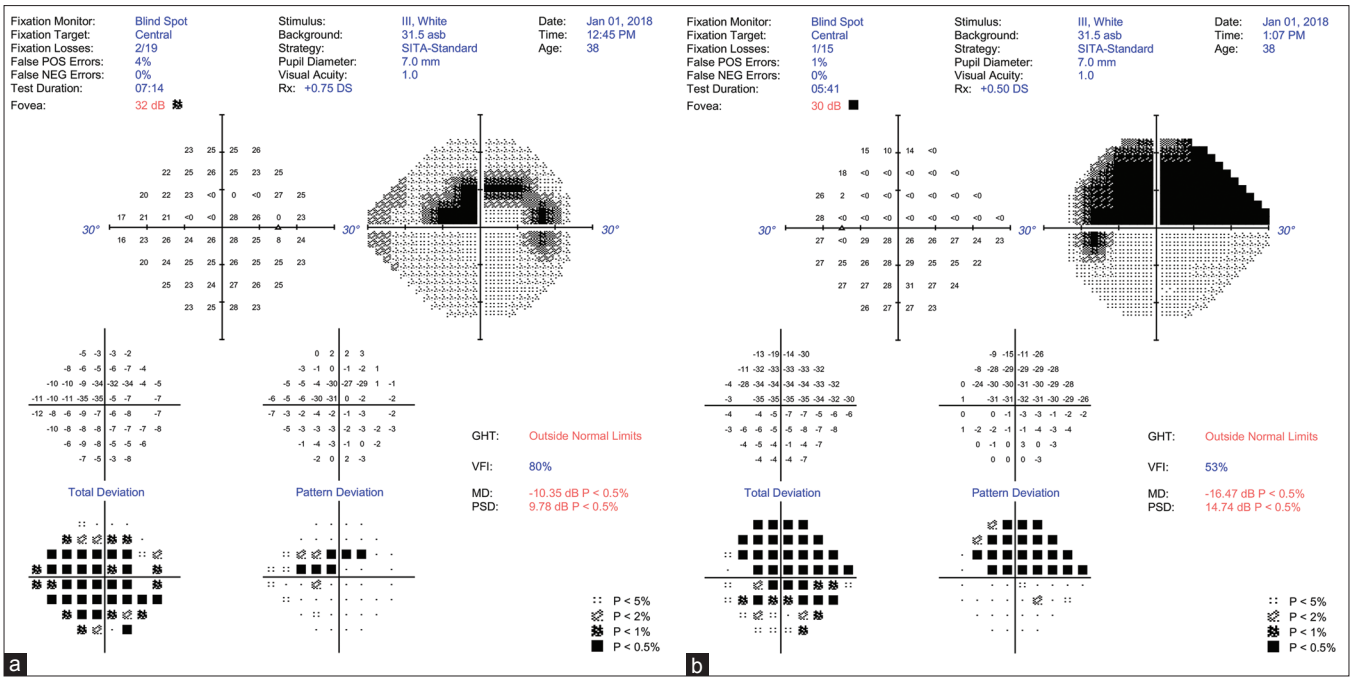


**Figure 3:** The Humphrey Visual field test (24-2) showing superior arcuate defect in the right eye (a) and left eye (b)

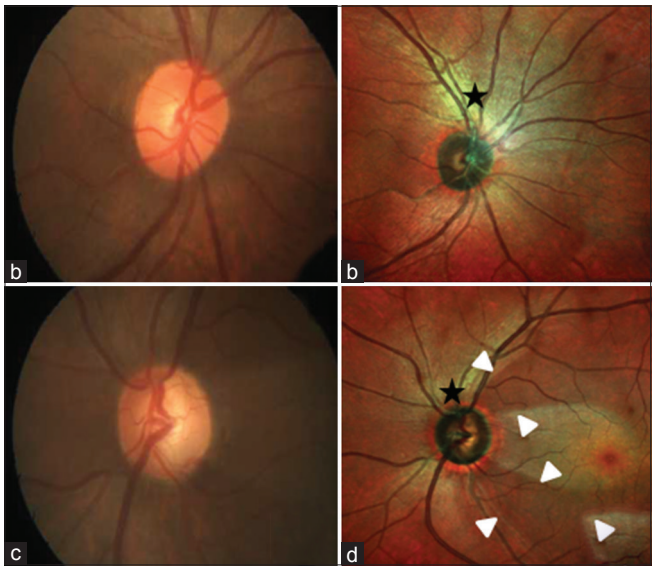


**Figure 4:** Colour fundus photograph of right eye (a) is normal. Color fundus photograph (c) of the left eye shows retinal nerve fiber layer thinning (arrowheads) which is seen better on multicolor composite image (d) as a wedge defect (arrowheads) with loss of greenish hue inferiorly in contrast to greenish hue emanating from intact retinal nerve fiber layer in the right eye (b) (black asterisk)

Conventional flash camera-based CFP is commonly used to document RNFL defect at baseline and at follow-up. However, CFP has various disadvantages. It uses discomforting bright white light and needs dilated pupil and clear media for optimum image quality. Images obtained with CFP have poor contrast, and subtle abnormalities are not highlighted. Multicolor scanning laser imaging is a recently introduced innovative technology developed for Spectralis SD-OCT (Heidelberg Engineering, Heidelberg, Germany). It uses three laser colors such as blue (488 nm), green (515 nm), and infrared (820 nm) that penetrate the tissue to different depths, simultaneously capturing and depicting information originating from different retinal structures. The IR image visualizes structures at the level of the outer retina and choroid. The GR image allows imaging of retinal blood vessels, hemorrhages, and exudates. The BR particularly provides details of the inner retina and the vitreoretinal interface such as epiretinal membranes, RNFL thinning, and macular pigment changes.[5] The information from these three images is integrated to form a composite multicolor image. This platform utilizes confocal technology and thus has unique advantages over CFP. MCI provides good image quality in hazy media and in small pupil.[5] It does not use bright white light and thus is not discomforting to the patient. Images obtained with MCI have better contrast and sharper borders as compared to CFP. Superiority of MCI vis-a-vis CFP is reported in various retinal conditions such as epiretinal membrane, age-related macular degeneration, and retinal dystrophy-related macular edema.[6,7,10] MCI is not yet reported in RNFL imaging. Both cases in this report dramatically highlight the superiority of MCI over CFP. The visibility of RNFLD in GR and BR image is much better as compared to conventional red-free photograph. Patients with glaucoma often have small nondilating pupil [i.e., postacute angle closure attack and pseudo exfoliation], thus intuitively making MCI a better choice than CFP. Furthermore, patients requiring OCT can be imaged in the same machine and need not go to a different machine to obtain the CFP.

## Conclusion

Composite multicolor image with the GR and BR channel provides excellent imaging of RNFLD in patients with glaucoma and can help in visualization and documentation of RNFL better than the conventional fundus photography. However, further large-scale studies are required to

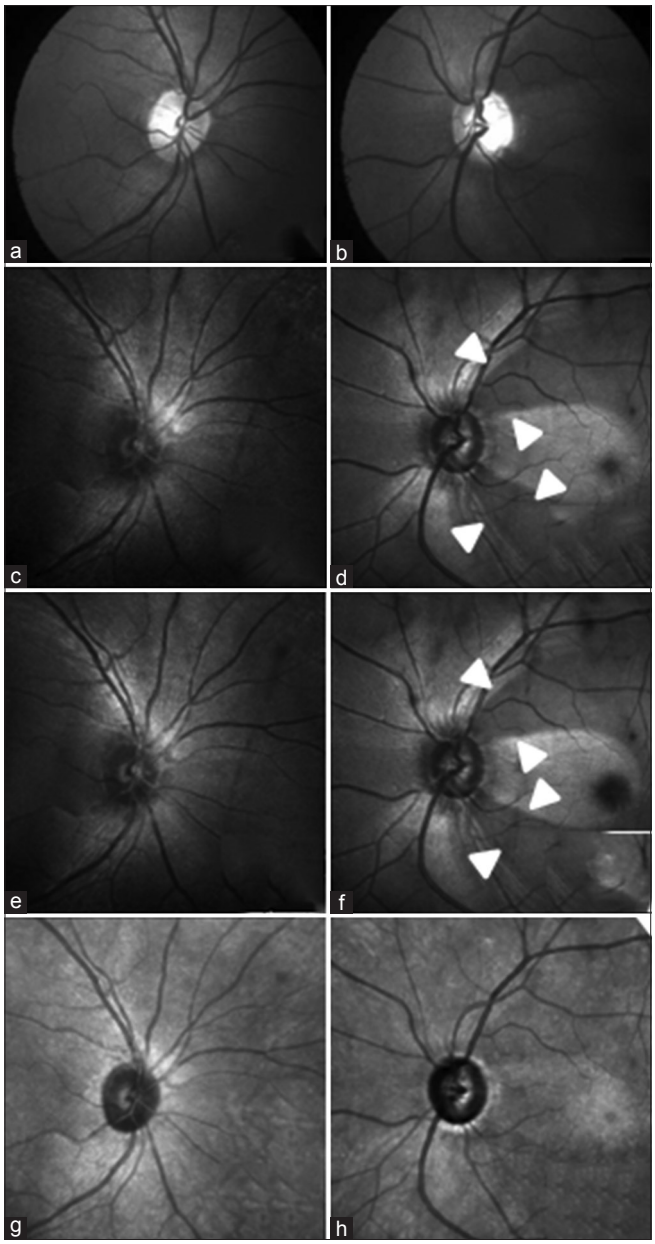


**Figure 5:** Red-free fundus photograph of the right eye (a) appear normal, left eye (b) shows retinal nerve fiber layer wedge defect (arrowheads) which is better seen on green (d) and blue (f) reflectance as a hyporeflectant wedge (arrowheads) while no abnormality in the right eye green and blue reflectance images (c and e] and on infrared reflectance (g and h)

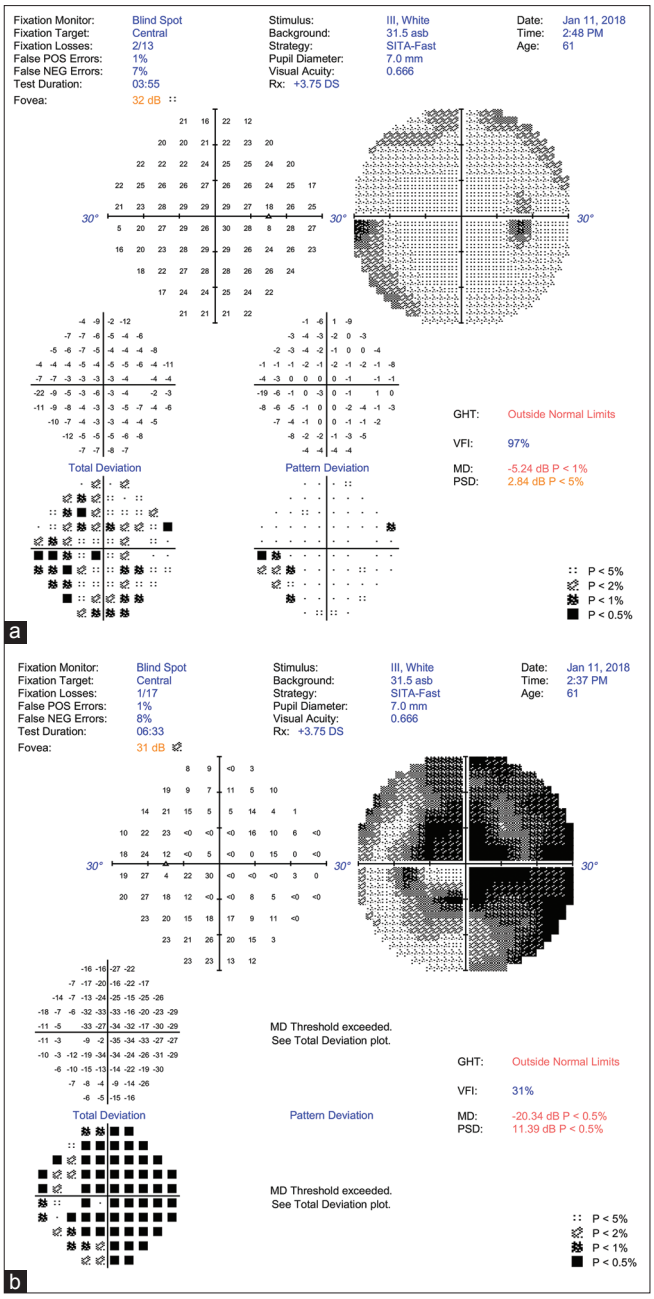


**Figure 6:** The Humphrey Visual field test (30-2) revealed few paracentral scotomas in the right eye and a biarcuate defect corresponding to retinal nerve fiber layer in the left eye (a and b)

validate its usage in detecting RNFLD in routine clinical practice.

## Acknowledgments

The authors would like to thank Miss Moupiya Das and Miss Marina Parvin, Ophthalmic Photographers.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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