N Asian J Med 2023;1(2):20-28

10.61838/kman.najm.1.2.3

New Asian Journal of
Medicine

Review Article

Evolving Visions: A Comprehensive Review of Contemporary and Emerging Technologies in Anterior Segment Imaging

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Received: 2023-10-24 **Reviewed:** 2023-10-25 **Re-submitted:** 2023-10-26 **Accepted:** 2023-10-26 **Published:** 2023-10-28

Background: The anterior segment of the eye, encompassing the cornea, iris, ciliary body, and lens, plays a vital role in visual function. Over the years, imaging of this segment has significantly evolved, with the development of various modalities to aid in the diagnosis and management of ocular conditions. The aim of this review was to provide a comprehensive overview of these contemporary imaging modalities.

Methods: A thorough literature review was conducted, focusing on the technical aspects and clinical applications of various imaging modalities, including slit-lamp biomicroscopy, anterior segment optical coherence tomography, ultrasound biomicroscopy, Scheimpflug imaging, corneal topography and tomography, in vivo confocal microscopy, specular microscopy, and anterior segment photography and videography.

Results: Each imaging modality offers unique advantages and has specific applications in diagnosing and managing various ocular conditions. Emerging technologies, such as intense pulse light, contoured prism spectacle lenses, smartphone-based imaging, artificial intelligence, and adaptive optics show promise in revolutionizing anterior segment imaging.

Conclusion: The advancements in anterior segment imaging have significantly improved the ability to diagnose and manage ocular conditions. These technologies offer practical implications in improving patient outcomes, enhancing clinical efficiency, and opening new avenues for research. As we continue to refine these technologies and develop new ones, we can expect to see further improvements in patient care.

Keywords: Adaptive Optics, Artificial Intelligence, Corneal Ectasia, Diagnostic Applications, Glaucoma, Intense Pulse Light, Keratoconus, Smartphone-based Imaging, Specular Microscopy, Ultrasound Biomicroscopy

How to cite this paper: Bhat L, KTRT Vedasalam S, Mrema Y. Evolving Visions: A Comprehensive Review of Contemporary and Emerging Technologies in Anterior Segment Imaging. N Asian J Med. 2023;1(2):20-28. doi: 10.61838/kman.najm.1.2.3

INTRODUCTION

The field of ophthalmology has witnessed substantial progress in anterior segment imaging (1). The advent of innovative imaging techniques, such as rotating Scheimpflug imaging (Pentacam-Scheimpflug) and anterior segment optical coherence tomography (Visante OCT and Slit-Lamp OCT) has transformed our understanding and visualisation of the eye's anterior segment (1). Imaging modalities in ophthalmology are crucial, offering a non-invasive, detailed perspective of the anterior segment, encompassing the cornea, iris, and anterior chamber (1). These techniques have considerably enhanced the diagnosis and management of numerous ocular conditions, particularly those impacting the anterior segment (2).

In the past, particularly before the early 2000s, anterior segment imaging was primarily conducted via slit lamp biomicroscopy (3). However, this method had its limitations, including the absence of an objective quantitative assessment of anterior segment structures (3). The introduction of new imaging tools has addressed these limitations, offering both qualitative and quantitative data about the cornea, anterior chamber, iris, iridocorneal angle, and lens (3, 4). The progression of these techniques has been swift. For example, rotating Scheimpflug imaging and anterior segment OCT (AS-OCT) have recently become available, supplementing more established imaging devices such as ultrasound biomicroscopy (UBM) and Orbscan scanning-slit topography (5). These novel modalities offer a plethora of information, including quantitative anterior chamber angle estimation, corneal power measurement, corneal flap depth following Laser-Assisted in Situ Keratomileusis (LASIK), and anterior chamber width before phakic intraocular lens implantation (6). Nevertheless, despite these advancements, there remain uncertainties in this field. For instance, the optimal imaging modality for specific clinical scenarios is still a topic of ongoing research. Moreover, while these imaging modalities offer a wealth of information, interpreting this information and integrating it into clinical practice is a complex task that necessitates further investigation and standardisation (5, 6).

The aim of this study was to review the potential and practical uses of these contemporary imaging modalities in diagnosing and treating conditions of the anterior segment.

METHODS

This narrative review was conducted through a comprehensive search of the literature on contemporary imaging modalities of the anterior segment. The search was carried out using several databases, including PubMed, Embase, and the Cochrane Library, up to July 2023. The search terms used included "anterior segment", "imaging modalities", "ophthalmology", "Slit-Lamp Biomicroscopy", "AS-OCT", "UBM", "Scheimpflug Imaging", "Corneal Topography", "Tomography", "IVCM", "Specular Microscopy", and "Emerging Technologies". The search was limited to articles published in English. The articles were then screened for relevance based on their titles and abstracts. The full texts of the selected articles were then reviewed for detailed information on the different imaging modalities. The information gathered was then synthesized and presented in this review. A summary of the key features, strengths, limitations, and applications of each imaging modality is presented in Table 1.

Table 1. Comparative Analysis of Contemporary Imaging Modalities for the Anterior Segment.

Imaging Modality	Strengths	Limitations	Use Cases	Diagnostic Applications	Year of Introduction	Prospects
The LipiScan Dynamic Meibomian Imager	Rapid imaging, non-invasive	Limited to meibomian glands	Dry eye clinics	Meibomian gland dysfunction	2015	Integration with other dry eye diagnostic tools
Slit-Lamp Biomicroscopy	High magnification, direct visualization	Operator dependent, Limited depth perception	Routine eye examination, Contact lens fitting	Corneal ulcers, Conjunctivitis, Cataracts	Early 20th century	Integration with digital imaging for enhanced documentation
Anterior Segment Optical Coherence Tomography	High-resolution, non-contact, non-invasive	Limited penetration depth	Corneal thickness measurement, anterior chamber angle assessment	Glaucoma, corneal edema	Late 20th century	Development of AI algorithms for automated analysis
Ultrasound Biomicroscopy	High-resolution, can image non-transparent tissues	Contact procedure, operator dependent	Ciliary body imaging, pre-operative assessment for cataract surgery	Ciliary body melanoma, anterior segment tumors	Late 20th century	Enhanced resolution and depth of penetration
Scheimpflug Imaging	Three-dimensional analysis, can image lens	Requires skilled operator for accurate results	Refractive surgery planning, keratoconus screening	Keratoconus, cataracts	Early 21st century	Integration with other imaging modalities for comprehensive analysis
Corneal Topography and Tomography	Detailed analysis of corneal shape and thickness	Cannot image posterior cornea	Refractive surgery planning, Contact lens fitting	Keratoconus, corneal ectasia	Late 20th century	Development of more precise and patient-friendly devices
In Vivo Confocal Microscopy	Cellular-level images, can image corneal nerves	Limited field of view, requires skilled operator	Diagnosing corneal infections and dystrophies	Fungal keratitis, corneal dystrophies	Late 20th century	Enhanced resolution for detailed cellular analysis
Specular Microscopy	Non-contact, can assess corneal endothelium	Cannot image other anterior segment structures	Evaluating corneal health before and after surgeries	Fuchs' dystrophy, corneal endotheliitis	Mid 20th century	Automated analysis of endothelial cell health
Anterior Segment Photography and Videography	Can document findings, monitor progress over time	Quality depends on equipment and operator skill	Documenting anterior segment conditions, patient education	Iris nevi, corneal opacities	Mid 20th century	Integration with electronic health records for seamless documentation
Optical Coherence Tomography Angiography	Vascular imaging, non-invasive	Limited depth	Retinal and choroidal diseases	Neovascularization, vascular abnormalities	Mid-2010	Improved resolution, wider field of view
Emerging Technologies (e.g., IPL, AI, Smartphone-based imaging)	Potentially more precise and efficient, patient-friendly	Still in early stages of development, requires further research	Depends on specific technology	Depends on specific technology	Early 21st century	Wide range of potential applications depending on specific technology

IPL: Intense Pulsed Light therapy; AI: Artificial intelligence.

RESULTS AND DISCUSSION

LipiScan Dynamic Meibomian Imager (DMI)

The DMI represents a significant advancement in the visualization of the meibomian glands (7), structures integral to the health of the ocular surface. This high-definition gland imager is specifically designed to provide a rapid and clear view of the meibomian glands in the eyelids, aiding in the diagnosis of meibomian gland dysfunction (MGD), a leading cause of dry eye disease (8). The LipiScan employs a specialized illumination system and transillumination technology to capture high-quality images of the glands, allowing clinicians to assess gland structure, density, and overall health [9]. Its non-invasive nature, combined with its quick imaging capability, makes it a valuable tool in routine clinical practice, offering insights into the early stages of MGD and guiding therapeutic interventions (9).

Slit-Lamp Biomicroscopy

The instrumentality of Slit-Lamp Biomicroscopy is decidedly pivotal in the realm of ophthalmology, particularly in relation to the anterior segment of the ocular structure (10). By virtue of this technique, a highly magnified visual representation of the anterior segment is accessible, thereby allowing for an in-depth scrutiny of the eyelids, eyelashes, glands along the eyelids, conjunctiva cornea, iris, lens, and the nexus between these constituents (10).

The slit lamp, which serves as the primary apparatus, comprises a high-intensity luminous source that is focussed to project a slender beam of light onto the eye (11). This operates in conjunction with a biomicroscope, a device conceived for the meticulous examination of the eye's anatomy. In this construct, the slit lamp plays the role of the illuminator, while the biomicroscope enhances the image, thereby enabling an elaborate depiction of the anterior segment (10, 11).

The methodology of Slit-Lamp Biomicroscopy demands the patient to be positioned with their chin and forehead in repose on respective supports, ensuring stability of the head (10, 11). Subsequently, the ophthalmologist embarks upon a comprehensive examination of the eye, utilising the biomicroscope for detailed observation of the ocular structures. The configuration of the slit lamp facilitates alteration of the beam's width and height, thus enabling various portions of the eye to be optimally illuminated and scrutinised (10, 12). In addition, the angle of incidence of the beam can be adjusted so that a single beam of light, allows visualisation of a cross section of the anterior segment, starting from the corneal epithelium and ending at the retro-lental vitreous (10, 12). The vital information yielded by Slit-Lamp Biomicroscopy is quintessential for the diagnosis and management of an array of ocular conditions. It enables the identification of irregularities in the anterior segment, such as corneal ulcers, cataracts, or iris anomalies (12). Furthermore, it plays an instrumental role in monitoring the evolution of disease and the efficacy of treatments (12).

Anterior Segment Optical Coherence Tomography (AS-OCT)

AS-OCT embodies a non-invasive imaging modality, harnessing the prowess of light waves to procure cross-sectional imagery of the anterior segment of the ocular organ, encompassing the cornea, iris, and anterior chamber (13). This technological innovation delivers high-resolution images, which are instrumental in the diagnosis and management of a variety of ocular maladies (13, 14). AS-OCT has indisputably brought a paradigm shift in ophthalmology by delivering intricate images of anterior segment structures, a task that was once formidable to accomplish. It empowers the practitioner to measure the anterior chamber depth, gauge corneal thickness, and assess the angle configuration – parameters that are critical for the evaluation of glaucoma, corneal diseases, and for the pre-operative appraisal for refractive surgery (13-15). The technique operates through a device that emits a light beam. The beam bifurcates into two separate entities, one targeting the tissue of interest and the other a reference mirror. The light reunites after reflection off both the tissue and the mirror, resulting in an interference pattern that is employed to generate a cross-sectional image of the tissue (15). AS-OCT holds several distinguishing attributes over other imaging modalities. Not only does it provide high-resolution imagery, but also it is non-invasive, repeatable, and can be executed with celerity. However, it is not devoid of constraints. For instance, it falls short in imaging structures situated posterior to the iris, such as the ciliary body and the lens. Regardless of these limitations, AS-OCT remains an indispensable asset in the ophthalmologist's arsenal (16).

Ultrasound Biomicroscopy (UBM)

UBM constitutes a high-frequency ultrasound imaging methodology that facilitates the visualisation of the anterior segment of the eye, which comprises of the cornea, iris, ciliary body, and anterior chamber (17). This imaging modality offers a comprehensive view of the anterior segment structures and is particularly instrumental in evaluating a multitude of ocular conditions, inclusive of glaucoma, cataracts, and anterior segment tumours (18).

UBM operates by emitting high-frequency ultrasound waves that permeate the eye tissues. When these waves encounter a variation in tissue density, they reflect back to the transducer, subsequently forming an image of the eye's internal structures. The elevated frequency of the ultrasound deployed in UBM (typically between 35-50 MHz) permits a resolution of up to 20 micrometers, a significantly superior resolution than that offered by conventional ultrasound techniques (18, 19).

The UBM technique requires the placement of a petite probe on the eye's surface, typically facilitated by a water bath or immersion shell to optimise the transmission of the ultrasound waves (18, 19). The probe is subsequently manoeuvred to capture imagery of distinct regions of the anterior segment. The procured images can be analysed to determine various parameters such as anterior chamber depth, angle width, and ciliary body thickness, thereby assisting in the diagnosis and management of numerous ocular conditions (19).

UBM has brought a transformative shift in the domain of ophthalmology, by delivering an unparalleled level of detail of the anterior segment structures. It has substantially augmented our comprehension of the pathophysiology of various ocular conditions and has particularly improved the precision of diagnosis and the effectiveness of treatment approaches (17, 19).

Scheimpflug Imaging

Scheimpflug imaging represents a distinctive imaging modality that delivers a detailed, three-dimensional depiction of the anterior segment (20). This technique deploys a rotating camera in tandem with a slit lamp to capture a multitude of images from varying angles [20]. Subsequently, these images are compiled to fabricate an encompassing, three-dimensional visualisation of the anterior segment, which includes the cornea, anterior chamber, and lens (20).

The Scheimpflug principle, christened after Austrian army captain Theodor Scheimpflug, is predicated on the alignment of the lens, object, and image planes. In circumstances where these three planes intersect at a singular point, the entirety of the field, extending from the foreground to the background, can be rendered in focus (20, 21). This principle finds notable utility in ophthalmology, as it permits precise measurement of the structures in the anterior segment, inclusive of the thickness and curvature of the cornea, depth of the anterior chamber, and thickness of the lens (22).

Scheimpflug imaging has brought about a revolution in the diagnosis and management of various ocular conditions (22). For example, it has significantly enhanced the precision of intraocular lens power calculation, an essential phase in planning for cataract surgery. Furthermore, it has proven to be a powerful tool in diagnosing and monitoring keratoconus, a degenerative condition resulting in the cornea thinning and protruding into a conical shape (22).

In addition, Scheimpflug imaging offers invaluable insights into the biomechanical properties of the cornea (22). By analysing the cornea's deformation response to a puff of air, this technique can evaluate the stiffness of the cornea, a parameter that could be altered in various ocular conditions such as glaucoma and keratoconus (20, 22).

Scheimpflug imaging is a powerful instrument in the field of ophthalmology, offering a detailed, three-dimensional perspective of the anterior segment (20, 22). Its capacity to assess various parameters of the structures in the anterior segment has substantially improved the diagnosis and management of a range of ocular conditions (20, 22).

Corneal Topography and Tomography

Corneal topography and tomography epitomise advanced imaging techniques, proffering a meticulous analysis of the corneal form and thickness (23). These techniques have induced a transformation in the sphere of ophthalmology, particularly influencing the facets of refractive surgery, keratoconus screening, and the fitting of contact lenses (23).

Corneal topography essentially maps the cornea's surface curvature, mirroring a topographic representation of the earth delineating changes in land elevations (24). It generates a colour-coded map of the corneal surface, thereby assisting in the identification of corneal irregularities and diseases. It finds its paramount utility in the planning stage of refractive surgery, wherein an accurate comprehension of the corneal shape is pivotal for successful outcomes (23-25).

Corneal tomography, on the other hand, presents a three-dimensional depiction of the cornea, allowing for the determination of corneal thickness (pachymetry) (25). This is of vital importance in screening for keratoconus, a condition characterised by a thinning and protruding cornea morphing into a cone-like shape, culminating in visual impairment. Early identification of keratoconus can inform treatment strategies and impede the progression of the disease (24). Knowing the corneal thickness is also essential for identifying and monitoring

another serious category of diseases known as glaucoma (24, 25).
Both corneal topography and tomography prove to be invaluable resources in fitting contact lenses. They offer comprehensive information about the corneal shape and size, allowing for a more precise and comfortable fit for the lens (24).
These imaging modalities have markedly amplified our ability to diagnose and manage a range of ocular conditions, thereby elevating patient care and enhancing outcomes (24, 25).

In Vivo Confocal Microscopy (IVCM)

IVCM has catalysed a revolution in the realm of ophthalmology by offering high-resolution, cross-sectional images of the cornea and conjunctiva [26]. This non-invasive imaging approach enables visualisation of cellular and subcellular structures, thus facilitating the diagnosis and management of a variety of ocular diseases (26).
IVCM has been instrumental in the study of corneal maladies, encompassing keratitis, dystrophies, and degenerations. It enables the visualisation of corneal nerves, a critical aspect in the diagnosis and management of neurotrophic keratopathy and peripheral neuropathies [26, 27]. In addition, IVCM plays a significant role in refractive surgery, where it aids in the preoperative screening and postoperative monitoring of patients (27).
Furthermore, IVCM has been used to investigate the ocular surface and its associated diseases (26, 27). It has demonstrated a particular utility in identifying and managing dry eye illness, where it can visualise morphological changes in the corneal and conjunctival epithelium, as well as alterations in the sub-basal nerve plexus (28). Despite its numerous advantages, IVCM presents certain limitations (26-28). The interpretation of IVCM images necessitates comprehensive training and experience. The equipment needed to perform these tests is expensive and occupies a large area, and hence this modality is limited to teaching and research institutes, where resources and funding is not a limitation. Moreover, the imaging of deeper ocular structures is impeded due to the scattering of light by the anterior structures (29).
IVCM represents a prominent instrument in the sphere of ophthalmology, offering invaluable insights into the microstructure of the eye's anterior segment (28, 29). It has significantly enhanced our understanding of numerous eye illnesses and harbours the potential to further elevate patient care in the future (28, 29).

Specular Microscopy

Specular microscopy, a non-invasive imaging technique, facilitates the visualisation and analysis of the corneal endothelium (30). The latter is fundamental to preserving corneal transparency, rendering its health integral for optimal vision (30).
Specular microscopy functions by projecting light onto the cornea and collecting the light reflected off the endothelial cells. This reflected light is subsequently employed to generate an image of the endothelial cells (30, 31). The technique facilitates the evaluation of endothelial cell density, morphology, and size – critical parameters in assessing corneal health (31).
Specular microscopy is particularly advantageous in the preoperative evaluation of patients preparing for intraocular surgery, such as cataract or refractive surgery (31). It aids in identifying patients susceptible to corneal decompensation, a condition wherein the cornea becomes cloudy, leading to impaired vision (32).
Moreover, specular microscopy proves valuable during the postoperative phase. It can monitor the health of the corneal endothelium following surgeries, detecting any potential damage or loss of endothelial cells (29). This is particularly crucial in procedures like corneal transplantation, where the survival and functionality of the graft are contingent on the health of the transplanted endothelial cells (30, 31).
Specular microscopy is an indispensable tool in the field of ophthalmology, offering crucial insights into the health of the corneal endothelium [30, 31]. Its non-invasive nature, along with its capacity for delivering prompt and accurate results, renders it an integral part of an ophthalmologist's armamentarium (30, 31).

Anterior Segment Photography and Videography

Anterior segment photography and videography are invaluable tools in ophthalmology, enabling the recording of clinical findings and the monitoring of disease progression and/or treatment response over time (33, 34). These techniques are especially beneficial in the anterior segment where changes might be modest and occur gradually over time (33, 34).
Anterior segment photography can capture high-resolution images of the cornea, anterior chamber, iris, and lens (33, 34). These images can be used to document various conditions like corneal opacities, iris nevi, or cataract morphology. They also allow for the long-term monitoring of these conditions, producing a visual record that can be referred to in future consultations (34). On the other hand, videography can capture dynamic processes in the anterior segment. For example,

it can be used to record the movement of the iris or lens during changes in lighting conditions or accommodation. This is particularly beneficial in diagnosing conditions involving abnormal movement or positioning of the anterior segment structures (34).

Both photography and videography can be performed using a slit-lamp equipped with a camera. The images or videos are then digitally recorded, making it simple to generate a visual chronology of a patient's condition. This aids in patient education and facilitates communication amongst healthcare providers (33).

Anterior segment photography and videography are powerful tools in the diagnosis, management, and documentation of anterior segment conditions. As technology continues to advance, these techniques are likely to become increasingly valuable in the field of ophthalmology (33).

Optical Coherence Tomography Angiography (OCTA)

OCTA is a non-invasive imaging technique that offers detailed images of the eye's blood vessels. It has been utilized in anterior segment imaging to visualize the vascular structures of the eye, which can aid in the diagnosis and monitoring of a variety of eye disorders (35).

Emerging Technologies

The field of anterior segment imaging is constantly evolving, and in recent years, numerous new technologies and breakthroughs have developed, pushing the frontiers of our understanding of the eye and its various disorders (36, 37). These novel technologies are pushing the envelope in ocular imaging, providing unprecedented insights into the anterior segment of the eye, and offering the potential to improve diagnostic capabilities and patient care in ophthalmology (36)

Intense Pulse Light (IPL)

IPL is a non-laser light source that provides full-spectrum, non-coherent light ranging from 500-1200 nm (36, 37). While IPL devices have traditionally been used to treat a variety of skin conditions, recent advancements have facilitated its use in anterior segment imaging (36, 37). The broad spectrum enables treatment customization based on the specific target's color and depth (36, 37).

Contoured Prism Spectacle Lenses

These are specially designed spectacle lenses that feature a contoured surface, providing a broader field of view than traditional lenses (38). They've been utilized in anterior segment imaging to offer a more comprehensive view of the eye's structures (38).

Smartphone-based Imaging

Smartphones have been used in anterior segment imaging due to their widespread availability and increasingly improved camera technologies (39, 40). Special attachments can be added to the smartphone's camera, enabling detailed imaging of the eye's anterior segment (39, 40).

Artificial Intelligence (AI)

Images of the anterior segment have been analyzed using AI, specifically machine learning techniques (41). These algorithms may be trained to detect patterns and abnormalities in the images, potentially resulting in earlier and more accurate diagnoses (41, 42).

Adaptive Optics

Adaptive optics is a technology used to enhance the performance of optical systems by reducing the effect of wavefront distortions (43). It is employed in astronomy to enhance the resolution of telescope images, and in ophthalmology, it has been utilized to refine the imaging of the eye's anterior portion (43).

Advanced imaging techniques like IPL, Contoured Prism Spectacle Lenses, Smartphone-based Imaging, AI in image analysis, OCTA, and Adaptive Optics, are just some examples of the exciting technologies being harnessed in the field. These innovations allow clinicians to examine the eye's anterior segment in extraordinary detail, leading to more accurate diagnoses and personalized treatment plans (44). Furthermore, they are aiding in the early detection of eye diseases, which is critical for effective treatment and prevention of vision loss. In addition to clinical applications, these advancements also offer significant benefits for research (44). Scientists can now study eye diseases at the cellular level, providing crucial insights into disease progression and the impact of prospective therapies (44). These novel techniques have opened up new avenues for exploration, leading to exciting discoveries and potential breakthroughs in eye care (44). As we look to the future, we should expect to see these technologies evolve further, boosting our ability to diagnose, treat, and comprehend eye diseases. The potential they hold for enhancing patient care in ophthalmology is truly exciting.

CONCLUSION

The domain of anterior segment imaging has witnessed considerable advancements recently, thanks to the inception of novel technologies and the refinement of existing ones. This progress has remarkably augmented our capacity to diagnose and manage a broad spectrum of ocular conditions, subsequently elevating patient outcomes. The adoption of technologies such as IPL, Contoured Prism Spectacle Lenses, Smartphone-based Imaging, AI, OCTA, and Adaptive Optics has triggered a revolution in the field. These technologies have not only bolstered the quality of the images obtained but also broadened the range of conditions that can be diagnosed and tracked. The implications of these advancements are indeed substantial in the practical realm. Armed with these technologies, clinicians are now capable of capturing detailed images of the anterior segment in a non-invasive manner, leading to prompter and more precise diagnoses. This evolution, in turn, facilitates the deployment of more effective treatment strategies, thereby enhancing patient outcomes. Moreover, these advancements have charted new avenues for research. For instance, the application of AI in image analysis could conceivably lead to the creation of automated diagnostic systems, thus reducing the strain on clinicians whilst bolstering diagnostic accuracy. However, whilst these advancements have substantially enhanced our capabilities, they are not without their set of challenges. The integration of these technologies into clinical practice necessitates a significant investment, both in terms of time and resources. Additionally, further research is warranted to fully comprehend the potential and limitations of these technologies. The advancements in anterior segment imaging have notably improved our ability to diagnose and manage ocular conditions. As we persist in refining these technologies and as we forge ahead in developing new ones, we anticipate witnessing further improvements in patient care. The future of anterior segment imaging is indeed promising, and we eagerly anticipate the advancements that lie in wait.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are openly available upon request from the corresponding author.

COMPETING INTERESTS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

AUTHORS' CONTRIBUTIONS

L.B, and S.K.V: conception and design.
L.B, and S.K.V: analysis and interpretation of the data.
L.B, and S.K.V: drafting of the paper.
L.B, S.K.V, M.D, and Y.M revising it critically for intellectual content.
All authors gave their final approval to the version that will be published.

ACKNOWLEDGEMENTS

Not applicable.

DECLARATION

In accordance with the New Asian Journal of Medicine's guidelines (45), we confirm that AI chatbot assistance was not utilized at any stage during the preparation of this manuscript (46).

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