*Perspective*

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# The photoreal new-age innovative pedagogical & counseling tool for glaucoma with 3D augmented reality (Eye MG AR)

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## Abstract

In this manuscript, we have reported an augmented reality (AR) application named, 'Eye MG AR' innovated by us, to show different anatomical/pathological parts of the eyeball pertaining to glaucoma, from multiple customized angles of the user's choice to simplify glaucoma learning and clinical counseling. It is available free of cost from the Google Play Store for Android users. Procedures ranging from a simple outpatient department procedure (yttrium aluminium garnet peripheral iridotomy) to a complex surgical technique (trabeculectomy/tube surgery) can be explained and counseled with this Android application. Also, complex structures such as the angle of the anterior chamber and optic nerve head, are constructed in advanced real-time three-dimensional (3D) high-resolution confocal images. These 3D models are useful for glaucoma neophytes' immersive learning and 3D patient counseling experiences. This AR tool aims to reinvent the approach to glaucoma counseling with 'Unreal Engine' software and is created in a patient-friendly approach. Incepting 3D pedagogy and counseling with AR in glaucoma with real-time and high-resolution TrueColor confocal images has never been reported in the literature according to our knowledge.

## Keywords

Glaucoma, neuro ophthalmology, angle-closure glaucoma, diagnostic techniques, neovascular glaucoma, open-angle glaucoma, retina

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Augmented reality (AR) is no more a science fiction concept and has paved its way into science-based reality in recent years.[1–3] But still practical challenges for AR applications exist as they are very costly and not accessible by all, especially medical practitioners. Lau S et al. has reported usage of AR application with the two-dimensional (2D) and three-dimensional (3D) animated images and videos pertaining to glaucoma, whereas we have used real-time images, that one come across in clinical practices. Hence, we have innovated a novel application named the 'Eye MG AR', and have provided it free of cost on the Google Play Store to revolutionize 3D glaucoma teaching and patient counseling in a way like never before.[4] For

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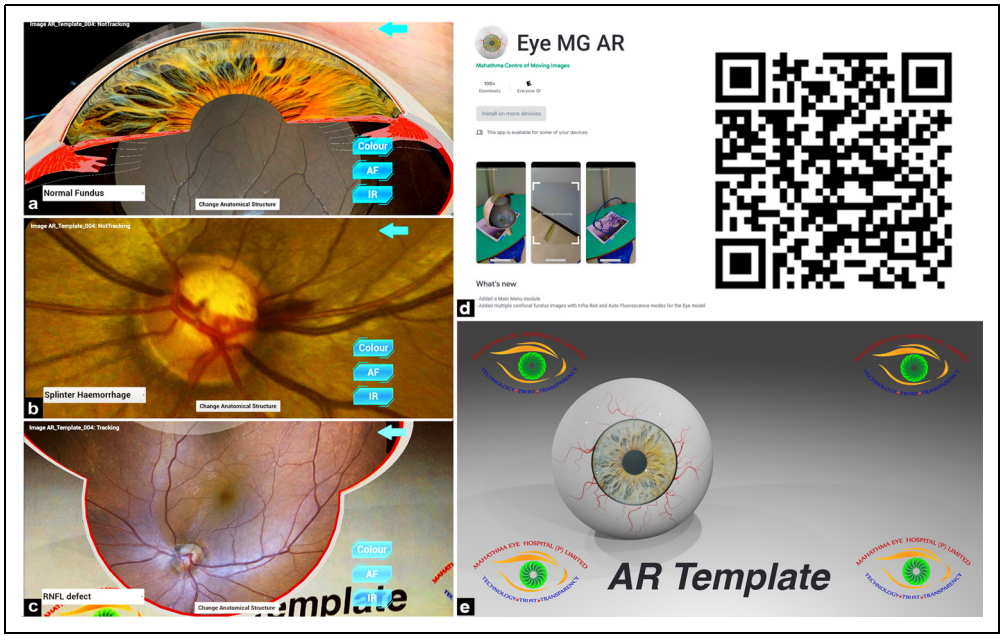


**Figure 1.** Image showing the user viewing (a) the zoomed view of anterior chamber angle (b) splinter hemorrhage in optic nerve head and (c) retinal nerve fiber layer (RNFL) defect in augmented reality (AR) through android smartphone. (d) Image showing the details of the 'Eye MG AR' app on the Google Play Store, and the QR code for downloading the application. (e) Image of the AR template which should be downloaded and printed for a successful AR experience. The AR model will spawn, once the camera scans the AR template.

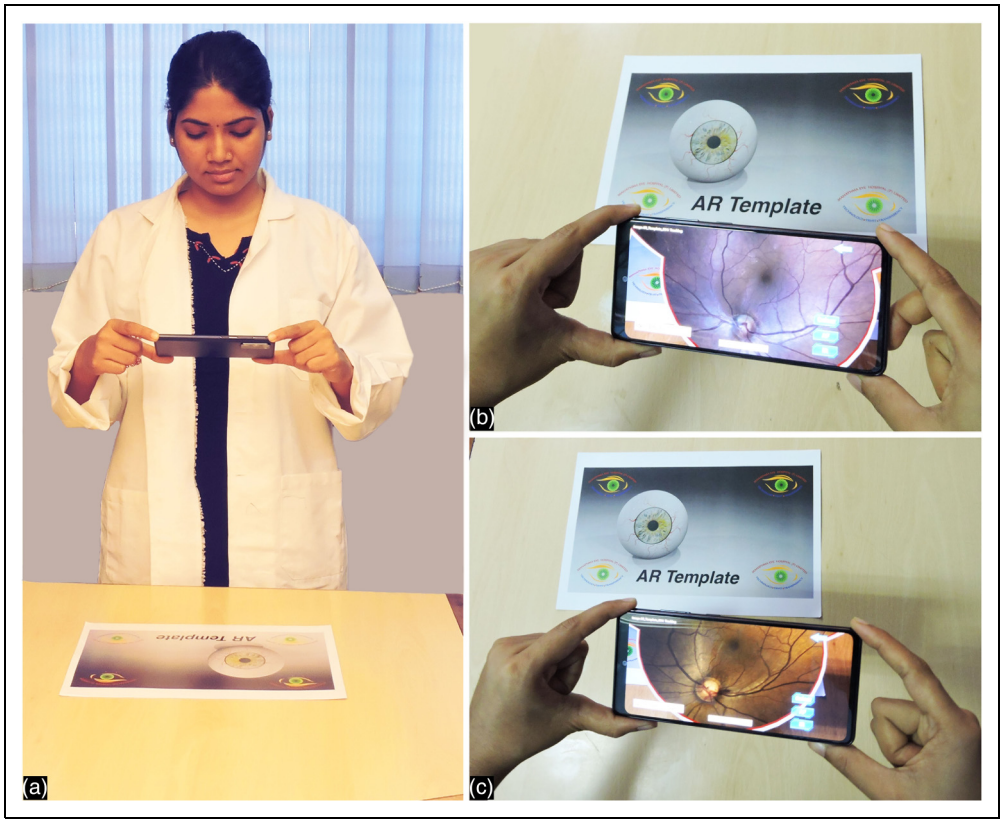


**Figure 2.** Image showing the user (a) beginning the AR teaching session by focusing the mobile camera over the AR template and (b) viewing the glaucomatous cupping with RNFL defect and (c) glaucomatous cupping with splinter hemorrhage in the mobile screen over the AR template.

**Table 1.** Survey data showing the difference in understanding of anatomical implications of glaucoma with and without the use of AR application.

| | With AR | | | | | Without AR | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Excellent | Good | Neutral | Unsatisfactory | Poor | Excellent | Good | Neutral | Unsatisfactory | Poor | *p* |
| **Teaching** | | | | | | | | | | | 0.001 |
| Angle Structure | 43 | 31 | 12 | 9 | 5 | 18 | 21 | 22 | 24 | 15 | |
| Pathological Changes In Posterior Pole | 44 | 35 | 11 | 5 | 5 | 15 | 28 | 24 | 19 | 14 | |
| Glaucoma Progression | 44 | 33 | 16 | 3 | 4 | 21 | 26 | 22 | 17 | 14 | |
| **Counseling** | | | | | | | | | | | |
| Angle Abnormalities | 36 | 32 | 19 | 7 | 6 | 24 | 13 | 28 | 18 | 17 | |
| Optic Abnormalities | 34 | 31 | 14 | 17 | 4 | 23 | 15 | 22 | 21 | 19 | |
| RNFL Abnormalities | 39 | 38 | 10 | 10 | 3 | 20 | 19 | 33 | 17 | 11 | |
| Glaucoma Progression | 44 | 36 | 14 | 4 | 2 | 19 | 25 | 22 | 16 | 18 | |

Independent sample t-test. ($p < 0.05$ is statistically significant). Sample Size = 100.

iPhone users, it is available in another app called 'Eye MG Max', where it can be downloaded free of cost from the App store, with an annual subscription pack for the AR module. The AR 3D eye anatomical and pathological (glaucoma) models (Figure 1(a)–(c)) created by us, are real-time high-resolution unanimated confocal images, and not graphics or animations, thus making our models unique.[5] It aims to revolutionize glaucoma pedagogy (Figure 2) and clinical counseling by bringing in the 3D element and addressing cognitive distortions for a smooth 360° learning and counseling experience.

Another unique feature of the 'Eye MG AR' application is that the fundus images are not only TrueColor confocal images, they are provided in color, autofluorescence, and infrared for a comprehensive glaucoma multimodal AR atlas (Clip 1). This application also opens up a new dimension for the angle of the anterior chamber pedagogy and aids effectively in patient counseling for laser procedures such as yttrium aluminum garnet peripheral iridotomy (YAG PI) and laser trabeculoplasty. Patients can also be given a representation of their real-time eyeballs created using the patient's own data in 3D as an AR hologram case sheet on their mobile handset for future reference. We can also use preset examples for counseling purposes which are already coded into the application.

To support the 'Eye MG AR' application, the android device must have a compass (magnetometer), a rear-facing camera, a gyroscope, a global positioning system (GPS), and an accelerometer. These Android devices would need to run Android 7.0 Nougat or later, and will need to be installed with Google Play Services for AR.[1,6] In this digitalization era, most modern-day Android phones have these prerequisites, and this application can be download from the Google Play Store or by scanning the QR code (Figure 1(d)).

To visualize the models in AR, the AR template (Figure 1(e)) is mandatory, which can be obtained from within the app using the 'download AR template option' and printed before using the application. After opening the app, choose the 'Start' option. The mobile camera should then be focused on the AR template and be fitted within the given borders shown on the display screen. The anatomical and pathological structure of the eyeball appears. To view the structures in customized degrees or angles, the AR template or the mobile phone can be rotated or moved as desired.

This AR tool can be used by any glaucoma specialist around the globe, to enhance glaucoma teaching and glaucoma patients' clinical counseling experiences for treatment and compliance by allowing them to visualise their own real-time images with pathological signs (such as splinter haemorrhage, RNFL defect, notching, high cup-disc ratio etc.) and glaucoma progression in a 3D module. Our real-world experience with this technology in both teaching and counseling has shown successful outcomes which was documented using surveys ($p$-value <0.001) (Table 1). Glaucoma is a field of medicine that is well suited for the application of AR, and with time the immersive experience provided by the digital overlay over the real world will have widespread use in clinical procedures and surgical training as well.[7]

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## Supplemental material

Supplemental material for this article is available online.

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