Letter to Editor

Ophthalmic Imaging in India - Past, Present and Future

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Abstract

Ophthalmic imaging has shown tremendous progress in the past century in terms of numerous advancements in the way we image and interpret the human eye, with all its intricacies. Recent times have emphasized imaging as a diagnostic tool, a modality to document patient progress, and a useful learning medium for budding clinicians. Imaging in ophthalmology is no longer as unidimensional as it used to be. It has expanded from simple slit lamp examination, which functioned on lights and mirrors, to now involve augmented reality technology with its four-dimensional capabilities, completely changing the course of how we diagnose ocular pathologies. India, as a country, has shown a steady pace in incorporating ocular imaging advancements into her regular ophthalmic practice, and there is hope that the country has massive purview in bringing in more technological betterments in the days to come.

Keywords: Ophthalmic imaging, Slit lamp, Ophthalmoscope, Fluorescein angiography, Optical coherence tomography, Artificial intelligence, Augmented reality.

Introduction: A Peep into How We Look at the Human Eye

Imaging into the human oculus remains the cornerstone of diagnosis and treatment of the various impediments that may occur to the visual health of an individual. As medical practice takes a hairpin bend towards becoming an overall patient-friendly experience, these imaging devices help give patients insight into what is going on in their eyes by seeing what their doctors see. Imaging modalities have thus expanded from its confines of merely being a diagnostic tool to being an educational tool for patients, as well as neophyte ophthalmic clinicians. Documentation is a crucial process in the follow-up of patients with progressive eye disease. Newer imaging modalities offer an established timeline of the patient's disease process in such cases, mapping the stage and extent of the disease at each step of the way. Furthermore, imaging modalities are perceptive about things that the human eye cannot normally see. The capabilities of such instruments enable ophthalmologists to delve deep into the ocular structures, identify intricate disease pathologies, and aid in the early diagnosis of diseases. This opens up new doors for clinical practice, cementing its footing in everyday ophthalmic practice.

The foot end of the past millennium witnessed the shift in ophthalmic imaging modalities to more advanced techniques in India and the world. Four decades ago, ophthalmologists were armed with what we now call, our basic line-up of imaging techniques, such as manual slit lamp photographs, traditional fundus photography, fluorescein angiography (FA), and ultrasound. The new millennium brought with it a wave of technological improvements, with pioneering imaging systems like artificial intelligence (AI), three-dimensional augmented reality (AR) technology, and well-known multimodal ophthalmic image-capture machines. These imaging systems, which are already in implementation in India, heralded the country's entry into a new era of diagnostics and patient management.

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You can't know where you are going, until you know where you have been – An insight into times past

History tells us that the first photograph of the human fundus photograph was taken by Elmer Starr and Lucien Howe in 1886.[1] Since then, this gold standard 35 mm film photography has been widely used in ophthalmic imaging for many decades. This has been replaced with digital image capture systems in the past 15 years. Some of the imaging techniques that have been around for a while in India include ultrasound, manual slit lamp photography, ophthalmoscopy, and fluorescein angiography, amongst others. The persistence of these instruments to this day, is proof that these instruments have laid a solid foundation in the field of ocular diagnostics. They have merely been improved upon rather than replaced. Some downfalls to traditional fundus imaging techniques are the requirement of mydriasis, which may impart ocular discomfort, apart from being time-expensive. The introduction of scanning laser ophthalmoscope (SLO) imaging, which was first described in 1981, and OCT imaging in the early 1990s have overcome these disadvantages and paved the way for better documentation and clarity in diagnosing eye pathologies.[2, 3]

The point of power is in the present moment, as it is fully yours to control - A delve into times current

The new century saw progress in Indian visual diagnostics from being linear to being more lateral. Diagnostics are no longer being focused on merely being diagnostic but also as a tool to document patient progress and objectively assess pathologies, which were impossible with traditional imaging modes. Recently, AI based on deep learning (DL) has sparked tremendous global interest. It has been widely adopted in image recognition, which is applied to fundus photographs, OCT and visual fields, achieving robust performance in the detection of diabetic retinopathy, retinopathy of prematurity (ROP), glaucomatous disc, macular diseases, and other fundus pathologies.[4] DL has potential issues, the major one being the inability to explain its diagnostic algorithms, known as the 'Blackbox Dilemma'. This has been circumvented by the development of an explainable artificial Intelligence modality that automatically detects diabetic retinopathy and glaucoma in fundus images, created by the Indian developers Ramesh *et al*.[5]

The current era also boasts of virtual mobile applications such as 3D AR, mixed reality (MR), and virtual reality (VR), which aid not only in patient counseling but also serves as an educational tool for budding young ophthalmologists (Figure 1). These applications are integrated with high-definition images of the eye, acquired using slit lamp, fundus imaging, OCT, and visual fields, providing detailed insight into the pathology. The users can choose their ideal frame from a 360-degree viewing angle using this effective cognitive tool, which doubles as a 3D encyclopedia and helps them fill in their cognitive and mental gaps.[6,7]

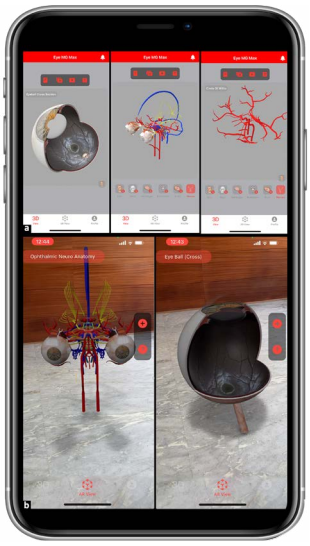

Figure 1: Image showing the 3D AR ophthalmic application. (a) 3D view of various models along with subtractive learning available in the application. (b) AR view of the various 3D models for immersive learning and counselling

Figure 2: Image showing e-counselling using the ophthalmic holograms (Mixed Reality) with HoloLens2 headset of a retinitis pigmentosa patient

The future represents hope that the best is yet to come – A look into the times coming

Extended reality (XR) is the most anticipated invention to arrive in the near future. XR is one of the leading high-tech technologies that is yet to be fully adopted in the field of ophthalmology in India. Mixed reality (MR), virtual reality (VR), and augmented reality (AR) are all extensions of XR. The use of XR technology will revolutionize the face of teaching, diagnostics and patient counselling on a whole new level (Figure 2). The field of clinical and surgical ophthalmology is steadily entering a 4D era, with its immersive cinematic photoreal experiences, which contain holograms as a digital overlay over the real world. This concept may be strengthened and controlled via touch in addition to being received visually, thereby invoking not

one, but two senses. The concept also allows for virtual surgical training via simulator models, heralding a new slew of educational tools for novice ophthalmologists.[8]

Conclusion - India, an archetype for progress

Despite being cited as a developing country, if the recent pandemic has taught us anything, it is that India is a survivor and an embodiment of growth. Slow, but steady continues to be the country's mantra with regard to technological advancements. The authors of this essay remain hopeful in anticipation that, despite the torpid pace, India will continue to see marvelous progress in the field of ophthalmic imaging as the years roll in.

Declaration of 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.

Conflict of interest

The authors declare no conflict of interest.

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