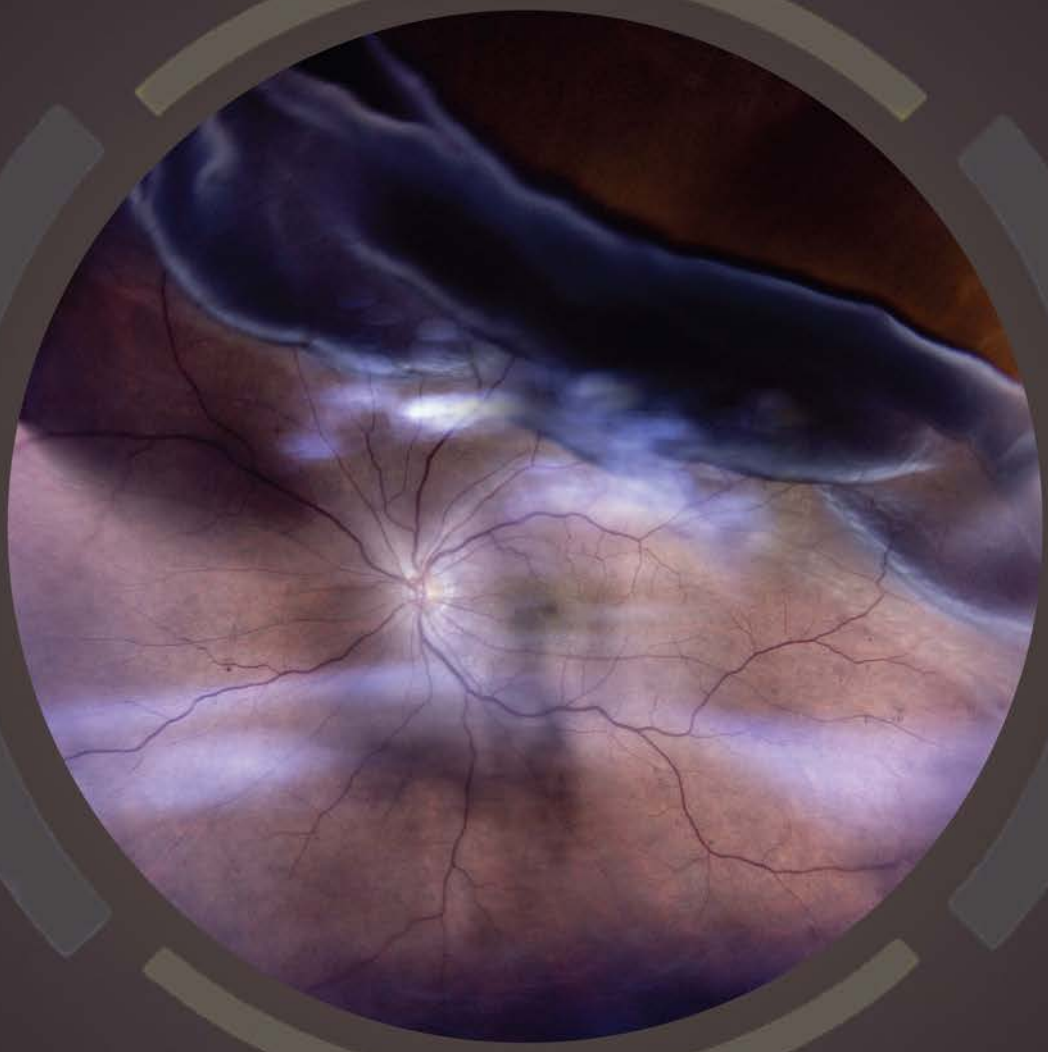
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HIGHLIGHTS

- Optimising Clinical Research in Ophthalmology in Kerala
- Eyes Wide Open: The Keratitis Spike in a recent measles outbreak in North Kerala- A cross sectional study
- Evaluation of AI generated responses of commonly asked ophthalmic queries
- Bearing the Brunt: A Case of Traumatic Enucleation in a Bear Encounter
- Retinal fairy lights: Benign flecked retina multimodal imaging

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Contents

Editorial

Catalyzing research-enabled clinical practice: What everyone can do
Lathika Vasu Kamaladevi 243

Guest Editorial

Optimizing clinical research in ophthalmology in Kerala: Expanding the clinician scientist pool and practitioner-researcher base
Praveen K. Nirmalan 246

Review Article

Paradigm shifts in management of paediatric myopia
Neena R. 251

Just A Minute Clinics

An anomalous course
Allen Mathew 258

Ophtha Courtroom

Intravitreal injections – Legal aspects
Ashok Nataraj, Mahesh Gopalakrishnan 260

Original Articles

Evaluation of the Arjun's Royal Air Force Rule device as a new tool for assessing near point of convergence and near point of accommodation
Ankit S. Varshney, Sanjay Mehta, Chetna Patel, Mahendrasinh D. Chauhan 262

A comparative study of corneal endothelial cell count in diabetics and nondiabetics in a tertiary care hospital in North Kerala
Chris Mathew Koshy, K. V. Raju, Irshad E, Lakshmi Cherungottil 273

Evaluation of artificial intelligence generated responses of commonly asked ophthalmic queries
Mahesh Babu, Boggarapu Sumanth, Shruthi Konatham 279

Comparison of superior and inferior laser peripheral iridotomies in primary angle closure disease – A randomized clinical trial
Mithun Thulasidas 284

Evaluating the impact of overnight orthokeratology on myopia control in patients with moderate myopia and astigmatism – A prospective study
Ankuj Tinna, Vikas Sharma, Anju Pannu, Gaurav Kapoor, Vinod K. Baranwal 290

The effect of induced fusional vergence on stereopsis
Swanandi S. Gawde, Rajvi Mehta, M. Purushottam Naidu, Rakesh Kaushal, Sankalp Rao 296

Pseudoexfoliation with cataract – Frequency, clinical profile, and challenges during cataract surgery
Ankita Jakhar, Anju Kochar, Nabab Ali Khan, Arif Khan, Shaheen Farooq, Manoj Kumari, Priyanka Sunda 301

Eyes wide open: The keratitis spike in a recent measles outbreak in North Kerala - A cross sectional study
Remya Edachery, Pushpangadan Peringeth, Preethi Nair, Binoo Divakaran 306

The Premiere

David Hubel and Torsten Wiesel: The duo that deciphered the visual brain
Sanitha Sathyan 311

Case Series

Eye: A window to the brain
Pooja Kumari, Harsha Pagad 315

Case Reports

Corneal lamellar patch graft: A remedy for hypotony maculopathy and leaking bleb
Devendra Maheshwari, Priya H. M., Madhavi R. Pillai, Techi D. Tara 319

Bearing the brunt: A Case of traumatic enucleation in a bear encounter
Malvika Sharma, Dhruval A. Khurana, Nancy Sharma 322

Vanishing act: The peril of a freely mobile foreign body hidden in the eyelid
Sonia Bhargav, Anshul Garg, Tarun Arora 324

Sudoriferous cyst near inner canthus of eye: A case report
Pramod K. Sahu, Akshita Sharma, Surbhi Gupta, Nitika Beri, Shimpa Kundan 327

Double trouble – A twin rarity in the same patient
Allen Mathew 330

A rare case of uniocular central retinal artery occlusion post laminotomy with lumbar decompression surgery
Sneha Punjabi, Divya Vaidya, Harsha Pagad, Archana Tadwalkar 334

An Eye for AI

Artificial intelligence in cataract surgery: Smart screening, precision planning, and cataract coaching
John Davis Akkara 339

Photo Essay

Retinal fairy lights: Benign flecked retina multimodal imaging
Thamana Salim, Aiswaria P, Harshali Kamat 344

An enigmatic partially sine-pigmento pupillary strand
Prateek Jain, Pooja Sah, Anshuman Pattnaik 349

Write it Right

How to Select an Indexed Journal for Publication?
Sruthi M. V 351

Journal Scan

Curated article summaries
Aswathy P 353

PG Capsule

Fellowship exams: A catalyst for excellence
Monisha Mohan, Remya Edachery, Bushra Thajudeen, Rakhi D. Cruz, Supreme Goel, Mini Ajith Mathew 355

KJO Videos

A closer look at the inferior oblique recession surgery
Remya Edachery 360

Management of Argentina flag sign in intumescent soft cataract
Balamurugan R, Gayathri R, Shubhangi S. N. Prasad, A. M. Raja 361

Letter to the Editor

SD-OCT in Sickle cell haemoglobinopathies
Pradeep Kumar Panigrahi, Rahul Bector 363

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Editorial Office
Dr Lathika Vasu Kamaladevi
MS(Ophth) DO FRCS(Glasgow)
Amala Institute Of Medical Sciences, Thrissur, Kerala, India.
Email: lathikamala.v@gmail.com

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Editorial

Catalyzing research-enabled clinical practice: What everyone can do

"Without data, you're just another person with an opinion." –W. Edwards Deming

In the evolving landscape of clinical practice, every patient encounter represents a potential contribution to scientific discovery. Yet, individual clinician experiences often do not translate into published evidence. So, there is an obvious need for practitioners to assume the dual roles of healthcare provider and knowledge creator. This transformative journey should begin as a self-driven change starting within every practitioner who desires to become a contributor, not just a consumer of scientific evidence. Upgrading ophthalmic clinics to research-enabled spaces can transform even modest practices into hubs of data-driven publication, thus democratizing clinical research. This editorial proposes a practical five-step framework to engage, equip, and empower clinician–researchers to integrate research habits, skills, and infrastructure within everyday ophthalmic practice.

STEP 1: INITIATE THE HABIT OF REGULAR SCIENTIFIC READING

The first step toward nurturing a research-enabled practice culture is cultivating the habit of regular scientific reading. Integrating short, focused reading sessions and dedicated reading time into daily work schedules encourages reflective practice, enhances clinical reasoning, facilitates evidence-based decision-making, and nurtures curiosity-driven inquiry—the bedrock of clinician-led research. Many Journals are now open access which means readers have free access to a large body of online scientific content, including short summaries and CME-linked updates, to support busy practitioners in keeping pace with emerging knowledge.[1,2] Case reports and photograph essays are a good place for beginners to start engaging seriously with scientific publications without being intimidated by statistical and research jargon. Regular reading of peer reviewed indexed journals also provides practitioners with valuable insights into contemporary publication trends and requirements, thus enabling identification of research gaps in their own practices, sparking independent investigations.

STEP 2: GET FAMILIAR WITH RESEARCH METHODOLOGY BASICS

Understanding the fundamentals of research methodology empowers clinicians to transform clinical observations into publishable scientific output. Key competencies include proficiency in using search engines and databases (PubMed, Scopus, Embase), manuscript writing and referencing tools (Mendeley, Zotero, EndNote), and data management and biostatistics software (SPSS, R, Jamovi). Equally important are sound principles of research ethics, including informed consent, data anonymization, and compliance with institutional review board (IRB) norms.

With the rapid emergence of artificial intelligence (AI) in research, clinicians are increasingly leveraging AI-driven tools for literature mapping (e.g., *Research Rabbit*, *Elicit*), automated referencing, and statistical assistance. Upskilling opportunities are plenty through workshops by academic institutions, instructional courses at conferences, and online, self-paced learning resources (e.g., The *Elsevier Researcher Academy*, *Clinical Research Methodology in Ophthalmology* series, *Museum of the Eye Research and Resources from the American Academy of Ophthalmology*). Webinars such as *Publish and Flourish* (*IJO–KJO*) and mentorship programs by *Harvard*, *AAO*, and *Women in Ophthalmology (WIO)* offer structured pathways for clinician–researchers to refine these essential skills.[3–6]

STEP 3: ACQUIRE CLINICAL DOCUMENTATION AND OPHTHALMIC IMAGING SKILLS

In ophthalmology, where disease expression and response to therapy are primarily visual, documentation extends far beyond written records. A research-enabled clinic should emphasize systematic capture, storage, and standardization of ocular photographs and imaging data. This includes fundus photography, slit-lamp imaging, anterior segment videos, and OCT scans, all of which contribute longitudinal visual data for both patient care and research.

For clinician–researchers, mastering basic ophthalmic photography and image quality control is essential. This

includes understanding illumination, focus, magnification, and image labeling standards to ensure reproducibility. Smartphone-based ophthalmic photography has revolutionized accessibility, enabling high-quality imaging in resource-limited settings. Low-cost devices [Table 1], such as Remidio Fundus on Phone (FOP), Phelcom Eyer, oDocs Nun, and D-EYE, allow retinal and anterior segment imaging with minimal training and cost.[7–9] Even simple DIY slit-lamp adapters using 3D-printed mounts can transform routine examinations into documented datasets. Academic institutions and resource rich practices may adopt integration with digital platforms and Cloud-based EMRs that further support secure image storage, annotation, and retrieval. Training opportunities in ophthalmic imaging, AI-assisted image analysis, and data anonymization are widely available through the skill transfer courses and workshops by professional bodies like AAO, AIOS, and other academic institutions. The goal for every aspiring clinical researcher, regardless of their practice setting, should be to upskill themselves in this respect to build a research-ready visual archive that fuels both clinical excellence and scientific discovery.

STEP 4: UPGRADE YOUR CLINIC TO A RESEARCH-READY SPACE

Building a research-ready clinical space requires integrating data systems, workflows, and processes that support ethical and efficient research. Essential elements include standardized data collection templates, secure cloud storage compliant with privacy regulations, and well-defined data retrieval systems. Clinics can adopt electronic health record (EHR) systems with research modules or structured data fields for automated export into spreadsheets or analytics tools. Maintaining a research logbook—digital or paper-based—helps track study ideas, ongoing data collection, and outcomes.

Creating this environment does not demand a large budget; it demands clarity and sense of purpose. Even small clinics can establish secure digital folders, assign basic roles for data entry, and use free project management tools (e.g., *Notion*, *Trello*, *Google Workspace*) for coordination. When such processes are normalized, clinical spaces become continuous engines of research—each patient encounter contributing to a growing body of practice-based evidence.

STEP 5: DEVELOP SOFT SKILLS FOR NETWORKING, COLLABORATION, AND COMMUNICATION

Clinical research thrives in collaborative ecosystems. Developing soft skills, particularly in communication, teamwork, and networking is vital for initiating partnerships and sharing ideas. Practitioners from outside academia have a lot to gain from finding and actively collaborating with likeminded research partners in academic institutions and centers of excellence having a robust research culture. Online platforms, like ResearchGate, LinkedIn, and ONE Network, enable clinicians to engage in scholarly discussions, access global resources, and seek coauthors or mentors. Participation in professional societies fosters opportunities for multicenter collaboration. Effective communication also extends to scientific writing and conference presentations, where clarity and persuasion determine impact. As clinician–researchers gain visibility, they contribute not only to science but also to development of a supportive culture of inquiry within their own institutions.[10,11]

CONCLUSION

Democratizing clinical research begins by nurturing scientific temper, clinical curiosity, and research skill enhancement in practitioners, irrespective of their practice settings. Further, transforming clinical spaces into research-ready environments embodies the philosophy that scientific discovery should not be confined to academic centers alone but should thrive wherever patients are being cared for. By adopting a five pronged action plan of regular scientific reading, foundational research training, ophthalmic imaging documentation, incorporating structured data workflow systems in practice and collaborative networking, clinicians engaged in patient care can generating high-quality,

Table 1: Low-cost ophthalmic imaging and documentation tools

Device/tool	Type	Key features	Clinical/research utility
Remidio FOP	Smartphone fundus camera	Non-mydriatic, teleophthalmology enabled	DR screening, field documentation
Phelcom Eyer	Smartphone fundus adapter	Portable, cloud integration	Remote fundus imaging, teaching
oDocs Nun	3D-printed adapter	Low-cost, fits most phones	Rural outreach, training
D-EYE	Smartphone ophthalmoscope	Compact, video capture	Anterior/fundus documentation
DIY Slit-Lamp Mount	3D-printed adapter	Simple, cost-effective	Routine anterior photography
ModMed/EHNOTE/eClinicalWorks Vision	Cloud EHR	Image integration, AI-ready	Data management & research archive

EHR=Electronic health record, Remidio FOP=Remidio Fundus on Phone, AI=Artificial intelligence, 3D=three-dimensional

practice-based evidence. These step-by-step, deliberate shifts in research culture to include individual clinician experiences can collectively accelerate the global movement toward equitable, evidence-based ophthalmic practice.

This editorial also marks my swansong and this issue, the final act of the current editorial team. Serving as Editor-in-Chief over the past two years has been a deeply gratifying, intellectually stimulating, and enriching experience. These years of focused effort have been marked by significant progress, reflected in the following *KJO* initiatives:

- Publication of six issues of *KJO*, including a focus issue on Glaucoma
- Introduction of more than a dozen new sections in the journal
- *Research to Reality*: A themed webinar series on evidence-based ophthalmic practice
- Two *KJO* sessions on research empowerment at *Drishti*
- *KJO* Online Quiz Series
- *KJO* Flash Cards
- A dedicated *KJO* channel on the KSOS website
- Launch of Digital *KJO*
- Introduction of *KJO* Appreciation Awards for outstanding reviewers and the most prolific author

It has been a privilege to contribute to the academic growth of our fraternity through these initiatives. I express my sincere gratitude to Dr. Thomas Cherian (President, KSOS 2023–24) for the opportunity to serve, and thank Dr Mahesh. G (President, KSOS 2024-25) and the KSOS team for all support extended. I am also indebted to our esteemed emeritus editors, Dr Sudha. V and Dr Smita Narayan, for their invaluable guidance. My sincere appreciation to Dr. Sujith Nayanar, KSOS website editor, whose seamless collaboration was instrumental in the success of many digital initiatives, particularly the *KJO* channel. I wholeheartedly thank Dr Praveen Nirmalan for his valuable contributions to the webinar series and related academic activities.

Finally, I acknowledge the efforts of my remarkable editorial team and appreciate their energy, commitment, and dedicated efforts which have made *KJO* grow from strength to strength. As I step down from the role of Editor-in-Chief, I do so with a smile on my lips and a song in my heart, knowing that I have given our journal my very best and, hopefully, left a few lasting imprints upon its hallowed pages. The future of *KJO* shines bright—I wish the incoming Editor and her team every success in taking this journal to even greater heights.

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Lathika Vasu Kamaladevi

Department of Ophthalmology, Amala Institute of Medical Sciences, Thrissur, Kerala, India

Address for correspondence: Dr. Lathika Vasu Kamaladevi, Department of Ophthalmology, Amala Institute of Medical Sciences, Thrissur, Kerala, India.
E-mail: lathikamala.v@gmail.com

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Guest Editorial

Optimizing clinical research in ophthalmology in Kerala: Expanding the clinician scientist pool and practitioner-researcher base

INTRODUCTION

Evidence is the foundational basis for the practice of modern clinical and preventive ophthalmology. High-quality clinical care, preventive strategies and efficient service delivery systems must be built on robust evidence to sustain and improve gains in eye care delivery outcomes. The translation of discoveries into better diagnostics, therapies, and preventive strategies depends on technological advances and the capacity of clinicians to investigate, analyze, publish and practice high-quality evidence. However, evidence is a dynamic construct that can change depending on multiple stressors, including environmental, lifestyle, personal or group risk behaviors, patient expectations of acceptable care outcome endpoints, compliance and comfort, besides the usual tropes of availability, affordability, and accessibility. The dynamic nature of evidence naturally requires a regular loop of feedback and action to maintain its high quality and for refinements as appropriate.

Kerala, often called the "health model of India," offers a fertile ground for ophthalmic research, with high literacy, strong healthcare utilization, and a rapidly ageing population. Lifestyle diseases and metabolic disorders are high and can result in the earlier onset of adult-onset chronic diseases.[1-7] Yet, despite high patient volumes and access to advanced technology in several centers, the state's ophthalmic research output in terms of inclusivity can be improved further to include individual clinician experiences (ICE).[8-12]

In this editorial, we present that the future of ophthalmic research in Kerala rests on two parallel but complementary pathways: (1) nurturing a cadre of clinician-scientists who can lead high-impact, hypothesis-driven, and translational studies, and (2) expanding a broader base of individual practitioner-researchers who contribute practice-based evidence from diverse clinical settings. Both groups are essential for a sustainable research ecosystem.

WHY DOES KERALA NEED A STRONGER OPHTHALMIC RESEARCH ECOSYSTEM?

Kerala's healthcare profile is unique due to several factors that include (but are not limited to),

- High life expectancy and ageing population, increasing the burden of cataract, glaucoma, lifestyle and metabolic disorder-related eye diseases, and age-related macular degeneration (AMD).
- An apparently strong health-seeking behavior, reflected in high rates of cataract surgery uptake and eye health care utilization.
- Robust private sector, with many ophthalmologists in solo or small-group practices across the state.

Despite this, the translation of these advantages into world-class research output has been limited. Research output

Praveen K. Nirmalan
Department of Research, AMMA Scans-AMMA Center for Diagnosis and Preventive Medicine Private Limited, Kochi, Kerala, India

Address for correspondence: Dr. Praveen K. Nirmalan, Department of Research, AMMA Scans-AMMA Center for Diagnosis and Preventive Medicine Private Limited, Kochi, Kerala, India.
E-mail: echasapt@gmail.com

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from Kerala in the form of case reports, retrospective series, cross-sectional studies, prospective studies or audits, randomized controlled trials, multicenter collaborations, population-based epidemiological studies, and translational studies can be further improved. The number of centers and practitioners contributing to research output can also be substantially increased from a primarily teaching hospitals and some academic private sector centers to include individual practitioners. A stronger research culture would not only improve local clinical practice but also provide globally relevant insights.

THE DICHOTOMY OF RESEARCH AND CLINICAL PRACTICE

A major limitation to integrating research into clinical practice is the dilemma of the scope of research and its impact on actual clinical practice. The term research can be broken down into two parts- re (signifying repeat) and search- or the repeated search for an answer. The repeated search emphasizes the dynamic nature of evidence and the need for constant appraisal of evidence. Research is therefore not limited to seeking answers to new questions but also includes reaffirming the validity, reliability, and relevance of existing information. New questions arise when existing information is found to be irrelevant or incomplete for optimal care.

A fundamental requisite for research is, therefore, a curiosity to observe and understand the current care pathways, their impact at the individual and group levels, and factors that affect outcomes. There are no answers to be sought if there are no questions that are asked and questions do not arise unless one observes what is happening. Clinicians are concerned about the impact on the individual patient and are constantly exploring ways to improve patient outcomes. This is a natural process of curiosity that is embedded in clinical or preventative care and forms the foundational basis for research. The curiosity exists already. It just needs to be encouraged, nurtured, and made meaningful.

If we carry this argument forward, research can be translated as an approach to satisfy one's curiosity to understand some questions:

- What is happening
- Why is it happening
- Who is affected (example: Differences between different demographic groups)
- Where is it happening (example: multiple levels from the macro to the micro)
- How is it happening
- What is being done
- What are the outcomes
- What are the gaps.

All these questions apply to every clinician *irrespective of* the setting of their practice. These are questions that are intuitively answered during the clinical and preventative care assessment and delivery process. The answers are assessed considering known knowledge, experience or evidence and appropriate care pathways are designed. All personnel involved in clinical care are thus engaging in some form of research daily in care delivery.

The dichotomy between clinical care and research is an artificial box that does no justice to the innate exploratory curiosity of the clinician to improve themselves for optimal care delivery.

THE DUAL STRATEGY: CLINICIAN-SCIENTISTS AND PRACTITIONER-RESEARCHERS

The ophthalmic research ecosystem cannot rely solely on a small number of academic centers. It must be broadened in scope and inclusivity to include every clinician providing care. The individual clinician experience (ICE) is important in the ecosystem of clinical research; however, it is often ignored in the context of research results. The generation of evidence from the few may not always translate into optimal health benefits for the many. Generated evidence must be tested in a diverse range of settings and contexts to ensure appropriate care for different groups of people, and ICE is an important part of this process.

Two groups need simultaneous development:

1. Clinician-Scientists: Ophthalmologists with structured research training, dedicated time, and mentorship who can lead hypothesis-driven studies, clinical trials, and translational research. They can be part of teaching institutes and tertiary care centers, and centers of excellence.
2. Practitioner-Researchers: Individual ophthalmologists in individual or group practice or district hospitals, or primary care who may not have extensive research training or advanced infrastructure but can contribute real-world data, clinical audits, multicenter studies on impact, and identify problems of relevance for clinical care at the ground level.

Both groups serve complementary roles: [Table 1].

Clinician-scientists drive innovation and complex research, forge new pathways of care, improve understanding of pathophysiologic basis at multiple levels and provide evidence for translational care.

Practitioner-researchers are equally important as they provide scale, diversity, and practice-based insights on what really works on the ground and is relevant for patients.

Practice-based researchers actually provide and complete the evidence feedback loop essential to refining and optimizing patient care.

DEVELOPING CLINICIAN-SCIENTISTS IN KERALA

Early exposure and training pathways

- Integrate research methodology, critical appraisal, and statistics into MBBS and postgraduate ophthalmology curricula. These must include formal structured training as well as providing a clinical environment that encourages and nurtures the natural curiosity of the budding or transitioning clinician. The focus must be on practical, pragmatic application or translation into practice of theoretical concepts rather than a theory-heavy approach. Understanding the interpretations and translation of statistics for clinical and preventive care is important. Improve the focus on critical thinking, encouraging a questioning approach.
- Restructure the MS/MD thesis or dissertation system by including postgraduate and undergraduate students in departmental research studies. Expecting a post-graduate student to come up with an original question of their interest within the first few months of residency is quirky, to put it mildly. Expecting them to complete a high-quality study within a limited timeframe is also not pragmatic. The conversion rates of residency dissertations to high-quality peer-reviewed publications are testament to this difficulty. Instead, it might be better to engage residents (and undergraduates) as investigators in departmental research studies using the opportunity to practically train them in structured pathways to seek answers to questions. The learning can be hands-on training on measuring variables, understanding confounders, bias, data documentation, privacy and ethical considerations, basic analysis, interpretation and presentation of data, how it is implemented into care delivery and for policy development. The process also allows for the continued integration and expansion of teaching programs to include clinicians who completed residency as practitioner-based researchers who continue to be part of a multicenter team.

Table 1: Comparison of clinician-scientists and practitioner-researchers

Attribute	Clinician-scientists	Practitioner-researchers
Training	Advanced research training (PhD, fellowships)	Workshops, modular short courses
Focus	Hypothesis-driven, translational, multicenter trials	Practice-based audits, real-world data
Setting	Academic institutions	Private practices, district hospitals
Output	High-impact publications, grants, policy-shaping evidence	Local data, applied evidence, multicenter registries, publications

Rapid advancements in technology translate to rapid shifts in the relevance of evidence. Skills to appraise evidence are of utmost importance for all care providers to differentiate appropriate information and misinformation. Replace the existing dissertation system with a more pragmatic skill-based appraisal that integrates making clinical decisions utilizing evidence appraisal as a foundation.

- Create MD-PhD/MS-PhD pathways in collaboration with universities to develop a pool of dedicated clinician-scientists.
- Formal mentorship networks linking young ophthalmologists with experienced researchers.
- State and university-level seed grants targeted at early-career ophthalmologists. Seed grants can be considered by the Ophthalmology Associations at the state and national level to answer questions of regional and national interest.
- Career advancement pathways that reward research productivity alongside clinical excellence.

BUILDING THE PRACTITIONER-RESEARCHER BASE

Simplifying entry into research

- Starting from the undergraduate and postgraduate levels, encouraging participation in research teams as co-investigators.
- Organize practice-based research workshops and hands-on mentoring through the Kerala Society of Ophthalmic Surgeons (KSOS) and district branches.
- Online courses and certification programs in clinical research and publication ethics. These must be integrated with pathways to join research teams on various care questions and develop their own locally relevant questions.

Infrastructure and ecosystem support

- Low-cost electronic health records with research-ready data fields.
- Shared biostatistics and data analysis support units at medical colleges accessible to private practitioners on payment of a fee. The fee can be used to improve the clinical care and research infrastructure of the department.
- Creation of live dashboards that can show impact of evidence translation into clinical practice in real time. Such dashboards can illustrate how each individual practitioner is contributing to the reduction of ocular morbidity at the district and state level.

Collaborative research networks

- Creation of a Kerala Ophthalmology Research Network (KORN) pooling data across practices in both the public and private sectors.
- Mentorship and guidance through KORN for all ophthalmologists in the state.
- Develop district-based subchapters of KORN. Encourage constant dialogues between clinician scientists and practitioners.
- Design multicenter studies on different eye conditions that can develop as long-term studies to inform practice and form a training ground for residents on acquiring and appraising evidence.
- Develop district-based data on various eye conditions and service gaps.

Ethics and regulatory facilitation

- Regional ethics committees serving clusters of practices.
- Simplified guidance documents on the Indian Council of Medical Research (ICMR) regulations for practitioners.

Challenges and solutions

- Create a roadmap with timelines to strengthen and broaden ophthalmic research in Kerala [Table 2].
- Time Constraints: Simplify data collection and promote collaborative studies.
- Prioritize quality of clinical care and emphasize quality checks, audits and evidence integration and appraisal at all levels of care.
- Research Quality: Provide methodological mentorship and peer review at the protocol stage. Shift focus from theory to hands-on applications and pragmatic, practical learning.
- Identify locally relevant questions: Focus on questions that impact care at the local level, building from feedback and inputs from practitioners on the ground.
- Ethical Hurdles: Streamline IEC approvals via pooled committees.
- Sustainability: Celebrate success stories and highlight the impact of research on clinical practice. Provide clear links from questions to answers to translation to clinical practice.
- Nurture long-term multidisciplinary and multi-setting teams
- Reshape mindsets from exclusivity to inclusivity. Consider all streams of curiosity-driven questions as important. All levels of care have their own unique set of problems that need to be addressed.
- Consider societal, community and patient impact of research outcomes and not just publication metrics. Clinical and public health research must lead to improved health outcomes and population metrics of eye care, including functional aspects and patient-reported outcomes.

Table 2: Proposed roadmap for strengthening ophthalmic research in Kerala

Timeframe	Key actions
Short-term (1-2 years)	Research workshops at district levels; restructure MS theses to become a pragmatic skills-based evidence acquisition, appraisal and interpretation tool (and not just a document submission system); create regional ethics committees
Medium-term (3-5 years)	Establish KORN; seed grants for early-career researchers; shared biostatistics support centers
Long-term (5-10 years)	Develop 20-30 clinician-scientists; 500+ practitioner-researchers; multicenter datasets on major eye diseases

CONCLUSION

Kerala stands at a pivotal moment in ophthalmology research. With its high patient load, advanced clinical practice, and robust healthcare infrastructure, the state has all the ingredients to become a national and global leader in ophthalmic research. Realizing this potential requires parallel investments: cultivating a cadre of well-trained clinician-scientists and empowering a large network of practitioner-researchers. Together, they can generate high-quality, locally relevant, and globally significant evidence. The initiative to scale and transform the ophthalmology research landscape in Kerala can be led by the professional organization of Ophthalmologists in Kerala (KSOS). Ophthalmologists in Kerala have a readily available medium to discuss and disseminate their research through the Kerala Journal of Ophthalmology and annual scientific conferences.

The vision for the next decade is clear: a Kerala where every ophthalmologist—whether in an academic institute or private clinic—sees research not as an optional extra, but as an integral part of improving patient care and advancing eye health.

Are we willing to shift gears?

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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Review Article

Paradigm shifts in management of paediatric myopia

ABSTRACT

The rising prevalence of pediatric myopia poses a major clinical and socio-economic burden. Understanding the genetic and environmental risk factors for progressive myopia has ushered in paradigm changes in the management of pediatric myopia. Among the various therapeutic options to control myopia, environmental modifications, low-dose atropine, peripheral defocus spectacles, multifocal contact lenses, and orthokeratology lenses have given promising results and many new emerging modalities of myopia control are being studied.

Keywords: Myopia control, pediatric/childhood myopia, pre-myopia, progressive myopia

INTRODUCTION

Myopia is a major cause of visual impairment; both in the developed and the developing world.[1-3] Myopia progresses rapidly from onset at an early age till early adulthood. Recently, there has been a surge in literature about the need to control progressive myopia. This review aims to have an analytical look at the real-world scenario of progressive myopia and offer evidence-based insights into the various therapeutic options available.

A literature search using PubMed for the keyword "Childhood/ Pediatric Myopia" with the following terms "prevalence," progressive myopia," "high myopia," etiology," "progression," "control," and "management," was made. The relevant articles including clinical trials, case-control studies, and review articles were analyzed.

THE GLOBAL BURDEN OF MYOPIA AND THE INDIAN SCENARIO

Pediatric myopia needs to be considered as an emerging global pandemic, given its rapid increase in prevalence. It is projected that by 2050, half of the global population is going to be myopic, with one-fifth going to have high myopia (myopia >6D).[4] Prevalence of myopia varies with country, age, and ethnic group and it is as high as 70-90% in East Asia,[5-10] particularly, in countries like Japan, South Korea, Singapore, Taiwan, Hong Kong, and China though much lower rates have been reported from South Asia and India.

Myopia prevalence in children was noted to be 4.1% in a rural population in South India[11] in contrast to an overall prevalence of 7.4% in an urban population in North India.[12] There was an age-related shift in refractive error from hyperopia in young children (15.6% in 5 year olds) towards myopia in older children (10.8% in 15 year olds).[12] The prevalence of myopia in urban school children in Delhi showed an increase to 13.1% with greater prevalence in private schools compared to government schools ($P < 0.001$), in girls vs. boys ($P = 0.004$), and among older (>11 years) children ($P < 0.001$).[13]

UNDERSTANDING MYOPIA JARGON[14]

1. Myopia: Spherical Equivalent (SE) less than −0.50 D when ocular accommodation is relaxed.

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Neena R.
Department of Paediatric Ophthalmology, Strabismus and Neuro-Ophthalmology, Giridhar Eye Institute, Kadavanthara, Kochi, Kerala, India

Address for correspondence: Dr. Neena R.,
Department of Paediatric Ophthalmology, Strabismus and Neuro-Ophthalmology, Giridhar Eye Institute, Kadavanthara, Kochi, Kerala, India.
E-mail: neenamed@gmail.com

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2. Progressive myopia: myopia that worsens year after year
3. High myopia: myopia of −6.00 D or higher
4. Rapid progression: ≥0.75-1 D/year.

THE IMPACT OF PROGRESSIVE MYOPIA

Each additional diopter (D) of myopia increases the risk of open-angle glaucoma, by 20%, posterior subcapsular cataract by 21%, retinal detachment by 30%, and myopic maculopathy by 58%.[15] The economic burden of myopia increases with its early onset and long duration. With increasing myopia prevalence, there is a mounting global cost of myopia correction in the form of spectacles, contact lenses, and refractive procedures. The annual prevalence-based direct costs for myopia were found to range from US $14–26 in the United States to US $56 in Iran and US $199 in Singapore per capita.[16] Not to mention the negative impact both corrected and uncorrected myopia has on a person's quality of life such as activity limitation as well as social and emotional well-being.[17] Thus, besides being a major cause of visual impairment, myopia is also a significant socio-economic burden and a public health concern!

DECODING THE PATHOPHYSIOLOGY OF MYOPIA

Failure of emmetropisation due to an uncoupling in the process of axial elongation and flattening of the corneal and lens curvature causes escalated axial growth and arrest of lens thinning by disruption of the equatorial expansion, leading to myopia.[18] The Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) Study, an observational cohort study of ocular development and myopia onset, found that an accelerated axial elongation (up to three times faster) was noted in myopic subjects 1 year before and after the onset of myopia, making axial growth a major determinant of the refractive status of the eye.[19] Peripheral hyperopic defocus has been implicated to be the stimulus for axial length elongation and myopia progression.[20] The role of other mechanisms such as accommodation lag that leads to hyperopic defocus has also been proposed.

ETIOLOGY

Myopia is the result of the interplay of complex genetic and environmental factors. Studies have shown that the number of myopic parents and monozygotic twins has a greater correlation with myopia than dizygotic twins.[21,22] Prolonged intense near work, reduced outdoor activities and urbanization are the major environmental factors responsible for myopia. Premature and low-birth-weight infants have also been found to be more at risk of developing myopia.[23,24]

UNDERSTANDING THE RISK FACTORS FOR MYOPIA ONSET AND PROGRESSION

1. Baseline refractive error: Less hyperopic/more myopic refractive error at baseline was found to be the most important risk factor predictive of juvenile-onset myopia by Zadnik *et al*.[25]
2. Early age of onset of myopia: Onset of myopia at a younger age is associated with a higher rate of progression and greater risk of myopia-related complications.[26]
3. Parental myopia: Children with two myopic parents have a threefold or more risk of developing myopia compared to children with no myopic parent.[27]
4. Visual environment: Sustained near work at a close reading distance for increased hours is an important risk factor for juvenile-onset myopia.[28] Reduced outdoor time, less physical activity, and lack of exposure to green spaces and natural daylight together with an excess of near work in children were found to be the potential environmental and behavioral risk factors for myopia progression in a Singaporean school-based study.[29] An association between increased screen time due to growing dependency on digital devices during the COVID-19 outbreak and the worsening or development of myopia was noted in various studies.[30,31]
5. Accommodation anomalies: Accommodation lag has been thought to be responsible for hyperopic defocus.
6. Ethnicity: East Asians and South Asians are more likely to be myopic with rapid progression.
7. Gender: Earlier onset of puberty in girls is associated with increased axial length elongation.

PRE-MYOPIA

The concept of pre-myopia has been introduced by the International Myopia Institute (IMI) to identify children with a greater likelihood of development of myopia.[32] Pre-myopia has been defined as "a refractive state of the eye of ≤ +0.75 D and ≥0.5 D in children by using cycloplegic refraction where the combination of baseline refraction, age, and other quantifiable risk factors predispose to the development of myopia."

WHY SHOULD WE PREVENT MYOPIA PROGRESSION?

Early onset of childhood myopia is associated with high myopia in adult life. Incidence of retinal detachment increases with the degree of myopia (0.015% in >4.74 D myopia, 0.07% in >5.00 D myopia, and 3.2% in >6.00 D myopia).[33] The risk of developing macular choroidal neovascularization is 4-fold for 3.00 to 4.00 D myopia and 9-fold for 5.00 to 6.00 D myopia. The ultimate goal of myopia control therapy

is to slow myopic progression during the years of most active eye growth thus minimizing the sequelae.

STRATEGIES FOR MYOPIA MANAGEMENT AND CONTROL

Different modalities include environmental, pharmacological, and optical options.

1. **Environmental:** Increasing outdoor time is an important method in controlling myopia. Possible theories which explain this include retardation of eye growth by the light towards the end of the UV spectrum, stimulation of dopamine by high luminance which prevents axial growth, supply of Vitamin D, decreased accommodative demand, and increased depth of focus and hence retinal image quality due to small pupil in light. In a large meta-analysis of five randomized control trials (RCTs) with 3014 subjects, outdoor time was associated with fewer new myopia cases (pooled risk ratio [RR], 0.76; 95% confidence interval [CI], 0.67–0.87), slower myopic shift in terms of refractive error (pooled mean difference [MD], 0.17 D; 95% CI, 0.16–0.18 D) and smaller change in axial length (pooled MD, −0.03 mm; 95% CI, −0.03 to − 0.03 mm).[34]
2. **Pharmacological:** Various pharmacological options include topical application of Pirenzepine, and 7-methyl xanthine but results with topical low-dose atropine have been most promising.

From ATOM to LAMP, what we know about LOW DOSE ATROPINE (LDA):

- Wells in the 19th century, first reported the use of atropine to slow myopia progression. It has been consistently found to regulate myopic progression with a good safety profile.

Mechanism of action

- Atropine blocks muscarinic receptors in the ciliary muscle, retina, and sclera thus preventing scleral remodeling. It also dilates the pupil which increases the exposure to UV rays thus hardening the collagen and thereby minimizing chances for axial elongation.
- ATOM 1; a randomized, double-masked, parallel-group, placebo-controlled, study reported that over 2 years, Atropine 1% eye drops slowed myopia progression by 77% with no axial elongation in Asian children with low-moderate myopia,[35] but not without the side effects of photophobia, blurred near vision and increased risk of ultra-violet light exposure. ATOM 2; a five-year clinical trial comparing the various concentrations of atropine concluded that a low concentration of 0.01% atropine had a better treatment-to-side effect ratio with fewer side effects and rebound after drop cessation but less effect on axial length increase.[36] LAMP 1 study showed that 0.05% atropine was most effective in controlling myopia progression and axial elongation over 1 year.[37] LAMP 2 confirmed that 0.05% remained the optimal concentration among the studied atropine concentrations in slowing myopia progression with a 64.5% efficiency over 2 years with no considerable axial length increase.[38] LAMP 3 concluded that continued atropine treatment had a better effect across all concentrations against washout and 0.05% atropine remained the optimal concentration with the least rebound over three years in Chinese children.[39]

The Indian Experience:

In a multicentric randomized trial by Saxena *et al*.,[40] 1-year data proved the efficacy of 0.01% atropine drops in reducing myopia progression in Indian children having mild to moderate myopia without any significant effect on axial length (AL) elongation. As per the pan-India multicentre study i-ATOM, myopia progression significantly decreased to −0.27 ± 0.14 D at the end of the first year and −0.24 ± 0.15 D at the end of the second year ($P < 0.001$).[41] Younger children ($P < 0.001$) and higher baseline myopia ($P < 0.001$) were associated with greater myopia progression and poor treatment response ($P < 0.001$ for both). In the Phase 1 clinical trial in children attending a tertiary eye care center in South India, low-dose atropine (0.01%) therapy was able to reduce the progression of myopia in the study group, compared to the controls with good tolerance and no change in the vision-related quality of life.[42]

A large meta-analysis of 12 RCTs and 15 cohort studies involving 5069 children aged 5–15 years on the efficacy of varying doses of topical atropine in slowing myopia progression found the weighted MD in myopia progression between atropine and control groups were 0.73 D, 0.67 D and 0.35 D per year for high dose (0.5-1.0%), moderate-dose (>0.01 to <0.5%) and low-dose (0.01%) atropine respectively.[43]

Thus, topical atropine has displayed a significant dose-dependent effect on both refractive change and axial elongation, with higher concentrations of atropine resulting in less myopia progression and less axial elongation. The ideal dosage for the atropine administration remains a topic of debate.

3. Optical: Conventional Optical strategies include single-vision spectacles and soft/Rigid Gas Permeable contact lenses but they are ineffective in control of myopia progression.

Optical options for progressive myopia: How do they work[44]?:

Most optical options have been designed to manipulate key visual signals that regulate eye growth and refractive state: defocus [Figure 1] and contrast.

The various optical options currently available are:

1. Bifocal/Multifocal spectacles
2. Peripheral Defocus Myopia controlling Spectacle lenses (DIMS/HALT/CARE)
3. Diffusion Optics Technology (DOT) Spectacle Lenses
4. Soft bifocal/Multifocal CL
5. Extended Depth of focus Contact Lenses (EDOF)
6. Orthokeratology (OK) Contact Lenses (CL)

a. *Bifocal/Multifocal Spectacles with Progressive Addition Lenses (PALs):* Were thought to be useful for children with an accommodative lag as they aimed to reduce both accommodation lag and peripheral hyperopic defocus. However, the COMET study,[45] a prospective multi-centric clinical trial comparing the 5-year efficacy of PAL with +2 D add versus single vision lenses, found that PALs were not clinically effective at slowing myopia progression, with a difference of only 0.13 D noted between the two groups.

b. *Peripheral Defocus Spectacles (DIMS/HALT/CARE)*

   i. Defocus Incorporated Multiple segments (DIMS) technology works on the concept of creating simultaneous defocus, during both distance and near viewing - one plane on the retina due to the single vision zone(s) of the lens, and one plane creating myopic defocus due to the +3.50 D defocus lenslets. In the two-year randomized clinical trial on Hong Kong Chinese children aged 8-13 years with myopia −1.00 to −5.00 D and ≤1.50 D astigmatism, DIMS lenses showed around 50% refractive and 60% axial length efficacy, with an absolute effect of 0.44 D lower refraction and 0.34 mm less axial elongation compared to single vision lenses.[46]

   ii. Highly Aspherical Lenslet Target (HALT) introduces the concept of volume of myopic defocus. Here, light rays are deviated continuously in a three-dimensional manner that creates a volume of myopic defocus. The results of a one-year clinical study on Chinese children aged 8–13 years with myopia of −0.75 D to −4.75 D; randomized into either single vision, highly aspherical lenslet (HAL), or slightly aspherical lenslet (SAL) spectacle lenses, demonstrated around 70% refractive and 60% axial length efficacy for HAL and 40% refractive and 30% axial length efficacy for SAL in Chinese children with an absolute effect of 0.54 D less myopia/0.23 mm less axial elongation for HAL wearers in 1 year.[47]

   iii. Cylindrical Annular Refractive Elements (CARE) consist of alternating defocus and correction zones in a ring-like pattern on the front surface, expanding towards the periphery of the lens. In a randomized controlled trial, looking at the one-year myopia control efficacy of cylindrical annular refractive element spectacle lenses versus single vision lenses; Liu *et al*.[48] found that adjusted 1-year myopia progression was -0.56 D for CARE and -0.71 D for single-vision spectacle lenses. The difference in progression was 0.14 D (95% CI, -0.04 to 0.32) for CARE versus single vision.

c. *Diffusion Optics Technology (DOT) Spectacle Lenses:* Abnormally high retinal contrast signaling has been reported to be associated with progressive myopia[49] and mild reductions in retinal contrast via novel spectacle lenses (Diffusion Optics Technology; DOT, Sight Glass Vision, Texas, USA) have shown promise in slowing eye growth and myopia progression. The 4 years multicentre,

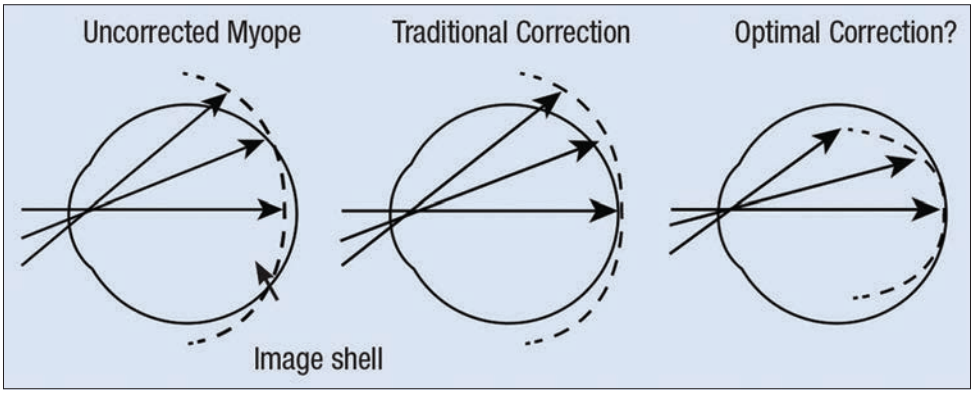


Figure 1: This picture illustrates myopic and hyperopic defocus, and the possible target for ideal correction. Image: Adapted from Smith EL. Optom Vis Sci 2011;88:1029-14[44]

randomized, controlled, double-masked trial comparing DOT (0.2) spectacle lenses and standard single vision control lenses in 256 North American children aged 6–10 years showed demonstrated superiority of DOT (0.2) over the control in both axial elongation and myopia control: with a difference between them of −0.13 mm for AL ($P = 0.018$) and 0.33 D for SE ($P = 0.008$) in first 3 years and −0.05 mm for AL ($P = 0.038$) and 0.13 D for SE ($P = 0.043$) in 4th year.[50]

d. *Soft Bifocal/Multifocal Contact lens:* Uses the technique of changing the center distance design to reduce the myopic progression. Different designs incorporating dual focus, multifocal, and extended depth of focus (EDOF) designs have been in use. Myopia progression was noted to be attenuated by 37%-38% in the multifocal contact lens group as compared to the single-vision contact lenses and there was a significant reduction in axial elongation in these subjects.[51] A multicentric, randomized controlled but non-masked trial reported a 59% reduction in mean cycloplegic spherical equivalent refractive error and a 52% reduction in axial elongation at 3 years with the MiSight; a dual-focus contact lens compared with spherical contact lens.[52] Extended Depth of Focus Contact Lenses[53] (EDOF) uses neuro-focus optics technology where it creates an extended depth of focus enabling around 2 times clearer vision compared to conventional glasses at all distances. Through manipulation of higher-order aberrations, the EDOF soft CLs aim to reduce the image quality for points posterior to the retina and thereby slow axial elongation. A 2-year clinical study of Caucasian children using EDOF soft CLs showed a reduced axial elongation and myopia progression compared to the use of distance single-vision spectacles (mean change in SE/AL in the CL group of –0.62 ± 0.30 D/0.37 ± 0.04 mm compared to –1.13 ± 0.20 D/0.66 ± 0.03 mm in the spectacles group with $P < 0.001$).[53]

e. *Orthokeratology (OK) Contact Lenses*[54]: These lenses are worn overnight and the idea behind these lenses is to flatten the central zone of the cornea surrounded by cornea steepening. The technique underlies inducing peripheral myopic defocus in both vertical and horizontal meridians thereby enabling reduction in accommodation lag and improvement in accommodative facility. OK contact lenses are associated with less axial elongation compared with controls after 1 year (standardized MD [SMD], −0.857 mm; 95% CI, −1.146 to −0.568 mm; $P < 0.001$) and this myopia control effect lasted up to 2 years (SMD, −0.701 mm; 95% CI, −1.675 to −0.272 mm; $P < 0.001$).[54] Despite being the only myopia treatment that allows children to see clearly without the need for any correction during the day and preferable in children who are active in sports; poor compliance, high cost, and risk of microbial infection have been major deterrents to its acceptance.

AVAILABILITY OF VARIOUS TREATMENTS:

Currently low dose atropine (0.01%), Peripheral Defocus Spectacles (DIMS/ HALT/ CARE), and Orthokeratology contact lenses are available in India and rapid myopia progressors may be put on a combination therapy for better control.

WHEN TO INITIATE ANTI-MYOPIA TREATMENT[14]?

The recommendations are:
1) Progression of myopic refractive error ≥ −0.50 D/year
2) Younger age of onset
3) Higher Baseline Myopia
4) Parental history of myopia.

If there is no evidence of myopia progression with minimal risk factors, observation and follow-up with regular cycloplegic refraction is sufficient.

(Evaluated in children 4–6 years up to 12–16 years of age, hence use of treatment options should be restricted to this age group[14])

WHAT DOES THE FUTURE HOLD FOR CONTROL OF MYOPIA?

1. **Low-Level Red Light (LLRL) Therapy:** Jiang *et al*.[55] proposed delivering light directly to the retina for short periods, through a device that emits red light at a wavelength of 650 nm as a method to control myopia. Their data; through a prospective multicenter trial, showed that low-level exposure to red light therapy is effective, safe, and highly acceptable to users. However other studies[56] have advised caution in using LLRL therapy for myopia in children until safety standards can be confirmed.
2. **Virtual Reality-Based Visual Training (VRVT):** In a randomized control trial among children aged 8–13 years with low myopia, nightly use of VRVT resulted in slowing myopia progression, and further trials are ongoing.[57]
3. **The Study of Genetics and Genetic Variants:** Preliminary studies have shown that genetic variants could influence the results of myopia control therapy and a detailed genetic mapping of the polymorphisms associated with myopia may be performed to improve the strategies

and interventions that are currently in place to slow the progression of myopia.

4. **ATOM 3 to Prevent the Onset of Myopia in Young Children Even Before it Starts, or Control it Just When it is Starting:** The Singapore National Eye Centre is conducting a study (ATOM3) to evaluate if low dose atropine eye drops (0.01%) can potentially prevent the onset of myopia in children at risk of myopia 5–9 years old with at least 1 parent with moderate myopia/with no myopia, but are at a pre-myopic state (+1.00 to −0.50 D) and in controlling the progression of low degrees of myopia in children at risk (young children with early low levels of myopia (−0.50 to −1.50 D) with a family history of moderate myopia).

CONCLUSION

With pediatric myopia poised to be the next global epidemic, the need of the hour is to act, assess risk factors, discuss options and decide treatment and control measures based on evidence, patient's risk factors and safety. The future of myopia control lies in recognizing it as a public health crisis, creating awareness, bringing about changes including effective regulation of near work and outdoor time and promoting a healthy visual environment for the child.

Author contributions

NR: Design, definition of intellectual content, literature search, clinical studies, experimental studies, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, manuscript review, guarantor.

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An anomalous course



Figure 1: Right eye

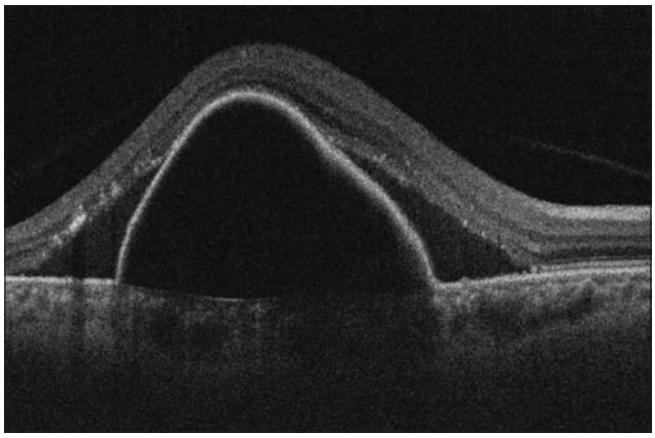


Figure 2: Optical coherence tomography of the right eye

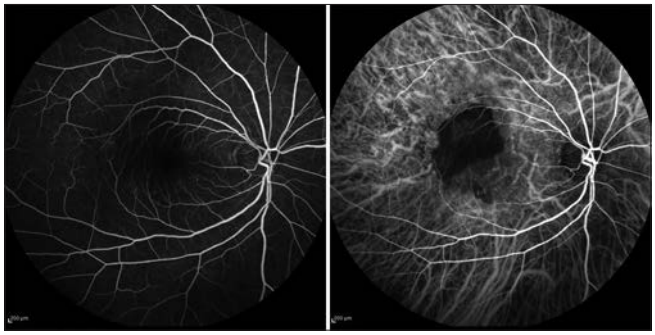


Figure 3: Fluorescein angiography and indocyanine green angiography of the right eye

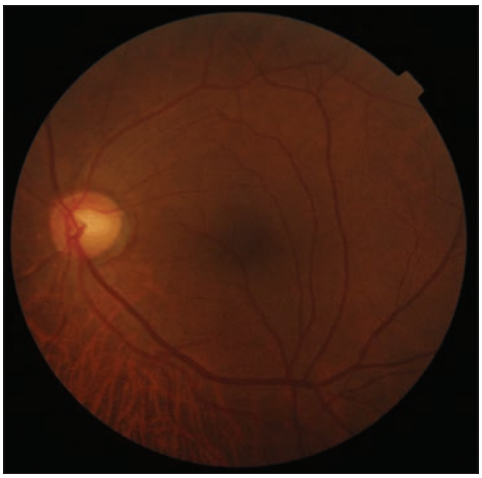


Figure 4: Left eye fundus

CLINICAL SCENARIO

A 72-year-old female presented with defective vision in her right eye (RE). On examination, her Snellen best corrected visual acuity was counting fingers at 1 meter in the RE and 6/6 in the left eye (LE). The anterior segment of both eyes was within normal limits, and pupils were bilaterally brisk. Her RE fundus [Figure 1] showed an elevation of the deep retina with associated hard exudates, and the optical coherence tomography (OCT) of the same showed a large dome-shaped detachment of retinal pigment epithelium with subretinal fluid [Figure 2]. Fluorescein angiography (FA) and indocyanine green angiography (ICGA) of the RE [Figure 3] showed multiple hyperfluorescent spots along the choroidal vessels, which were suggestive of polypoidal choroidal vasculopathy (PCV). Her LE fundus is shown in Figure 4.

Question: What abnormality do you observe in the fundus of her LE?

Answer: Congenital retinal macrovessel (CRM).

DISCUSSION

CRM is an aberrant retinal vessel that crosses the macula and supplies or drains the macula superior and inferior to the horizontal raphe.[1] These vessels originate from the mesenchyme at about the 15th to 16th week of gestation, when differentiation of retinal vessels into arteries and veins occurs.[2] It was first described by Mauthner in 1869, and the reported prevalence is 1 in 200,000.[2] It originates commonly from veins but occasionally may arise from arteries or from both arteries

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and veins.[3] Unlike normal macular vessels, these vessels are of a larger caliber and course across the horizontal raphe. Patients are usually asymptomatic with normal vision, and the disease is usually unilateral. A decrease in visual acuity in the eye affected by CRM could be due to a multitude of causes, such as CRM crossing the foveola, thickening, and distortion of the macular architecture due to CRM, foveal cyst, foveal ectopia, macular exudates, or hemorrhage, serous macular detachment, and due to a relative angioscotoma.[4] CRM is also known to be associated with cerebral venous malformations.[5]

The patient in the given clinical scenario had an incidentally detected CRM in the LE. OCT of the LE [Figure 5] shows a normal fovea, but multiple areas of vascular shadowing due to the CRM coursing through the superficial layers of the retina can be observed. Her LE OCT angiography [Figure 6], FA, and ICG [Figure 7] clearly demonstrate the coursing CRM, which is seen to originate from the inferotemporal vein and travel toward the fovea. Another peculiarity is that she has multiple other CRM that do not course toward the fovea but instead form a communication between the superotemporal and inferotemporal vascular arcade in the LE.

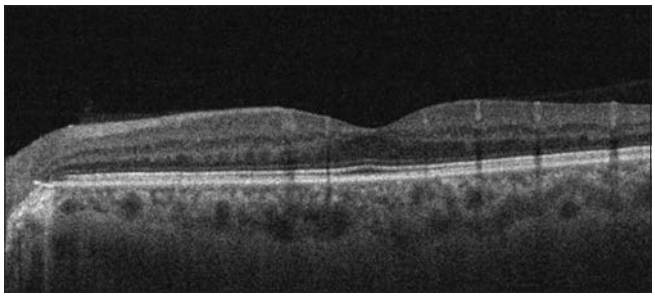


Figure 5: Optical coherence tomography of the left eye

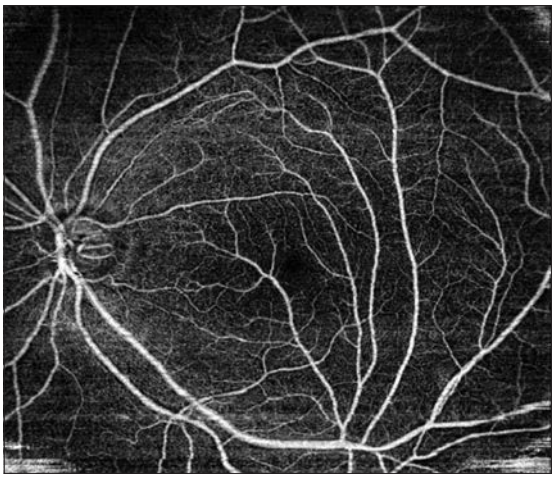


Figure 6: Optical coherence tomography-A of the left eye



Figure 7: Fluorescein angiography and indocyanine green angiography of the left eye

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Conflicts of interest

There are no conflicts of interest.

Allen Mathew

Department of Ophthalmology, Government Medical College, Kollam, Kerala, India

Address for correspondence: Dr. Allen Mathew, Kavumpurathu House, Koovapally P. O., Kanjirapally, Kottayam - 686 518, Kerala, India.
E-mail: allenmathew23@gmail.com

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Intravitreal injections – Legal aspects

Intravitreal injections have become commonplace in ophthalmic practice nowadays. The total number of global intravitreal injections in 2016 was estimated to be over 20 million, with numbers increasing over time. Post-injection risks of intravitreal injections can be vision-threatening and require prompt diagnosis and treatment.[1]

The significant impact of these adverse events on a patient's quality of life can lead to legal actions, with an ever-growing number of malpractice claims for huge compensation. In ophthalmology, between 5–10% of physicians face a malpractice claim each year.[1]

Out of the several cases of medical negligence decided by the NCDRC from 2002 to 2018, about 3% of cases were related to ophthalmology. A total of 73.3% of the alleged cases of medical negligence in ophthalmology were proved, and compensation for the cases ranged between Rs. 200,000 and Rs. 10 million.[2]

Judgment was given against the ophthalmologist even for a complication well-reported in the published literature. For example, an ophthalmologist in Gujarat was asked by the consumer court to pay Rs. 100,000 compensation to a patient for vitreous hemorrhage following an anti-VEGF (Avastin) injection in the patient's eye, leading to temporary blindness.[3]

In another case reported from Punjab (2017), the State Consumer Disputes Redressal Commission passed a judgment against the hospital and the ophthalmologists for their medical negligence in the treatment of the patient and failure to produce the pertaining medical records.[4] It was alleged that the ophthalmologist could not prove that adequate measures were taken to control diabetes before the procedure that led to eye infection.

WHAT IS THE REMEDY? SALIENT POINTS

- Create a protocol that puts multiple checks in place. The eye to be operated on should be marked in the ward itself and confirmed in the operation theater. In case of intravitreal injection, it is also important to double-check which injection must be administered to the eye. It is a good practice to ask your staff to read out the patient's name, the eye to be injected, and what injection is to be given just before the procedure.
- Injections are given under topical anesthesia. It is always better to avoid unnecessary talk in the operation room, which may create inadvertent confusion regarding the procedure in the mind of the patient.
- Cleaning of the eye using povidone iodine, use of adhesive drapes, and local application of povidone iodine both before and after the procedure help to avoid endophthalmitis in most patients.
- A proper consent, preferably in the patient's own language, clearly mentioning the complications of the procedure, should be taken. In an ideal situation, the consent must be written by the patient himself/herself. If it is a printed consent, the patient can be asked to write that he has read and understood what is printed, in his own handwriting at the end.
- Documentation is also very important. Investigation reports, treatment data, and the course of treatment should be documented with the time and date. Simple things like instillation of povidone iodine drops before and after the procedure should be entered in the case sheet.
- Finally, clear communication with the patient and relatives before and after the procedure is vital. A good doctor–patient relationship is the foundation of efficient service delivery, as effective communications help both the doctor and the patient to understand each other's perspective. This ultimately minimizes the chances of mishaps leading to legal suits.[5]

TAKE HOME MESSAGE

Protocol-based practice, prompt documentation, and good doctor–patient communication are key factors that can minimize litigation following intravitreal pharmacotherapy.

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Conflicts of interest
There are no conflicts of interest.

Ashok Nataraj, Mahesh Gopalakrishnan[1]
Department of Vitreo Retina, Precise Eye Care, Trivandrum, [1]Department of Vitreo Retina, Giridhar Eye Institute, Kochi, Kerala, India

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Address for correspondence: Dr. Ashok Nataraj, Precise Eye Care, Trivandrum, Kerala - 695 033, India.
E-mail: drashok.eye@gmail.com

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Original Article

Evaluation of the Arjun's Royal Air Force Rule device as a new tool for assessing near point of convergence and near point of accommodation

ABSTRACT

Context: The Arjun's Royal Air Force Rule (ARAF) device is a newly developed digital tool designed to assess Near Point of Convergence (NPC) and Near Point of Accommodation (NPA). It aims to address limitations of the traditional Royal Air Force (RAF) rule by enhancing precision, comfort, and clinical usability. **Aims:** To evaluate the accuracy, efficacy, and user satisfaction of the ARAF device compared to the RAF rule in assessing NPC and NPA. **Settings and Design:** A prospective observational study was conducted at a tertiary eye care center, involving 56 participants with a mean age of 21.55 ± 5.36 years. **Methods and Material:** Participants underwent NPC and NPA assessments using both the ARAF device and the RAF rule. The order of device usage was randomized, with three trials per device for each participant. Subjective feedback on comfort and usability was collected using a structured questionnaire. **Statistical Analysis Used:** The Wilcoxon Signed Rank Test was used for statistical comparison, with significance set at $P < 0.05$. **Results:** The ARAF device demonstrated statistically significant improvements in measurement precision for NPC ($P = 0.004$) and NPA (monocular: $P < 0.01$; binocular: $P = 0.003$) compared to the RAF rule. Effect sizes indicated a moderate impact favoring the ARAF device. Subjective feedback showed 53.57% of participants rated the ARAF device as more comfortable and user-friendly, highlighting its ergonomic design and automated digital readout as advantages. Preference for the RAF rule was limited to 28.57%, while 17.85% expressed no preference. **Conclusions:** The ARAF device provides a precise, reliable, and user-friendly alternative to the RAF rule for NPC and NPA assessments. Its automation enhances diagnostic accuracy, reduces examiner fatigue, and improves patient comfort, making it valuable for high-throughput clinical settings and in pediatric or geriatric care. Further studies with diverse populations are recommended to validate these findings.

Keywords: ARAF device, binocular vision assessment, digital optometry tools, near point of accommodation, near point of convergence, RAF rule

INTRODUCTION

Binocular vision is a complex visual function essential for spatial orientation, depth perception, and reading comfort. It requires the coordinated effort of both eyes to maintain a single, clear visual image, particularly when focusing on objects at varying distances.[1] Two critical components of binocular vision assessment are the Near Point of Convergence (NPC) and the Near Point of Accommodation (NPA), which evaluate a person's ability to converge their eyes on a close target and adjust focus for clear vision, respectively.[2] NPC measures the closest point at which both eyes can maintain single vision, a critical metric in diagnosing conditions like convergence insufficiency, which can lead to eye strain, headaches, and blurred vision during close work. NPA, However, assesses

Ankit S. Varshney, Sanjay Mehta, Chetna Patel, Mahendrasinh D. Chauhan

Department of Optometry, Shree Bharatimaiya College of Optometry and Physiotherapy, Surat, Gujarat, India

Address for correspondence: Dr. Ankit S. Varshney, Department of Optometry, Shree Bharatimaiya College of Optometry and Physiotherapy, B/h Big Bazaar, Vrudhashram, Vesu Road, Surat, Gujarat - 395 007, India
E-mail: ankitsvarshney@yahoo.com

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the closest point at which the eyes can focus clearly, with deficiencies often signaling accommodative insufficiency or presbyopia.[3,4]

Traditionally, the Royal Air Force (RAF) rule has been the standard tool for measuring NPC and NPA. This manual instrument uses a target on a calibrated rod that an examiner moves toward or away from the patient until the point of double or blurred vision is noted. Despite its widespread use, the RAF rule has inherent limitations that can affect measurement reliability.[5,6] For instance, measurements rely heavily on subjective patient feedback and the examiner's skill and consistency, introducing potential variability in results. Sharma *et al*. (2016)[4] and Neethu *et al.* (2015)[7] highlighted that variations in NPC and NPA measurements could arise from differences in examiner technique, patient cooperation, and fatigue. Such variability poses a significant challenge in clinical diagnosis, especially for sensitive cases requiring precise measurements.

To address these limitations, digital devices have been developed to introduce automation, minimize subjective input, and enhance measurement precision. In many areas of healthcare, such as audiology and cardiology, digital devices have been shown to improve diagnostic accuracy by reducing examiner-related variability and offering real-time data collection (Menjivar, 2017).[8] In optometry, the need for reliable, objective tools is particularly crucial for conditions like convergence insufficiency, accommodative dysfunction, and other binocular vision anomalies that require accurate measurements for effective diagnosis and treatment planning.

In response to this need, the Arjun's Royal Air Force Rule. (ARAF) device was developed as a digital alternative to the RAF rule. Designed with laser distance sensors and an ergonomic interface, the ARAF device provides automated, objective measurements for NPC and NPA. By automating target movement and capturing precise measurements without reliance on subjective patient feedback, the ARAF device aims to reduce the examiner's influence on results and improve overall diagnostic reliability. Furthermore, the ARAF device's digital readout and user-friendly design enhance patient comfort, potentially improving cooperation during assessments and reducing fatigue, particularly in pediatric, and geriatric populations.

Early pilot tests of the ARAF device suggested promising results in terms of measurement precision and user comfort, making it a viable tool for high-throughput clinical settings, as well as for specific populations that may struggle with traditional, manual assessments. By reducing manual handling and subjective variability, the ARAF device holds potential for a more standardized approach to binocular vision testing. However, rigorous evaluation of the device's clinical performance and its practical benefits compared to the RAF rule is essential.

This study aims to conduct a comprehensive evaluation of the ARAF device, focusing on its accuracy, usability, and comfort compared to the RAF rule. By systematically analyzing these aspects, this research seeks to determine the clinical viability of the ARAF device across varied clinical and community-based settings, particularly for diagnosing and managing binocular vision anomalies. In doing so, it aims to contribute to the advancement of digital optometry tools and support the integration of more reliable, patient-friendly diagnostic devices in clinical practice.

SUBJECTS AND METHODS

Study design and setting

This prospective, observational study was conducted at a tertiary eye care center in Surat, aiming to evaluate the accuracy, usability, and comfort of the newly developed ARAF device for assessing NPC and NPA, compared to the traditional RAF rule. The study received ethical clearance from the Institutional Review Board (Approval No.: IEC/2023/45), ensuring compliance with the Declaration of Helsinki guidelines for human research.

Sample size determination and statistical power

To ensure sufficient statistical power, the target sample size was determined based on a moderate anticipated effect size ($d = 0.5$) to achieve 80% power at a 5% significance level. This sample size of 56 participants was considered adequate to detect clinically meaningful differences between the ARAF and RAF devices in terms of measurement precision, comfort, and usability.

Participants

Inclusion and exclusion criteria

Participants aged 10 to 40 years were recruited from the clinical population at the eye care center. Inclusion criteria required corrected visual acuity of 6/6 with no significant ocular pathologies, neurological conditions, or severe refractive errors that might interfere with binocular vision assessments. Mild refractive errors correctable with standard prescriptions were acceptable, as they are not typically expected to impact NPC or NPA measurements. Exclusion criteria included any history of ocular surgery (e.g., strabismus surgery), conditions affecting convergence or accommodation (e.g., presbyopia,

accommodative dysfunction), and motor impairments like nystagmus that might interfere with stable visual fixation.

Participant demographics and potential bias

The final sample included 41 male (73.21%) and 15 female (26.79%) participants, with a mean age of 21.55 ± 5.36 years. Although the chosen age range aimed to capture a range of binocular vision profiles, the gender imbalance could introduce bias, especially for subjective comfort assessments, as gender-related ergonomic preferences may vary. Future studies are recommended to include a balanced gender representation to examine potential gender-specific comfort preferences and improve the generalizability of results.

MATERIALS

Devices and instrumentation

RAF Rule: The RAF rule is a manual measurement tool comprising a graduated rod with a movable target that the examiner adjusts until the patient reports diplopia for NPC or blur for NPA. This method relies on the examiner's expertise and the patient's subjective feedback, which can lead to variability in results, as illustrated in Figure 1.

Control Instruments: Control instruments used in the study included an auto-refractometer to ensure that all participants achieved corrected vision to 6/6 before NPC and NPA assessments. A Snellen chart and a trial lens set were also used to confirm visual acuity, eliminating refractive error as a potential confounding variable.

ARAF Device: The ARAF device is an innovative tool designed for precise and efficient assessments of NPC and NPA. It integrates advanced hardware and software to ensure accurate results, enhance user comfort, and reduce examiner fatigue. The hardware components include an Arduino Uno microcontroller [Figure 2], which serves as the central processing unit, coordinating the device's operations and facilitating seamless communication between sensors, motors, and display modules. A VL53L0X laser ranging sensor [Figure 2] is used to measure target distance with millimeter-level precision, ensuring reliable readings of NPC and NPA, regardless of environmental lighting conditions. The HC-06 Bluetooth module [Figure 2] enables wireless data transmission, allowing examiners to monitor and record results remotely, thereby improving usability.

The custom circuit board [Figure 3] integrates all electronic components, ensuring smooth operation and reducing wiring complexity. Its optimized layout minimizes signal interference and power consumption, contributing to the device's reliability. The device also includes a rotatable target and eye slot covers, specifically designed for both binocular and monocular testing. These targets incorporate standardized visual stimuli to maintain consistency across trials. Mechanical components, such as a micro motor and threaded rod, provide smooth, automated target movement, housed within a robust 3D-printed PETG filament enclosure for durability and ergonomic handling. A battery holder powers the device, while a 1.8-inch TFT display delivers real-time feedback to ensure clarity and convenience.

The software complements the hardware, integrating GeoGebra for performing precise mathematical calculations required for NPC and NPA assessments. It supports real-time data processing and visualization. A custom smartphone application enhances



Figure 1: Displays the Royal Arm Force (RAF)

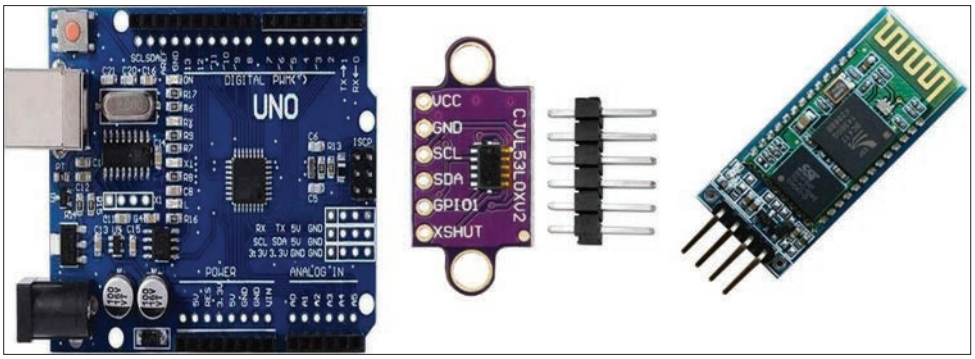


Figure 2: Displays the Hardware Components of the ARAF Device – Arduino Uno, VL53L0X Laser Ranging Sensor, and HC-06 Bluetooth module. ARAF = Arjun's Royal Air Force Rule

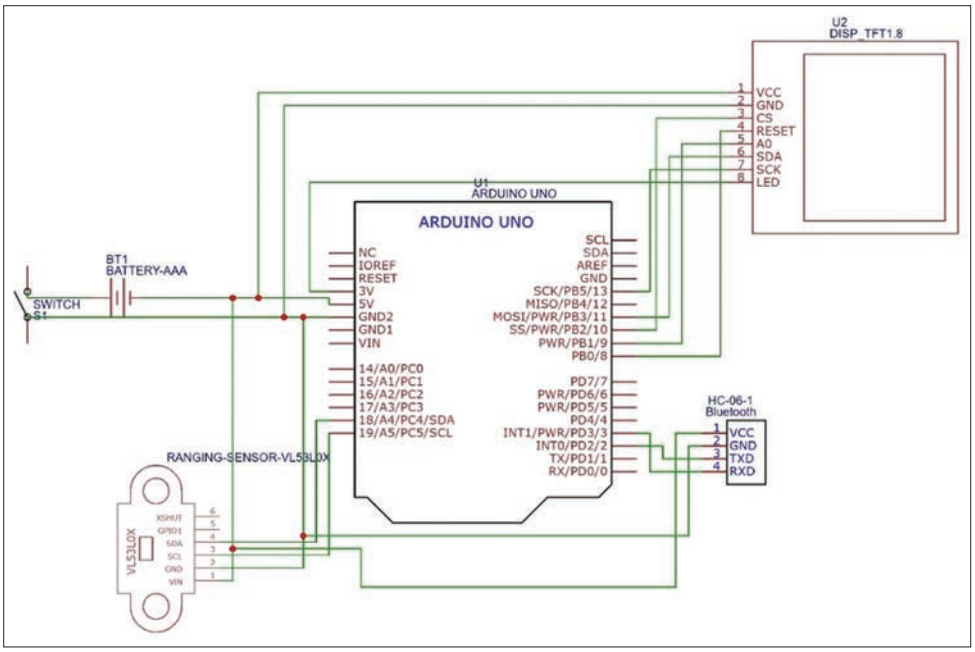


Figure 3: Presents the custom circuit board of the ARAF Device – Integrated layout for optimized signal processing and power efficiency. ARAF = Arjun's Royal Air Force Rule

remote device control and data acquisition, offering an intuitive interface that allows examiners to configure testing parameters and instantly review results. Proprietary algorithms, developed specifically for the ARAF device, automate target movement and data capture, ensuring precise and reproducible measurements while minimizing examiner input.

The ARAF device features an ergonomic and futuristic design [Figure 4], engineered for comfort and efficiency in clinical use. Its compact and lightweight design facilitates easy handling for both examiners and patients. The fully functional prototype [Figure 5] reflects the culmination of iterative prototyping and refinement, with an optimized layout for enhanced performance and usability. Rigorous testing [Figure 6], conducted in controlled and clinical settings, confirmed the device's reliability, accuracy, and usability, demonstrating its superiority over traditional methods.

Environmental controls

All measurements were conducted in a well-lit, temperature-controlled room to minimize visual strain and ensure consistency. Temperature was regulated at 22°C ± 1°C, and participants were comfortably seated with their back supported to reduce physical strain that could impact visual performance. Standardized ambient lighting (500 lux) was maintained to avoid pupil constriction or dilation, which could influence accommodation measurements.

METHODS

Calibration and blinding procedures

The ARAF device underwent calibration checks before each session, performed by an independent technician to ensure measurement consistency. Device order (ARAF vs.

RAF rule) was randomized for each participant to prevent systematic bias. The examiner was blinded to device preference to avoid potential influence on participant responses. All measurements were conducted by a single trained examiner to ensure consistency, particularly for the RAF rule.

Measurement procedure

For assessing the NPC, the ARAF device required the participant to fixate on a target that moved automatically until diplopia occurred, with the distance digitally recorded by the laser sensor. In contrast, using the RAF rule, the examiner manually moved the target along the rule's rod until the participant reported diplopia, and the distance was recorded manually.

For the NPA, the ARAF device moved the target toward the participant under both monocular and binocular conditions until blur was reported, automatically recording the distance. Meanwhile, with the RAF rule, the examiner manually adjusted the target until the participant experienced blur onset, and the distance was recorded by hand.

Each device was used in a randomized order to reduce measurement bias, and three trials per device were conducted for each participant, with the mean distance recorded. A summary of the study's methodology is presented in Figure 7.

Bias mitigation strategies

Randomization was applied to prevent systematic bias by randomizing the order of device use for each participant. The examiner, who guided participants through the procedures, was blinded to specific hypotheses regarding usability and comfort to avoid any influence on participant responses. To ensure consistency, all measurements, particularly those involving the RAF rule, were conducted

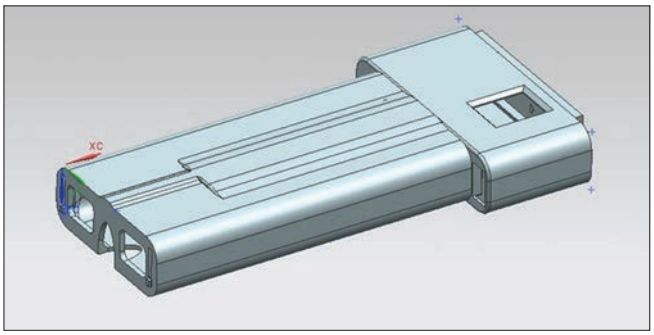


Figure 4: Illustrates the ergonomic and futuristic design of the ARAF Device – Compact and user-friendly for clinical application. ARAF = Arjun's Royal Air Force Rule



Figure 6: Shows Rigorous Testing of the ARAF Device – Evaluation of accuracy and usability in controlled and clinical settings. ARAF = Arjun's Royal Air Force Rule

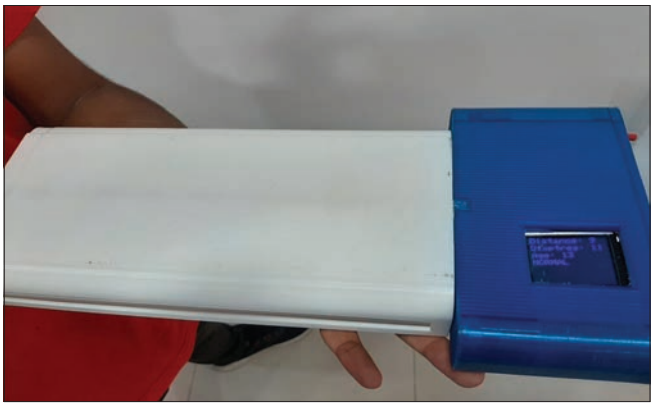


Figure 5: Shows fully functional prototype of the ARAF Device – Final design with enhanced features for binocular vision assessment. ARAF = Arjun's Royal Air Force Rule

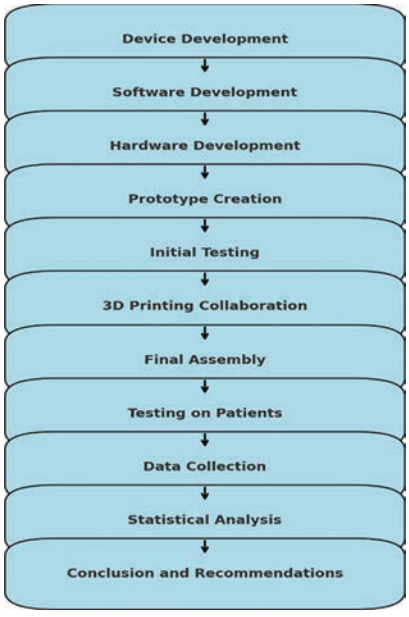


Figure 7: Illustrates the methodology flowchart

by a single trained examiner to minimize variability in subjective assessments.

Statistical analysis

The Wilcoxon Signed Rank Test, a non-parametric test for paired data, was used to compare NPC and NPA measurements between the ARAF device and the RAF rule due to the non-normal distribution of data. Statistical significance was set at $P < 0.05$. Effect sizes (Cohen's d) and 95% confidence intervals were calculated to quantify the differences between devices. Thematic analysis was conducted on qualitative feedback from participants, identifying common themes related to comfort, ease of use, and ergonomic features, which provided additional insights into user experience.

Reproducibility and data availability

Calibration files and measurement protocols for the ARAF device were maintained for reproducibility, and all measurements and data management practices were documented for study replication. Data files are available upon request.

Control conditions and reliability measures

Device calibration for the ARAF device was verified before each session, with all measurements digitally recorded to maintain data integrity. Visual acuity was corrected to 6/6 for all participants to ensure that differences in device performance were isolated in the analysis, minimizing the impact of confounding factors.

Ethics and compliance

Informed consent was obtained from all participants, who were informed about the study's purpose, procedures, and their right to withdraw at any time without penalty, in alignment with ethical guidelines.

Limitations and future directions

While this study provides preliminary evidence of the ARAF device's accuracy and comfort benefits over the RAF rule, the sample's gender imbalance, and age restriction limit generalizability. Future studies should aim to include a more diverse demographic across age and gender, ideally with larger sample sizes and multi-site testing, to confirm the ARAF device's broader clinical applicability.

RESULTS

A total of 56 participants successfully completed the study, including 41 males (73.21%) and 15 females (26.79%), with a mean age of 21.55 ± 5.36 years. All participants were either emmetropic or had refractive errors corrected to 6/6 vision, ensuring that visual acuity did not affect the NPC or NPA measurements. The results, which included confidence intervals, effect sizes, and subgroup analyses, revealed no significant demographic differences in age or gender distribution that could influence binocular vision metrics. This confirms the representativeness of the sample for evaluating device performance, as illustrated in Figure 8. A summary of NPC and NPA measurements by device is presented in Table 1.

Subjective NPC measurements

While objective measurements favored the ARAF device, subjective NPC assessments showed no significant difference between the two devices. The mean subjective NPC measurement for the ARAF device was 7.88 ± 2.56 cm, compared to 8.10 ± 2.65 cm for the RAF rule. Statistical analysis revealed a non-significant difference ($P = 0.072$), as illustrated in Figure 9, indicating that participants perceived similar convergence points regardless of the device used. This consistency in subjective measurements highlights that while objective accuracy differed, both devices provided

Table 1: Summary of NPC and NPA Measurements by Device

Measurement Type	Device	Mean ± SD (cm)	Effect Size (Cohen's d)	p-value	95% Confidence Interval
Objective NPC	ARAF	7.80 ± 2.60	0.42	0.004	[0.25, 0.57]
	RAF Rule	8.16 ± 2.81			
Subjective NPC	ARAF	7.88 ± 2.56	-	0.072	-
	RAF Rule	8.10 ± 2.65			
Monocular NPA	ARAF	10.22 ± 2.15	0.39	<0.01	[0.31, 0.78]
	RAF Rule	10.89 ± 2.48			
Binocular NPA	ARAF	9.98 ± 2.25	0.43	0.003	[0.42, 0.83]
	RAF Rule	10.61 ± 2.36			

NPC=Near Point of Convergence, NPA=Near Point of Accommodation

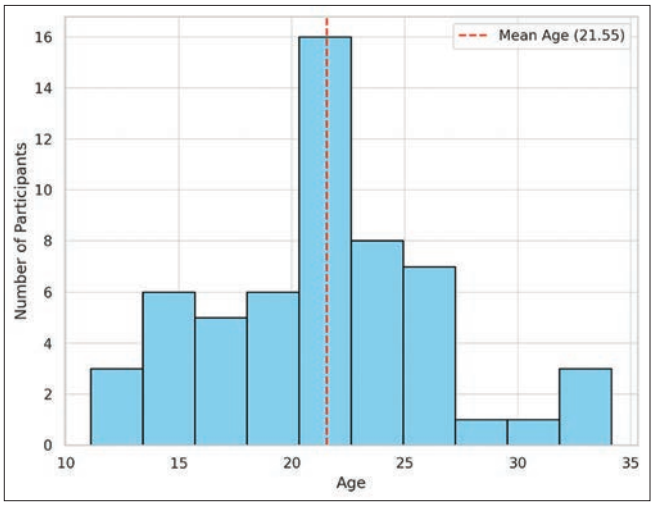


Figure 8: Age Distribution of Participants. The histogram reveals a clustering of participants around the mean age of 21.55 years

comparable patient-perceived convergence experiences. The box plot in Figure 9 compares the NPC measurements between the ARAF device and the traditional RAF rule, with the ARAF device demonstrating a tighter interquartile range, indicative of reduced variability and improved precision in NPC measurements.

Objective Near Point of Convergence measurements

The ARAF device demonstrated significantly improved precision in measuring the NPC compared to the RAF rule. The mean NPC measurement with the ARAF device was 7.80 ± 2.60 cm (95% CI: 7.30–8.30 cm), while the RAF rule yielded a mean of 8.16 ± 2.81 cm (95% CI: 7.55–8.77 cm). A Wilcoxon Signed Rank Test was conducted to assess the paired differences between the two devices, revealing a statistically significant difference ($P = 0.004$), with an effect size of d = 0.42, indicating a moderate effect in favor of the ARAF device for NPC accuracy. This result suggests that the automated, laser-based measurement capability of the ARAF device reduced variability, allowing for more consistent and precise convergence points. The tighter interquartile range shown in Figure 10 further supports the increased precision provided by the ARAF device. Figure 11, which illustrates the objective NPC value distribution for the RAF rule, shows a wider spread of values, indicating greater variability compared to the ARAF device.

Near Point of Convergence measurements

The ARAF device also outperformed the RAF rule in both monocular and binocular NPA measurements, demonstrating its superior precision in assessing accommodative function. For monocular NPA, the mean measurement with the ARAF device was significantly lower (10.22 ± 2.15 cm) compared to the RAF rule (10.89 ± 2.48 cm, $P < 0.01$), indicating that the ARAF device detected a closer accommodative point. This difference is likely due to the ARAF device's automated precision in detecting even subtle changes in accommodation distance. Similarly, binocular NPA measurements were closer with the ARAF device (9.98 ± 2.25 cm) than with the RAF rule (10.61 ± 2.36 cm, $P = 0.003$), further highlighting the ARAF device's ability to detect subtle accommodative deficiencies in clinical settings, as illustrated in Figures 12 through 14. The effect size for monocular NPA was moderate (d = 0.39) with a 95% confidence interval of [0.31, 0.78] cm, while the effect size for binocular NPA was slightly higher (d = 0.43) with a 95% confidence interval of [0.42, 0.83] cm, suggesting clinically meaningful improvements in NPA measurements with the ARAF device. As shown in Figure 15, the histogram of NPA measurements reveals a leftward shift for the ARAF device, indicating its enhanced ability to detect closer accommodative points, which may improve diagnostic capabilities in clinical practice.

Participant comfort and usability

Participant feedback strongly favored the ARAF device over the RAF rule, as shown in Table 2. Most participants (53.57%) rated the ARAF device as more comfortable and user-friendly, with its ergonomic design and automated digital interface being highlighted as key factors contributing to its appeal. In contrast, only 28.57% preferred the RAF rule, primarily due to familiarity, while 17.85% expressed no specific preference, as shown in Figure 16. The mean comfort rating for the ARAF device (4.32) was significantly higher than that of the RAF rule (3.78, $P < 0.05$), which correlates with the device's superior objective precision. Participants noted that the ARAF device's automated measurements alleviated the strain typically associated with the repeated manual adjustments required by the RAF rule.

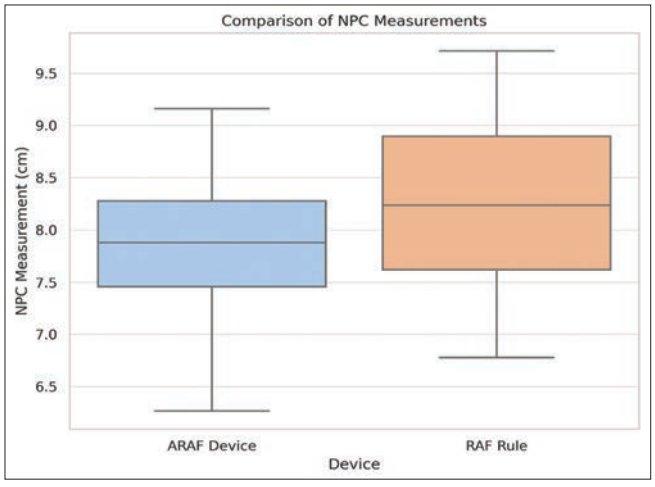


Figure 9: Subjective NPC Values Comparison (ARAF vs RAF). The boxplot reveals a comparable distribution of subjective NPC values for both ARAF and RAF devices, with similar IQRs and medians. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force, NPC = Near Point of Convergence

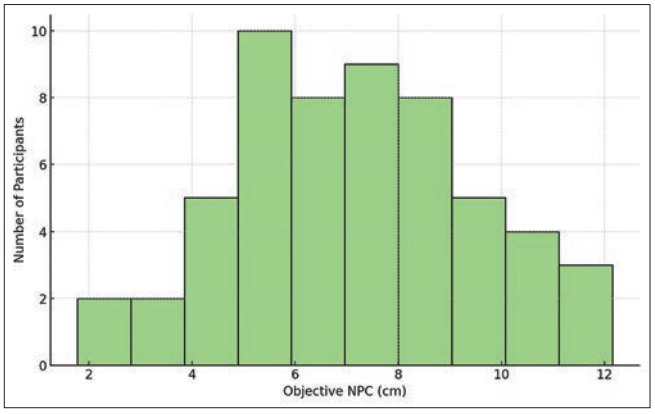


Figure 10: Objective NPC Value Distribution (ARAF). The histogram reveals a skewed distribution of objective NPC values measured using the ARAF device, suggesting a greater degree of precision compared to the RAF device. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force, NPC = Near Point of Convergence

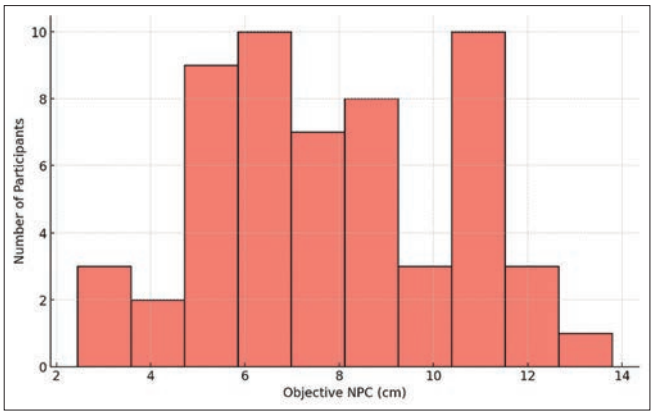


Figure 11: Objective NPC Value Distribution (RAF). The histogram reveals a wider distribution of objective NPC values measured using the RAF rule, indicating greater variability compared to the ARAF device. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force, NPC = Near Point of Convergence

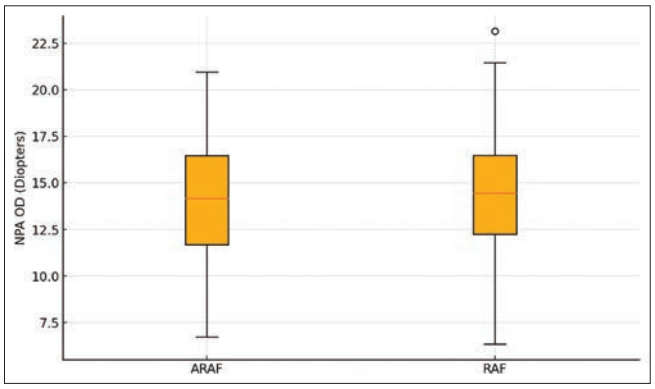


Figure 12: NPA OD Values Comparison (ARAF vs RAF). The boxplot illustrates the distribution of NPA OD values for both ARAF and RAF devices, revealing a significant difference with a tighter distribution for ARAF. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force, NPA = Near Point of Accommodation

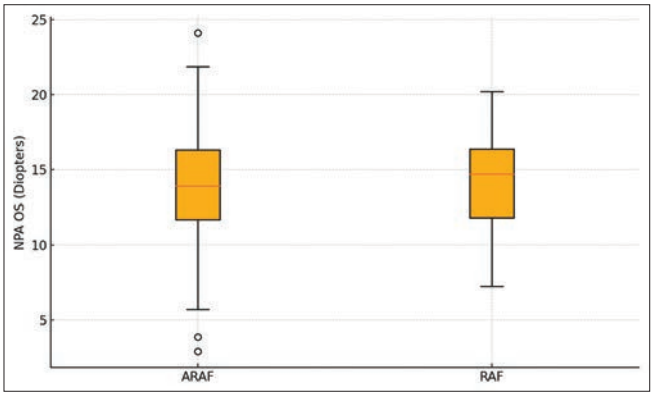


Figure 13: NPA OS Values Comparison (ARAF vs RAF). The boxplot compares the NPA OS values for the ARAF and RAF devices, showing a tighter range of values and fewer outliers for the ARAF device. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force, NPA = Near Point of Accommodation

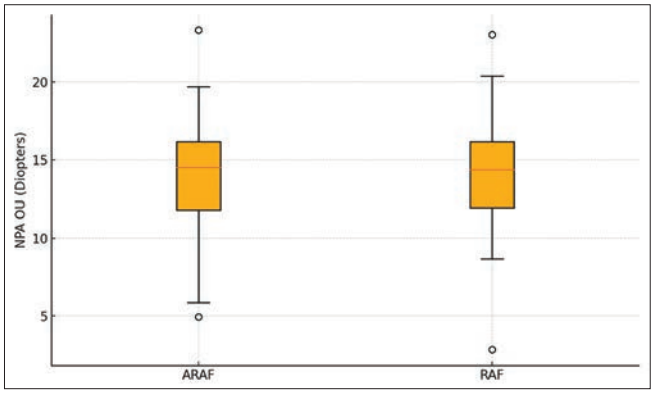


Figure 14: Binocular NPA (OU) Values Comparison (ARAF vs RAF). The boxplot illustrates the distribution of binocular NPA (OU) values for both ARAF and RAF devices, revealing a significant difference in precision, with the ARAF device providing more accurate measurements. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force, NPA = Near Point of Accommodation

Qualitative feedback further emphasized the "ease of use" and "reduced testing time" as significant advantages of the ARAF device, particularly for pediatric and elderly populations.

Subgroup analysis

In participants under 20 years, the ARAF device's increased accuracy was particularly pronounced, with younger individuals preferring the digital device due to its ease of measurement without manual adjustments. For adults, while precision remained high, comfort was the leading factor.

Although no significant gender difference was found in NPC or NPA outcomes, comfort preferences varied, with female participants reporting a slight preference for the ARAF device, particularly in ergonomic feedback.

Summary of key results

Overall, the ARAF device demonstrated statistically significant improvements in objective NPC and NPA measurements and received higher subjective comfort ratings. The digital automation of the ARAF device appears to enhance both diagnostic precision and user experience, indicating its potential as a preferable alternative to the traditional RAF rule in clinical settings.

DISCUSSION

This study evaluates the ARAF device, a novel digital alternative to the traditional RAF rule, designed to measure NPC and NPA. Our investigation focused on the ARAF's precision, comfort, and clinical relevance. Results suggest that the ARAF device offers significant advantages for binocular vision assessments, particularly in diagnosing convergence insufficiency and accommodative dysfunction.

Enhanced measurement precision

The ARAF device demonstrated superior measurement accuracy compared to the RAF rule, evidenced by

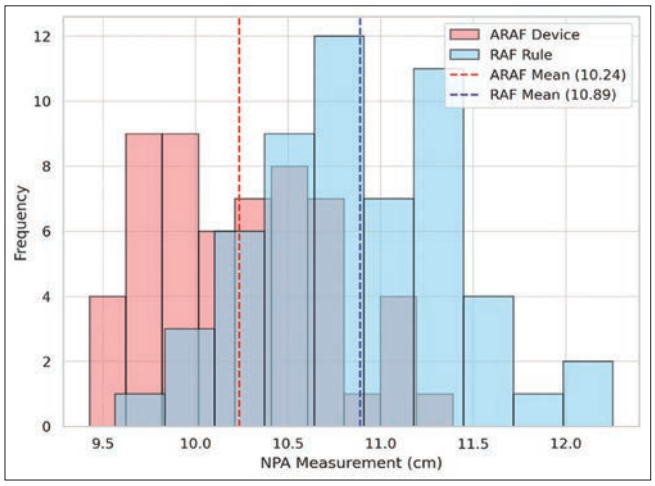


Figure 15: NPA Measurement Distribution (ARAF vs RAF). The histogram shows the distribution of Near Point of Accommodation (NPA) measurements for both devices. The ARAF device's measurements are shifted leftward, indicating its ability to detect closer accommodative points with greater accuracy compared to the RAF rule. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force

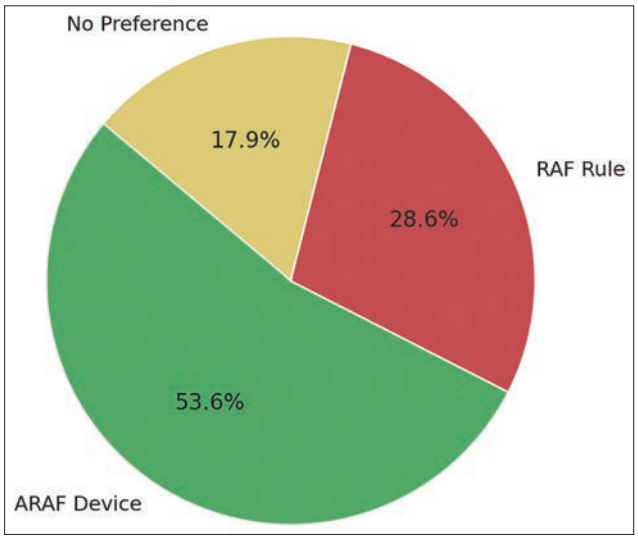


Figure 16: Participant Comfort Preference (ARAF vs RAF). The pie chart illustrates participant comfort preferences, showing a clear majority favoring the ARAF device over the RAF rule due to its ease of use and lightweight design. ARAF = Arjun's Royal Air Force Rule, RAF = Royal Air Force

Table 2: Participant comfort and device preference

Comfort Rating (1-5)	ARAF Device (%)	RAF Rule (%)
1 (Very Uncomfortable)	2%	8%
2	5%	12%
3 (Neutral)	18%	23%
4	21%	25%
5 (Very Comfortable)	53%	32%

Device Preference	ARAF Device	RAF Rule	No Preference
Percentage of Participants	53.57%	28.57%	17.85%

statistically significant improvements in consistency. This precision, reflected in a narrower interquartile range, is attributed to the device's automation and laser-based distance sensors. These features mitigate variability stemming from manual adjustments and subjective patient feedback, a limitation previously highlighted by Sharma *et al.* (2016)[4] and Neethu *et al.* (2015).[7] Their studies underscored that examiner variability in traditional RAF rule assessments often introduces deviations, affecting clinical accuracy.

By integrating laser technology, the ARAF device addresses these challenges, providing consistent, objective measurements. Recent advancements in digital optometry tools, such as those noted by Menjivar (2017),[8] emphasize the importance of such innovations in reducing examiner-induced variability. Enhanced measurement precision is particularly crucial for conditions like convergence insufficiency, where reliable NPC and NPA data are essential for accurate diagnosis and treatment planning. The ARAF's ability to reduce variability and improve diagnostic reliability underscores its potential clinical utility.

Clinical implications

The improved precision of the ARAF device carries substantial clinical implications, notably in reducing diagnostic errors linked to examiner variability. Accurate measurements of NPC and NPA are essential for diagnosing binocular vision anomalies. The ARAF device shows promise for managing conditions like accommodative insufficiency, where early and precise interventions are critical.

The automated design of the ARAF device is especially advantageous for pediatric and geriatric populations. For children, the non-intrusive testing reduces fatigue and enhances cooperation, addressing the limitations of prolonged focus required in traditional methods. Similarly, elderly patients benefit from the device's user-friendly design, which accommodates age-related variability and minimizes discomfort. These age-specific advantages highlight the ARAF device's capacity to meet diverse clinical assessment needs.

Comfort and user preference

Participants rated the ARAF device as more comfortable than the traditional RAF rule, with over 53% expressing a preference for its use. This preference is attributed to the ARAF's ergonomic design and automated functionality, which eliminate manual adjustments that may cause discomfort. Conversely, only 28.57% of participants preferred the RAF rule, reinforcing the positive reception of the ARAF.

Patient comfort is the critical factor influencing clinical assessment reliability. Discomfort during testing can compromise measurement accuracy or lead to noncompliance.

The ARAF's design minimizes these issues, enabling accurate measurements with reduced need for retesting due to discomfort-related variability. This advantage is particularly relevant in high-volume clinics and school screenings, where efficiency and consistent accuracy are essential.

Limitations and challenges

While the ARAF device offers significant benefits, it has limitations. The relatively small sample size and restricted age range of this study limit the generalizability of findings. Although age and gender did not significantly influence results, future research involving a broader demographic, including pediatric and geriatric populations, is necessary to optimize the device's clinical utility.

Another limitation is the device's dependence on electronic components, which may hinder its use in resource-limited settings. The simplicity and independence from electricity of the traditional RAF rule make it more practical in remote areas. Enhancements such as rechargeable batteries or solar power options could improve the ARAF's adaptability for such environments, extending its utility to fieldwork and rural clinics.

Comparison with other digital devices in optometry

Digital devices in optometry often prioritize measurement accuracy but may require complex calibration, limiting their usability outside specialized clinics. Studies, including those by Menjivar (2017),[8] have highlighted these limitations. The ARAF device differentiates itself by balancing precision with ease of use, making it accessible to a wider range of practitioners.

Unlike many digital tools requiring extensive training, the ARAF's intuitive design and automated features simplify operation, increasing its potential for widespread adoption in varied clinical settings. This balance between functionality and user-friendliness aligns with the growing demand for accessible diagnostic tools.

Potential for remote or telemedicine applications

The integration of telemedicine in healthcare presents opportunities for the ARAF device. Future adaptations, such as Bluetooth connectivity or mobile application compatibility, could enable remote or at-home assessments. These features would be particularly beneficial for tracking NPC and NPA over time under clinical supervision. Such advancements could enhance access to vision assessments in underserved or remote regions, further demonstrating the device's practical versatility.

Economic considerations

A cost-benefit analysis of the ARAF device highlights potential economic advantages for clinical practices. The device's precision and comfort-driven reduction in retesting could lead to long-term savings. High-volume clinics stand to benefit from improved patient throughput and reduced time spent on repeat assessments. Comparisons of long-term cost-effectiveness with traditional tools would substantiate its economic viability further.

Future directions

Further research is needed to validate the ARAF device's utility across broader demographics and clinical conditions. Studies focused on pediatric, elderly, and special-needs populations will provide comprehensive insights into its accuracy and usability. Additionally, evaluating the device's long-term reliability and performance under routine clinical use is critical.

Potential enhancements include integrating data analytics for longitudinal tracking of NPC and NPA. Such features would enable clinicians to monitor binocular function changes over time, offering insights into disease progression or treatment efficacy. Connectivity with electronic health record systems could streamline data management, improving diagnostic precision.

CONCLUSION

The ARAF device is a precise and user-friendly alternative to the traditional RAF rule for assessing NPC and NPA, offering statistically significant improvements in measurement accuracy (NPC: $P = 0.004$; NPA monocular: $P < 0.01$; NPA binocular: $P = 0.003$). Its automated digital design reduces variability and enhances diagnostic reliability, especially in conditions like convergence insufficiency.

In clinical practice, the ARAF device improves operational efficiency through quicker, automated assessments, and enhances patient comfort—benefiting high-volume clinics, school screenings, and elderly care settings. Its ease of use also supports applications by non-specialists in community health programs.

Further research should explore solutions for the device's calibration and power needs to optimize use in low-resource settings. Overall, the ARAF device meets the growing demand for precision and efficiency in binocular vision assessment, offering significant potential to elevate clinical standards.

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We also acknowledge the contributions of healthcare professionals and researchers whose prior work on evaluating the ARAF device as a tool for assessing Near Point of Convergence (NPC) and Near Point of Accommodation (NPA) served as the foundation for this study. Their dedication to advancing patient care, rigorous data collection, and scholarly research has been instrumental in broadening our understanding of this critical aspect of binocular vision assessment.

Key messages

The ARAF device offers a clinically significant advancement in binocular vision assessment, combining precision, comfort, and usability, and holds promise for broad adoption in clinical practices.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

A comparative study of corneal endothelial cell count in diabetics and nondiabetics in a tertiary care hospital in North Kerala

ABSTRACT

Background: Diabetes mellitus (DM) is a metabolic condition with numerous etiologies characterized by persistent hyperglycemia and abnormalities in metabolism of carbohydrates, fats, and proteins as a result of abnormalities in either insulin action or insulin secretion. Diabetes can lead to ocular problems that include diabetic retinopathy, corneal endothelial cell change, superficial punctate keratitis, recurrent corneal erosion, and persistent epithelial abnormalities. The prevalence of Type 2 diabetes has risen to a global pandemic level. Diabetes may cause corneal endothelial morphological alterations in average cell size, coefficient of variation, and a decrease in corneal ECD and hexagonality. Keratopathy is a significant consequence of diabetes mellitus. Changes in corneal findings are increased along with progression of diabetic retinopathy. In this study, we compared corneal endothelial cell count in diabetics and nondiabetics using noncontact, noninvasive specular microscopy to detect any clinically significant change. **Aims and Objectives:** To study corneal endothelial cell count in Type 2 DM patients and nondiabetic individuals and to assess morphological changes in corneal endothelium in Type 2 DM patients. **Methods:** This is a comparative, cross-sectional, hospital-based study conducted in the OPD of Ophthalmology, Malabar Medical College Hospital and Research Center, Kozhikode, in the year 2022 to 2023. The study population was selected by convenient sampling. Noncontact specular microscopy was done among already diagnosed Type 2 DM patients and nondiabetic individuals in the age group between 18 and 70 years. Data were collected from both eyes of the patient, and analysis was done using the observations in the right eye. All subjects underwent routine ocular evaluation and dilated fundus examination to rule out diabetic retinopathy. **Results:** In this study, 92 patients (50%) had Type 2 DM and 92 (50%) were nondiabetic, age-matched healthy individuals. In the diabetic group, 67.4% were aged 61–70 years, compared to 55.4% in the nondiabetic group. Diabetic patients had decreased corneal endothelial cell density and hexagonality but increased average cell size and coefficient of variation compared to nondiabetics. Diabetic retinopathy severity increased with higher HbA1c values and longer diabetes duration, correlating with decreased corneal endothelial cell density. Diabetic corneas showed increased polymegathism and pleomorphism, indicating a significant association between keratopathy and DM compared to nondiabetics. **Conclusion:** In the current scenario, all diabetic patients visiting the ophthalmology OPD for routine vision checkups should be evaluated for corneal morphological parameters—endothelial cell density, average cell size, coefficient of variation, and hexagonality—using a noncontact specular microscope, alongside a dilated fundus examination for diabetic retinopathy. Routine screening for diabetic keratopathy and DR aids in early detection and treatment.

Keywords: Corneal endothelium, diabetes mellitus, diabetic retinopathy, endothelial cell density, pleomorphism, polymegathism, specular microscopy

INTRODUCTION

Diabetes mellitus (DM) is a metabolic condition with numerous etiologies that is characterized by persistent hyperglycemia and abnormalities in metabolism of

Chris Mathew Koshy, K. V. Raju, Irshad E, Lakshmi Cherungottil

Ophthalmology, Malabar Medical College Hospital and Research Centre, KUHS, Kozhikode, Kerala, India

Address for correspondence: Dr. Chris Mathew Koshy, Ophthalmology, Malabar Medical College Hospital and Research Centre, KUHS, Kozhikode, Kerala, India.
E-mail: chrismathewkoshy@gmail.com

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carbohydrates, fats, and proteins as a result of abnormalities in either insulin action or insulin secretion. DM implications include long-term harm, failure, and malfunction of several organs.[1] Diabetes can lead to ocular problems that include diabetic retinopathy, corneal endothelial cell change, superficial punctate keratitis, recurrent corneal erosion, and persistent epithelial abnormalities.[2] The prevalence of Type 2 diabetes has risen to a global pandemic level. An estimated 463 million individuals, or almost 8.8% of the population, have diabetes. Without prompt diagnosis and treatment, diabetic retinopathy—the most frequent consequence of diabetes that affects the retinal blood vessels—has an insidious onset and can result in permanent blindness. About 34.6% of people worldwide are thought to have diabetic retinopathy.[3]

Light beams entering the eye are transmitted and refracted by the cornea. This function is connected to the continual fluid pumping activity of the corneal endothelium, which maintains the corneal stroma's deturgescence and transparency.[4] The corneal endothelium, a single layer of hexagonal cells, is crucial for maintaining corneal clarity. Studies on corneal endothelial anomalies and diabetes yielded mixed results. Research has found a lower endothelial cell density in diabetes individuals. Diabetes may lead to changes in the morphology of the corneal endothelium, including a reduction in the proportion of hexagonal cells and a high polymegathism.[2] Keratopathy is a significant consequence of diabetes mellitus. Changes in corneal findings are increased along with progression of diabetic retinopathy. In that regard, we may recommend that diabetic patients' keratopathy be assessed with greater caution.[5] The severity of diabetes is correlated with the morphologic characteristics of endothelial cells.

In comparison to nondiabetic corneas, diabetes corneas were thicker and more autofluorescent. The corneal hydration is affected by DM. Numerous variables affect the endothelium morphology.[1] Age, race, and refractive errors all have an impact on the variations in endothelial morphology, such as endothelial cell density (ECD), coefficient of variation (CV), and percentage of hexagonal cells. In contrast to nondiabetic individuals, diabetic patients' corneas may exhibit a high coefficient of variation in cell area and a lower percentage of hexagonal cells due to morphological anomalies.[1] This study's goal was to examine corneal morphological characteristics (ECD, CV, hexagonality, and average cell size) between diabetics and age-matched, nondiabetic control patients using a noncontact noninvasive specular microscope and to determine how these parameters correlated with the period of DM, glycemic status, and severity of DR.[6]

METHODOLOGY

This hospital-based comparative and cross-sectional study was conducted among already diagnosed Type 2 DM patients and normal healthy age-matched individuals in the age group between 18 and 70 attending ophthalmology OPD of a tertiary health care center, Malabar Medical College and Research Centre, Calicut. Age-matched nondiabetic controls were selected from those coming for health checkup. The duration of study was 1 year from November 2022 to November 2023 after ethical clearance. 92 eyes of patients with type 2 DM were taken as the study group, and 92 eyes of nondiabetic patients were taken as the control group, based on a study, Comparative Evaluation of Corneal Endothelial Parameters in Diabetic and Non-Diabetic Individuals using Specular Microscopy by E.Hussein *et al*. in 2021.[4]

Convenient sampling was done. Inclusion criteria for cases include patients between ages of 18 and 70 years, with already diagnosed type 2 DM and/or on treatment. Inclusion criteria for controls include healthy individuals without Type 2 DM between ages of 18 and 70 years coming for health checkup in Malabar Medical College Hospital, who were selected and recruited for the study. Exclusion criteria include contact lens users, history of dry eye disease, patients who underwent any procedures like laser, intravitreal injections or previous ocular surgeries, anterior segment disease/any corneal diseases that may cause corneal scarring, Type 1 diabetics, history of glaucoma, ocular trauma history, and continuous use of topical medications for any ocular disease.

Instruments of study include slit lamp biomicroscopy with a 90 D lens, corneal endothelial cell count density assessment by using a noncontact specular microscope [Figure 1], and an indirect ophthalmoscope with a 20D lens. A comprehensive ocular examination was performed on all subjects. Visual acuity was recorded with an illuminated LOGmar chart. For each eye, the presenting and best corrected visual acuities were recorded independently. Retinal studies included pupils dilated with 1 drop of phenylephrine (5%) and tropicamide (0.8%) combination in both eyes. Dilated fundus examination was done using an indirect ophthalmoscope and 20D lens. Clinically significant macular edema (CSME) assessed using slit lamp biomicroscopic examination with a 90D lens. Diabetic retinopathy was categorized based on early treatment diabetic retinopathy study (ETDRS) classification.

Details of the study were explained in simple language to the patient. Written informed consent has been obtained from those willing to participate in the study. Patient data were

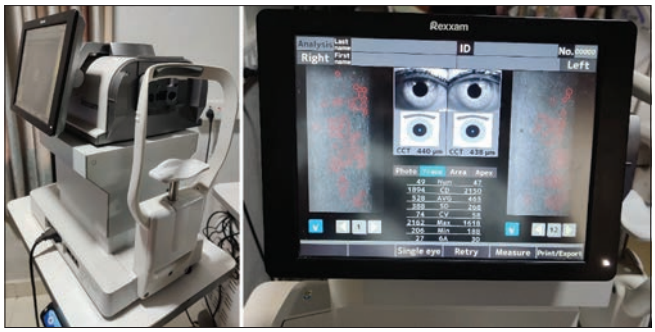


Figure 1: Noncontact specular microscopy

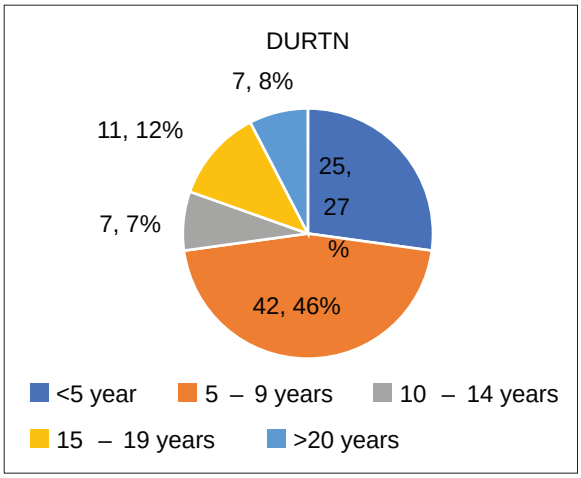


Figure 3: Duration of DM frequency and percentage.

kept confidential. They were approved by the institution's ethical committee. The study was conducted among T_2DM patients and nondiabetic individuals coming for health checkup in MMCH between ages of 18 and 70 years attending the Ophthalmology OPD of the institution. Data were collected from both eyes of the patient, and analysis was done using observations in the right eye. Cases were taken from already diagnosed diabetic patients or those on treatment for diabetes in the present or past, and available RBS, FBS, and PPBS values were recorded.

Statistical analysis

Quantitative data collected were coded, entered into Microsoft Excel version 2016, and analyzed using SPSS software version 20. Numerical variables were presented as mean +/- standard deviation. The frequency and percentage of categorical variables were displayed. Suitable statistical techniques, such as the independent *t*-test, Pearson correlation, and Chi-square test, were used during the analysis. A statistically significant *P* value is defined as one that is < 0.05.

RESULTS

In the study group, those with family history of diabetes were slightly more than those with no family history [Figure 2].The

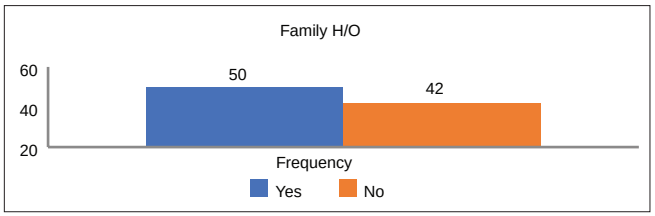


Figure 2: Family history of DM frequency

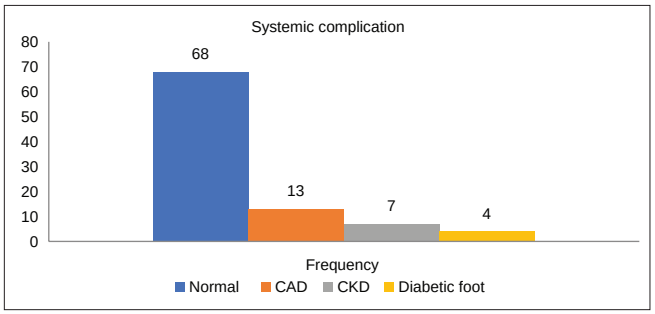


Figure 4: Systemic complication

distribution of duration of duration of diabetes in the study population is depicted in Figure 3. Sixty eight patients had no systemic complication, while twenty four patients had systemic complications [Figure 4]. On comparing corneal morphological parameters from the observations in RE by SM of the diabetic group by using Pearson correlation, it was observed that corneal endothelial cell density has positive correlation with hexagonality and negative correlation with average cell size and coefficient of variation. It was observed that average cell size has positive correlation with coefficient of variation and negative correlation with corneal endothelial cell density and hexagonality.

On comparing corneal morphological parameters from the observations in RE by SM of the diabetic group [Table 1], it was observed that the mean corneal endothelial cell density was 2232.815, the mean average cell size was 446.946, the mean coefficient of variation was 45.554, and the mean hexagonality was 39.315. On comparing corneal morphological parameters from the observations in RE by SM of diabetic with nondiabetic group by independent *t*-test Table 2, it was observed that the mean corneal endothelial cell density and mean hexagonality in the diabetic group are decreased when compared to the nondiabetic group; the mean average cell size and mean coefficient of variation in the diabetic group are increased when compared to the nondiabetic group. This signifies that there is pleomorphism and polymegathism in the diabetic group.

35.9% were normal, 21.7% were having mild NPDR, 14.1% were having moderate NPDR, 8.7% were having severe NPDR, 8.7%

Table 1: Correlation of corneal morphological parameters (RE) in diabetic group

Correlation - DM		ECDRE	Avgre	CVRE	HCRE
ECDRE	Pearson Correlation	1	-0.907	-0.081	0.162
Avgre		-0.907	1	0.194	-0.170
CVRE		-0.081	0.194	1	-0.341
HCRE		0.162	-0.170	-0.341	1

Table 2: Comparing BCVA and corneal morphological parameters (RE) in DM and NDM

	Group	*n*	Mean	*t*	*P*	sig
BCVARE	DM	92	0.423	2.485	0.014	<0.05, sig
	NDM	92	0.293			
ECDRE	DM	92	2232.815	3.205	0.002	<0.05, sig
	NDM	92	2383.391			
Avgre	DM	92	446.946	2.620	0.010	<0.05, sig
	NDM	92	416.609			
CVRE	DM	92	45.554	4.399	0.001	<0.05, sig
	NDM	92	39.174			
HCRE	DM	92	39.315	11.34	0.001	<0.05, sig
	NDM	92	53.033			

Table 3: Comparing diabetic retinopathy with HbA1c

Fundus	*n*	Mean	Std. Deviation	*F*	*P*	sig
Normal	33	6.255	0.7645	14.211	0.0001	<0.05, sig
Mild NPDR	20	6.575	0.7752			
MOD NPDR	13	7.115	0.9737			
Severe	8	6.713	0.8659			
Very severe	8	7.950	0.9885			
Early PDR	4	9.550	0.5972			
High risk PDR	4	8.250	0.8660			
ADED	2	8.900	1.1314			

were having very severe NPDR, 4.3% were having early PDR, 4.3% were having high-risk PDR, and 2.2% were having ADED.

On correlating HbA1c with diabetic retinopathy [Table 3], it was found that diabetic retinopathy severity increases with increase in HbA1c values. This observation was considered statistically significant as the *P* value obtained is <0.05. On correlating duration of diabetes with diabetic retinopathy, it was found that diabetic retinopathy severity increases with increase in duration.

On correlating duration of diabetes with corneal morphological parameters of diabetic patients obtained by specular microscopy, observations from the right eye were compared, which shows that the mean corneal endothelial cell density decreased with increase in duration of diabetes [Table 4]. The mean average cell size increased with increase in duration of diabetes. These two observations were considered statistically significant as the *P* value obtained is < 0.05.

Correlating diabetic retinopathy severity with corneal morphological parameters [Table 5] of diabetic patients shows that the mean corneal endothelial cell density decreased with increase in severity of DR. The mean average cell size increased with increase in severity of DR. These two observations were considered statistically significant as the *P* value obtained is < 0.05.

DISCUSSION

Keratopathy is a significant consequence of diabetes mellitus. All of the cornea's structural layers are affected by DM. Recurrent epithelial erosion, delayed wound healing, neurotrophic ulcers, and diminished corneal sensitivity are among the clinically noted consequences of diabetic corneal disease. Diabetic endothelium damage has been linked to a number of pathophysiological pathways, including osmotic damage from excessive sorbitol buildup, oxidative damage from AGEs, and impaired corneal endothelial cell adhesion due to adhesion protein changes. The corneal endothelium undergoes morphological and functional alterations as well, and diabetes raises the risk of endothelial damage following intraocular surgery.

In this study, a total of 184 patients were compared, in which 92 patients (50%) were confirmed cases of Type 2 DM and the remaining 92 patients (50%) were nondiabetic age-matched healthy individuals. It was observed that in the diabetic group, 54.3% (50 patients) had family history of diabetes, 50% of patients had history of hypertension, 38% of patients had history of dyslipidemia, 14.1% had CAD, 7.6% had CKD, and 4.3% had diabetic foot. On comparing corneal morphological parameters of the diabetic group by using Pearson correlation, it was observed that corneal endothelial cell density has positive correlation with hexagonality and negative correlation with average cell size and coefficient of variation. On comparing corneal morphological parameters of diabetic with nondiabetic group, it was observed that the mean corneal endothelial cell density and mean hexagonality in the diabetic group are decreased when compared to the nondiabetic group; the mean average cell size and mean coefficient of variation in the diabetic group are increased when compared to the nondiabetic group. This signifies that there is pleomorphism and polymegathism in the diabetic group.

In a study conducted by E. Hussein A *et al.*[4] in 2021 in Egypt, analysis of demographic data revealed that most of the diabetic group were female patients (16 female versus 7 males), while there were 12 females versus 11 males in the nondiabetic group. Analysis of the HbA1c values between both groups revealed higher HbA1c values in diabetic

Table 4: Comparing duration of diabetes and corneal morphological parameters

Duration with corneal parameters		*n*	Mean	Std. Deviation	*F*	*P*	sig
ECDRE	<5 year	25	2490.720	275.0125	34.089	0.0002	<0.05, sig
	5 – 9 years	42	2350.429	233.9149			
	10 – 14 years	7	1881.714	114.1355			
	15 – 19 years	11	1771.364	226.2929			
	>20 years	7	1682.286	173.9710			
Avgre	<5 year	25	389.520	57.6557	27.629	0.0001	<0.05, sig
	5 – 9 years	42	419.452	55.2565			
	10 – 14 years	7	533.143	34.0804			
	15 – 19 years	11	542.909	81.8040			
	>20 years	7	580.000	69.8594			
CVRE	<5 year	25	44.360	8.9017	1.201	0.316	>0.05, no sig
	5 – 9 years	42	47.548	8.6029			
	10 – 14 years	7	45.857	5.1778			
	15 – 19 years	11	41.818	13.0140			
	>20 years	7	43.429	6.3733			
HCRE	<5 year	25	41.680	5.9772	1.753	0.146	>0.05, no sig
	5 – 9 years	42	38.452	7.1711			
	10 – 14 years	7	34.857	8.5718			
	15 – 19 years	11	39.727	6.1982			
	>20 years	7	39.857	4.2201			

Table 5: Comparing diabetic retinopathy and corneal morphological parameters

Fundus with Corneal Parameters		*n*	Mean	Std. Deviation	*F*	*P*	SIG
ECDRE	Normal	33	2333.606	327.9392	4.813	0.0001	<0.05, SIG
	Mild NPDR	20	2247.800	323.4592			
	MOD NPDR	13	2447.231	244.0776			
	Severe	8	2132.875	366.9825			
	Very severe	8	1827.625	339.2260			
	Early PDR	4	2269.500	437.7370			
	High risk PDR	4	1927.250	312.1713			
	ADED	2	1584.500	301.9346			
AVGRE	Normal	33	428.212	73.6732	5.120	0.0001	<0.05, SIG
	Mild NPDR	20	437.350	76.5488			
	MOD NPDR	13	394.462	52.0426			
	Severe	8	452.625	86.3414			
	Very severe	8	550.000	92.8855			
	Early PDR	4	452.750	84.3263			
	High risk PDR	4	511.750	67.8546			
	ADED	2	617.000	158.3919			
CVRE	Normal	33	44.818	7.9035	1.317	0.252	>0.05, NO SIG
	Mild NPDR	20	47.650	9.9593			
	MOD NPDR	13	42.692	5.3133			
	Severe	8	45.250	11.7565			
	Very severe	8	46.875	11.9933			
	Early PDR	4	55.250	9.6393			
	High risk PDR	4	40.250	4.7871			
	ADED	2	42.500	12.0208			
HCRE	Normal	33	39.879	7.2962	1.274	0.273	>0.05, NO SIG
	Mild NPDR	20	36.100	8.0322			
	MOD NPDR	13	41.308	5.6478			
	Severe	8	38.000	6.4807			
	Very severe	8	39.000	4.3425			
	Early PDR	4	43.250	3.3040			
	High risk PDR	4	41.250	3.4034			
	ADED	2	44.000	1.4142			

patients. It was clearly observed that there was a significant difference between the diabetics and other subjects regarding endothelial cell parameters. The endothelial cell density and percentage of hexagonal cells were less in diabetic patients than in the nondiabetic group.

In this study, on correlating HbA1c with diabetic retinopathy, it was found that diabetic retinopathy severity increases with increase in HbA1c values. This observation was considered statistically significant as the *P* value obtained is < 0.05. In this study, on correlating diabetic age with diabetic retinopathy, it was found that diabetic retinopathy severity increases with increase in diabetic age, and on correlating diabetic age with corneal morphological parameters, it shows that the mean corneal endothelial cell density decreased with increase in diabetic age. The mean average cell size increased with increase in diabetic age. These two observations were considered statistically significant as the *P* value obtained is < 0.05. According to a study by Taşlı N *et al*.[5] at Erzincan Binali Yildirim University, it was seen that diabetic patients had a significantly higher central corneal thickness, average cell size, and CV% than healthy controls but significantly lower ECD and hexagonal cell ratios. The ECD and hexagonal cell ratio declined as diabetic retinopathy progressed, although the average cell size and CV% increased. When correlation analysis was done, ECD and diabetic age revealed a strong negative association.

Additional research revealed that individuals with type 2 diabetes also had a significant decline in ECD and hexagonality and an increase in CV. The corneal endothelia in diabetics and nondiabetics have been examined in a number of studies, and the majority of them conclude that diabetes patients' corneal endothelium undergoes morphological alterations. Nonetheless, a number of studies discovered no differences in the ECDs of individuals with diabetes and those without it; in the current investigation, significant differences were found in ECD, CV, average cell size, and hexagonality between individuals with long-term diabetes and controls of all ages.

Limitations of this study include restrictions associated with specular microscopy. A number of variables, including corneal pathology, patient compliance, and clarity of the cornea, might impact the quality of the image. A more community-based study would have provided more accurate data. Also, the sample size of our study, 92 in each group, obtained based on a previous study, may not have been sufficient to know the true extent of the disease.

CONCLUSION

In this study, it is found that there are alterations in corneal morphological parameters with presence of Type 2 diabetes mellitus, increase in diabetic age, and severity of diabetic retinopathy. Presence of microscopic changes in diabetic corneas may increase their sensitivity to harmful stimuli. In diabetic patients, there will be corneal morphological alterations and it is found that there is decreased corneal endothelial cell density, increased average cell size, increased coefficient of variation (polymegathism), and decreased hexagonality (pleomorphism), which is not associated with age-matched nondiabetic individuals. The results of this investigation corroborate previous notions of reduced ECD among participants with Type 2 DM compared to nondiabetic persons. Hence, early ophthalmologic screening of patients with DM can help in detection of keratopathy and retinopathy. This signifies importance of screening programs and patient education to diabetic patients to avoid preventable blindness caused due to diabetes-associated retinopathy and keratopathy. Thus, in those with DM, routine corneal endothelial evaluation and dilated fundus examination are necessary.

Ethical approval

The study was approved by the Institutional Ethics Committee.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Evaluation of artificial intelligence generated responses of commonly asked ophthalmic queries

ABSTRACT

Purpose: To evaluate artificial intelligence generated responses of commonly asked ophthalmic queries. **Methods:** In this study, 10 common questions related to ophthalmic conditions were prepared by experienced ophthalmologists based on common queries by patients in India. The responses to these questions were obtained from ChatGPT. The responses were scored for accuracy, completeness, and understandability by two experienced unacquainted ophthalmologists. **Results:** In this study, mean values of overall scores for accuracy, completeness, understandability of ChatGPT responses graded fair (mean scores of 3.25 ± 0.75, 1.95 ± 1.5 and 2.3 ± 0.7, respectively). Understandability of responses to surgery related queries were significantly low compared to non-surgical ones (P = 0.041). **Conclusions:** Study findings indicate ChatGPT's responses to overall accuracy, completeness and understandability were just fair, suggesting ChatGPT offers information to some extent, but it falls short of expert ophthalmologist's level.

Keywords: Accuracy, artificial intelligence, ChatGPT, completeness, understandability

INTRODUCTION

Artificial intelligence (AI), the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.[1] AI in varying forms and degrees has been used to develop different function like Automation, Machine learning and vision, Natural language processing, Robotics, Self-driving car.[2] Artificially intelligent computer systems are used extensively in medical sciences. Applications of AI in the field of medical sciences include matching patient symptoms to appropriate physician, patient diagnosis, patient prognosis, drug discovery, bot assistant that can translate languages, transcribe notes, and organize images and files.[3]

AI-based ChatGPT developed by OpenAI is now widely accepted in several fields, including education. ChatGPT is a public tool developed by OpenAI that is based on the GPT language model technology (Kirmani, 2022). It is a highly sophisticated chatbot that can fulfill a wide range of text-based requests, including answering simple questions and completing more advanced tasks such as generating thank you letters and guiding individuals through tough discussions about productivity issues. The term "Generative Pre-trained Transformer (GPT)" refers to a language processing model trained on massive data to produce writing that resembles a person. As a result, it creates information more conversationally, picks up knowledge from those talks, and then can provide ever more specifically customized replies. ChatGPT behaves like a person, while giving instructions to users and providing information. This technology can do various activities, including creating poetry, coding, answering inquiries, writing emails and essays, and translating documents. ChatGPT differs from other chatbots in that it can respond instantly, resulting in more varied and lively discussions on almost all topics.[4,5]

Mahesh Babu, Boggarapu Sumanth, Shruthi Konatham

Department of Ophthalmology, KVG Medical College and Hospital, Sullia (D K), Karnataka, India

Address for correspondence: Dr. Boggarapu Sumanth, Department of Ophthalmology, KVG Medical College and Hospital, Sullia (D K), Karnataka - 574 327, India.
E-mail: sumanthboggarapu@gmail.com

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In March 2023, OpenAI released ChatGPT-4, which has enhanced capabilities in advanced reasoning, complex instructions, and creativity. While the earlier version is a text-to-text model, the updated version is a multimodal model accepting image and text inputs and emitting text output. Furthermore, the updated version's neural network has approximately 100 trillion parameters compared with the earlier version's 175 billion parameters.[6]

Now a days most of the people relay on digital platforms that are supported by artificial intelligence like ChatGPT for their symptoms analysis and to clear their doubts related medical conditions. So, in this study we aimed to assess the accuracy, completeness, understandability of AI generated responses to commonly asked queries related to ophthalmic conditions.

METHODOLOGY

This study for undertaken after obtaining institutional ethics committee approval (dated 19-11-2023). In this study 10 common questions related to ophthalmology prepared by the experienced ophthalmology doctors based on patients' way of presenting symptoms and asking doubt's related to common ocular ailments. There were 10 questions with possible detailed descriptive responses. The responses to these questions were obtained from Bing: Chat with AI and GPT-4 POWERED BY ChatGPT's GPT-4. The responses were recorded and analyzed and scored for accuracy, completeness, and understandability by two expert Ophthalmologist with more than 10 years of experiences by using Likert scale as follows.

Accuracy refers to the correctness of the information provided; Completeness refers to the extent to which the information provided covers all relevant aspects of a topic and Understandability refers to how easily the information can be grasped and interpreted by users.

Scoring of AI-generated responses were done as follows:

1. Scoring for Accuracy
    - Incorrect: score 1
    - More incorrect than correct: score 2
    - Equal incorrect and equal correct: score 3
    - More correct than incorrect: score 4
    - Correct: score 5.

2. Scoring for completeness
    - Incomplete: score 1
    - Near complete: score 2
    - Complete: score 3.

3. Scoring for Understandability
    - Complex (too technical to understand): score 1
    - Understandable (need simplification): score 2
    - Simple and understandable: score 3.

If the scores between the two sets differ by more than one value, a third ophthalmologist is consulted for adjudication. The mean value of the scores from the initial two experts, and the score provided by the third ophthalmologist, is calculated. If the score from the third ophthalmologist does not align with the initial assessments by the first two experts, the mean of all scores is considered for final evaluation.

Final grading based on the mean score was as follows,

1. Accuracy Grading:
    - Good Accuracy: Mean scores above 4 (>4)
    - Fair Accuracy: Mean scores between 2 and 4 (2–4)
    - Poor Accuracy: Mean scores below 2 (<2).

2. Completeness Grading:
    - Good Completeness: Mean scores greater than 2.5 (>2.5)
    - Fair Completeness: Mean scores between 1.5 and 2.5 (1.5–2.5)
    - Poor Completeness: Mean scores less than 1.5 (<1.5).

3. Understandability Grading:
    - Good Understandability: Mean scores greater than 2.5 (>2.5)
    - Fair Understandability: Mean scores between 1.5 and 2.5 (1.5–2.5)
    - Poor Understandability: Mean scores less than 1.5 (<1.5)

The data was entered in Microsoft excel sheet and analyzed using statistical Package for the Social Sciences (SPSS) version 20. Kruskal Walli's test was performed to evaluate scores awarded for each question. *Post hoc* analysis using Tukey's test were used to determine if there were significant difference in accuracy between scores provided by two ophthalmologists. Chi square test was used to analyses the scores. A P value of < 0.05 was considered significant.

RESULTS

The first ophthalmologist's mean accuracy score was 3.2 ± 0.8, the mean completeness was 2.2 ± 0.8 and the mean understandability score was 2.1 ± 0.9. The 2nd ophthalmologist's mean accuracy score was 3.3 ± 0.6, the mean completeness was 1.8 ± 0.8 and the mean understandability score was 2.0 ± 0.5. However, there were no statistically significant difference between mean scores of two ophthalmologists ($P > 0.05$) suggesting scores were comparable as shown in Table 1.

The individual accuracy scores for all 10 responses were graded as "fair" (as none of the questions got a score

above four and below two) whereas for completeness and understandability the scores were grade "good," "fair," and "poor." Combined scores (ophthalmologist 1 and 2) of the accuracy, completeness, understandability of individual responses are shown in Table 2.

Combined scores of ophthalmologists 1 and ophthalmologists 2 for Accuracy the combined score for accuracy graded as "fair." Among all the queries, response to query four got better score of four, whereas queries 3, 8, and 10 scored lowest with score of 2.5. The scores of all the 10 queries graded "fair" with scores between 2 and 4. And for completeness responses to queries 5 and 7 got a score of 2.5 and lowest score of 1.5 for responses to the queries 3, 9, and 10 and for understandability Among all queries, responses to queries 4 and 7 got a score of 3 and graded as good and rest of responses were graded "fair." Mean values of overall scores for accuracy, completeness, and understandability are shown in Table 3 and is graded as "fair."

In our study among 10 responses, responses of queries 1, 2 and 3 were related to the surgical procedure and explanation about it. Response to remaining 7 queries were not related to surgical procedures.

The Table 4 shows the comparison of responses with surgical component and without surgical component. There is statistically significant difference in the overall mean understandability responses between the surgical component and with non-surgical component with *P* value of 0.041, however overall mean accuracy and overall mean completeness show no significance with *P* value being >0.05.

Table 1: Comparison of mean values of scores awarded by two ophthalmologists

	Ophthalmologist 1			Ophthalmologist 2			*P*
	Mean	SD	IQR	Mean	SD	IQR	
Accuracy	3.2	0.8	2.0	3.3	0.7	1.0	0.174
Completeness	2.2	0.8	0.0	1.8	0.8	1.0	0.075
Understandability	2.1	0.9	1.0	2.0	0.5	0.0	0.176

DISCUSSION

ChatGPT is a highly sophisticated chatbot that can fulfill a wide range of text-based requests, including answering simple queries. As ChatGPT is more widely accessible and useful to the public these days, it has become a popular way for the public to get information about general health concerns and questions regarding eye problems.

In our current study, we evaluated the responses provided by ChatGPT to the questions related to ophthalmic conditions and diseases prepared by experienced ophthalmology doctors based on commonly asked doubts by Indian patients to ophthalmologists in India. To the best of our knowledge, this is the first study to evaluate the AI response.

Mean scores awarded to the AI-generated responses by two different ophthalmologists were comparable as the difference was not statistically significant.

In our study, individual scores for responses to accuracy were graded as "fair," while for completeness and understandability grading varied.

From cumulative scores for accuracy, no response got a score of 5. Response to query 4 (What are the effects of smoking in the eyes?) got better score of 4 and was graded "fair" probably because the query was simple and straight forward. Response to queries 3, 8 and 10 got lowest score of 2.5 mostly because the queries were complex and required lots of comprehension.

For completeness, Response to query 5 (What are the causes of blurring of vision in children?) and for Query 7 (What are the causes of watering of eyes?) got a better score of 2.5 and graded as "fair." This could be because of nonspecific and vague nature of queries. Responses to queries 3, 9, and 10

Table 2: Combined scores of the accuracy, completeness, and understandability of individual responses

Queries	Combined accuracy (maximum 5)	Combined completeness (maximum 3)	Combined understandability (maximum 3)
1. Which surgery is good for refractive error	3.5	2.0	1.5
2. What are the treatment options for glaucoma	3.5	2.0	2.0
3. What is the best treatment for cataract in old age people?	2.5	1.5	2.0
4. What are the effects of smoking in the eyes?	4.0	2.0	3.0
5. What are the causes of blurring of vision in children?	3.5	2.5	2.5
6. What are the causes of redness in the eye?	3.5	2.0	2.5
7. What are the causes of watering of eyes?	3.5	2.5	3.0
8. What are the effects of diabetes in the eye?	2.5	2.0	2.0
9. What are the effects of pregnancy in the eye?	3.5	1.5	2.5
10. What are the causes of double vision?	2.5	1.5	2.0

Table 3: Mean values of overall scores for accuracy, completeness, understandability

	Over all mean±SD
Accuracy (maximum score of 5)	3.25±0.75
Completeness (maximum score of 3)	1.95±1.5
Understandability (maximum score of 3)	2.3±0.7

Table 4: Mean scoring for responses to questions related to and not related surgical procedures

	Queries related to surgical procedures		Queries not related to surgical procedure		*P*
	Mean	SD	Mean	SD	
Overall accuracy	3.16	0.42	3.28	0.48	0.097
Overall completeness	1.83	0.21	2.00	0.26	0.130
Overall understandability	1.83	0.27	2.50	0.29	0.041*

got the lowest score of 1.5. This is probably because of the specific nature of queries.

And for understandability, Responses to query 4 and 7 got a better score of 3 and were graded as "good," this could be because of direct and simple nature of queries. And for response to query 1 got lowest score of 1.5 and graded as "fair," this could be because of the complex nature of the response.

However, over all the mean values of the combined scores of ophthalmologists 1 and ophthalmologist 2 for accuracy, completeness, and understandability were graded as "fair."

Responses to queries 1, 2, and 3 are explained with surgical procedures. For these three queries, the mean scoring for overall accuracy 3.16 ± 0.42, for Overall completeness the mean scoring 1.83 ± 0.21. and Overall understandability, the mean scoring 1.83 ± 0.27.

The final seven queries have only a medical management as an explanation. For these seven responses, the mean scoring for Overall accuracy, completeness, and understandability are 3.28 ± 0.48, 2 ± 0.26, 2.5 ± 0.29, respectively.

When we compared responses of surgical and non-surgical queries, they fall under the grades of "fair" for accuracy completeness and understandability, but there is statistical significance difference with respective to mean values for understandability, this suggest response to queries related to surgical procedure are not easily understood by common people due to a lot of medical terminology were used.

In comparison with queries related to surgical procedures, queries with a non-surgical procedure have a noticeably lower understandability rate, for which the *P* value is 0.041, which is less than 0.05.

The most critical technical issue is training data bias, as ChatGPT's underlying algorithms are only as good as the data they are trained on, and are therefore prone to errors in their responses. Consequently, it would be part of GCP (Good clinical practice) to train and validate the ChatGPT algorithm, for example, for diagnosis and therapy-accompanying applications on relevant, evidence-based knowledge bases, before it can be used. Here, approaches and concepts as known from medical device approval should be considered, including requirements and usability engineering, risk assessment and clinical evaluation.[7]

CONCLUSION

Our study findings indicate that ChatGPT's responses to overall scores, particularly in the medical and surgical ophthalmic domain, were rated as fair and only few individual responses were rated as good.

Responses of ChatGPT with respective common ophthalmic queries were just "fair" and not completely accurate, complete, and understandable by common people. Future response to surgery related queries were too complex to be understood.

This suggests that while ChatGPT offers information to some extent, its accuracy, completeness, and understandability fall short of expert levels compared to the ophthalmologists. ChatGPT's responses may lack depth or overlook important details that could be crucial for making informed decisions in medical contexts.

Therefore, relying solely on ChatGPT for medical advice or information in ophthalmology may not be advisable. Our comparison underscores the importance of seeking professional expertise, when dealing with medical queries or concerns in ophthalmology. Consulting with expert ophthalmologists ensures that individuals receive accurate, comprehensive, and easily understandable information tailored to their specific needs and circumstances.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Comparison of superior and inferior laser peripheral iridotomies in primary angle closure disease – A randomized clinical trial

ABSTRACT

Aim: The purpose of this study was to assess the efficacy and side-effects of superior versus inferior laser peripheral iridotomy (LPI) in the management of primary angle-closure disease (PACD). **Methods:** In this prospective interventional randomized single-masked study, patients who were 30 years of age or older, diagnosed as primary angle-closure suspects (PACS) or primary angle closure (PAC) or primary angle-closure glaucoma (PACG) were randomized into two groups- superior LPI and inferior LPI. The outcome measures were patency of iridotomy, intraocular pressure (IOP), and visual side-effects at each visit during the six-month follow-up. **Results:** Three hundred and four eyes of 152 patients were included. The mean IOP reduced from 24.64 ± 6.35 mmHg and 24.62 ± 7.34 mmHg to 19.08 ± 2.86 mmHg and 19.07 ± 2.62 mmHg in superior and inferior LPI eyes, respectively. All LPIs were patent at six months. The mean total laser energy required to perform LPI was less in group 2 (2.8 ± 1.4 mJ) than in group 1 (4.4 ± 1.6 mJ, $P < 0.01$), though similar initial laser energy settings were used in both groups. The post-LPI inflammation was also lesser in inferior LPI ($P = 0.033$). Two patients in both groups demonstrated dysphotopsia symptoms after LPI ($P = 1.00$). **Conclusion:** Both superior and inferior LPIs were equally effective though inferior LPIs required lower laser power.

Keywords: Angle closure glaucoma, Inferior laser peripheral iridotomy, laser peripheral iridotomy, primary angle closure disease, superior iridotomy

INTRODUCTION

Laser peripheral iridotomy (LPI) is the primary treatment for treating angle-closure glaucoma caused by relative or absolute pupillary block.[1] LPI eliminates pupillary block by allowing the aqueous to pass directly from the posterior chamber into the anterior chamber, bypassing the pupil, which results in a significant increase in angle width.[2-4]

LPI is performed with either an argon laser or a neodymium: yttrium aluminum garnet (Nd: YAG) laser, or in certain circumstances, with both. The iridotomy site should be in the peripheral third of the iris, just anterior to the arcus. A crypt or a thinned area of the iris is recommended. Conventionally, many ophthalmologists place the iridotomy between 11 and 1 o'clock, where the lid may cover it. Some previous studies suggested that the superior location of the LPI might be responsible for visual disturbances after the procedure.[5,6] A few studies implicated LPI location proximate to the eyelid margin as the cause of dysphotopsias, whereas others found no such association.[6-9] Inferior peripheral iridectomy in patients receiving silicone oil has previously been reported.[10]

There have been studies comparing superior to temporal LPI, but there is limited research assessing the differences between superior and inferior LPI.[7,9] In our clinical practice, we sometimes choose to perform LPI inferiorly, particularly when there is an iris crypt or a thinner area of the iris present. Emphasizing the importance of further research in this area

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Mithun Thulasidas
Department of Glaucoma, Trinity Eye Hospital, Calicut, Kerala, India

Address for correspondence: Dr. Mithun Thulasidas, Department of Glaucoma, Trinity Eye Hospital, Calicut, Kerala - 673 016, India.
E-mail: mithun.thulasidas@gmail.com

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could significantly enhance our understanding and treatment options in iridotomy procedures. The purpose of the present study was to compare the efficacy and side effects of superior and inferior laser LPI in patients who had presented with primary angle closure disease (PACD).

METHODS

This prospective interventional randomized single-masked double-centre study was conducted between April 2023 and April 2024. The Institutional ethical committee approval was obtained before beginning the study. A written informed consent according to the tenets of the Declaration of Helsinki was obtained prior to inclusion in this study.

The inclusion criteria were as follows (based on the International Society for Geographical and Epidemiological Ophthalmology [ISGEO] classification system):[11]

a. Primary angle closure suspect (PACS) group comprising of eyes with iridotrabecular contact (ITC) ≥180°, normal intraocular pressure (IOP), no evidence of peripheral anterior synechiae (PAS), and no optic nerve damage
b. Primary angle closure (PAC) group comprising of eyes with ITC ≥180°, elevated IOP or evidence of PAS and no optic nerve damage
c. Primary angle closure glaucoma (PACG) group comprising of eyes with ITC ≥180°, elevated IOP or evidence of PAS, and glaucomatous optic neuropathy.

Among PACS group, only those with a family history of glaucoma or contralateral eyes of PAC/PACG or ITC 360 degrees were included in the study.

Patients <30 years of age, on anti-glaucoma medications, diagnosed to have secondary glaucoma, with evidence of any anterior segment pathology like conjunctivitis, keratitis, or acute uveitis, history of opaque ocular media (as in cataracts, corneal opacities, vitreous opacities), ocular surface disorders, ocular surgery including prior laser procedures, ocular trauma, non-glaucomatous optic neuropathies, vascular or non-vascular retinopathies, choroidal pathologies, and other ocular or systemic diseases that may affect vision were excluded.

Randomization and masking

Using a binary random number generator, one eye was selected and then randomized to an LPI in the superior or inferior location using the same method. The other eye was, by default, assigned the opposite location. Patients were masked to the location of treatment performed in each eye (single-masked). Figure 1 shows the patient disposition flowchart.

LPI procedure

The LPI was placed in the superior region (between the 10 and 2 o'clock positions) (group 1) or in the inferior region (between the 4 and 8 o'clock positions) (group 2) in the peripheral third of the iris, wherever the iris appeared thinnest. Pilocarpine 2% was instilled twice into the intervention eye before treatment. An Abraham (+66 dioptres) iridotomy lens was placed on the eye with coupling gel. Nd: YAG laser (Appa Yag Laser, Model 307, Appasamy Associates, Tamil Nadu, India) was used at an initial setting of 1 mJ (zero defocus) and then increased, if required, to 3 mJ until the iris was fully perforated and an iridotomy of approximately 0.3-0.5 mm was achieved. Full-thickness perforation was confirmed when aqueous came forward from the posterior chamber to the anterior chamber with pigment dispersion. Immediately after the LPI patients were given a drop of Brimonidine tartrate 0.2% to blunt any spike in IOP. At 1 hour after completion of LPI, the IOP was rechecked to ensure that it did not increase significantly. An anti-glaucoma medication is added only if the elevated IOP at one-hour post-procedure is >25 mmHg. However, PACG patients were given anti-glaucoma medication based on the severity of glaucoma on visual field analysis. All patients were given 1% Prednisolone eyedrops to apply four times daily for one week. The laser energy was determined by multiplying the energy setting per shot by the number of shots. All patients had a follow-up on day one, one week, one month, three months, and six months.

The outcome measures included the patency of LPI, IOP at different follow-ups, side-effects and dysphotopsia associated with LPI. The patency of LPI is confirmed by gonioscopy and the appearance of a fully perforated iris on anterior segment optical coherence tomography (AS-OCT, CIRRUS HD-OCT, Model 5000). The IOP is measured using Goldmann applanation tonometry. Clinically significant iritis is defined as ≥ grade 2 + cells using the Standardization of Uveitis Nomenclature (SUN) grading system.[12]

Sample size calculation

The sample size was estimated using the formula-

$$N = Z2\ (1\text{-}a/2)\ SD2/D2$$

where N = required/minimum sample size, z = standard normal variate corresponding to 95% confidence level = 1.96, SD = Standard deviation of the variable = 0.2 and D = Margin of error of 5% (standard value, being 0.05). This gives a sample size of 280 (140 subjects) to achieve 80% power with a 5% level of significance to detect the differences between the two groups. After adding contingencies such as the non-response rate or record error, the sample size was

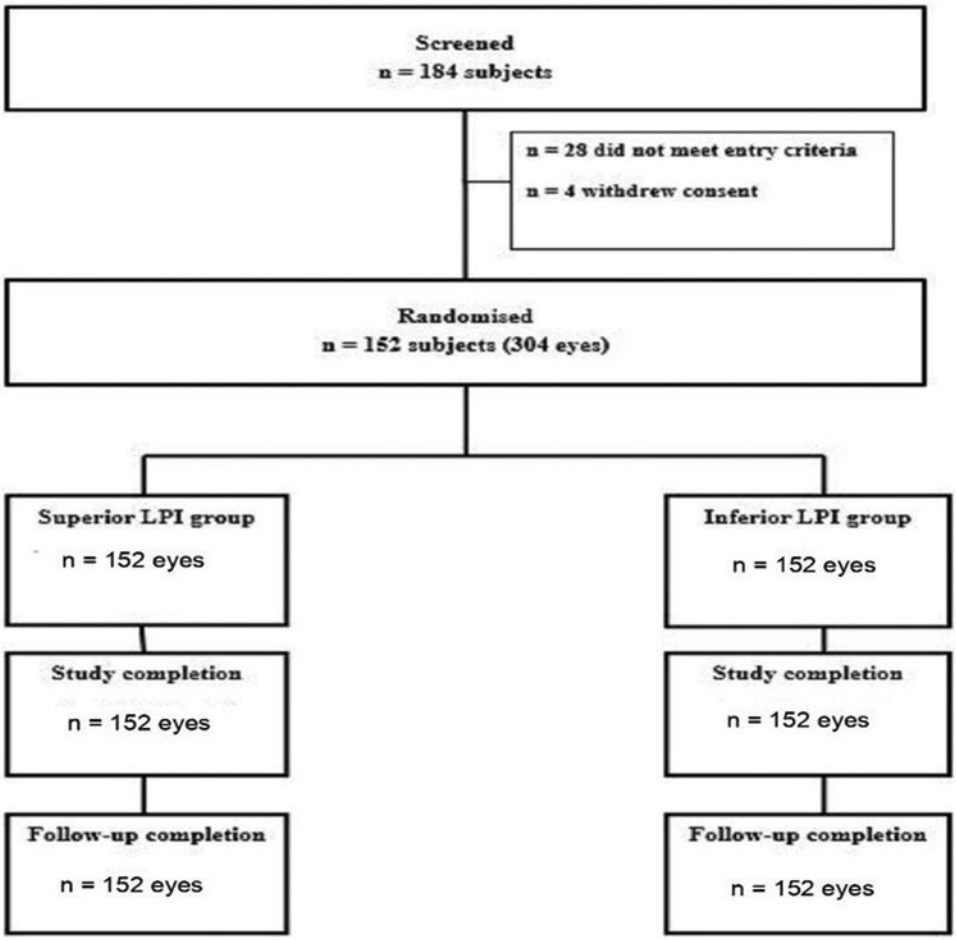


Figure 1: Patient disposition flowchart

finalized at 304 (152 subjects) with equal distribution (152 eyes) in the two arms of the study.

Statistical analysis

Data were entered in the Microsoft Excel software in codes, and analysis was done with Statistical Package for Social Sciences (SPSS-24, IBM software computer package). Categorical variables were expressed as frequency and percentages. The test of normality was done using Kolmogorov-Smirnov and Shapiro-Wilk. Continuous variables were summarized with measures of central tendency. The paired *t*-test and McNemar test were used to compare the differences between the groups. For all the tests of significance, a *P* value less than 0.05 was considered statistically significant.

RESULTS

A total of 304 eyes of 152 patients were analysed (152 eyes in each group). There were 53 (34.86%) males and 99 (65.13%) females. The mean age was 56.74 ± 8.2 years. Table 1 shows the demographic data.

A full-thickness iris perforation was achieved in all eyes with less than five shots without the need for augmentation later. At day 1, the mean IOP reduced from 24.64 ± 6.35 mmHg and 24.62 ± 7.34 mmHg to 19.08 ± 2.86 mmHg and 19.07 ± 2.62 mmHg in superior and inferior LPI eyes, respectively. Table 2 shows the change in IOP at different follow-up periods between the groups. All the iridotomies were patent at six months follow up. The same initial laser energy settings were used in both groups, starting with 1 mJ. However, the mean total laser energy required to perform LPI was less in group 2 (2.8 ± 1.4 mJ) than in group 1 (4.4 ± 1.6 mJ, $P < 0.01$). Table 3 shows the comparison of total energy used for LPI in different stages of PACD.

There was no significant difference in the incidence of iris bleeding or IOP elevation following treatment. No eyes had an IOP elevation >25 mmHg at one-hour post-procedure. However, a significantly lesser post-LPI iritis was observed with inferior LPI than with superior LPI ($P = 0.033$). Table 4 shows the side effects post-LPI in both groups.

Table 1: Demographic data of study participants

Characteristic	
n	152 (304 eyes)
Age (years)	
Mean±SD	56.74±8.2
Gender (*n*)	
Male	53 (34.87%)
Female	99 (65.13%)
Stage of PACD (*n*)	
PACS	42 (27.63%)
PAC	78 (51.32%)
PACG	32 (21.05%)

SD=Standard deviation, PACD=Primary angle closure disease, PACS=Primary angle closure suspect, PAC=Primary angle closure, PACG=Primary angle closure glaucoma

Table 2: Intraocular pressure changes at different follow-up periods between the groups

	Intraocular pressure (mmHg)		*P*
	Group 1, Superior LPI (*n*=152)	Group 2, Inferior LPI (*n*=152)	
Baseline	24.64±6.35	24.62±7.34	0.792
Day 1	19.08±2.86	19.07±2.62	0.671
1 month	17.06±1.56	17.02±1.58	0.567
3 months	16.98±1.68	16.87±1.52	0.249
6 months	16.78±1.76	16.74±1.6	0.568

LPI=Laser peripheral iridotomy, paired-*t* test

There were no differences in reported dysphotopsia after LPI for both superiorly treated and inferiorly treated eyes though two patients demonstrated linear dysphotopsias in both groups after LPI ($P = 1.00$).

DISCUSSION

LPI has been placed superiorly for many years, between 11 and 1 o'clock. Although there has been some anatomical justification for this choice of location, such as avoiding certain blood vessels, the primary reason for choosing this location was to cause the PI to be covered by the eyelid most of the time. The belief was that this would prevent the creation of visual aberrations. However, some studies concluded that nasal or temporal LPI locations are better or equivalent to superior LPI concerning the production of visual dysphotopsia symptoms.[7,9] In the present study, we assessed the outcomes of superior versus inferior LPI in Indian patients with PACD.

Jiang *et al*.[13] found that 82.4% of patients had a successful outcome after three years of Nd: YAG LPI for acute angle closure glaucoma. In our study, all 304 iridotomies in both groups were patent at six months follow-up. We included the entire spectrum of PACD (PACS, PAC, PACG) and only the Nd: YAG laser was used for the procedure.

Ahmadi *et al*.[14] evaluated the efficacy and safety of superior versus inferior LPI in the treatment of PACG. They observed

Table 3: Comparison of total energy used for laser peripheral iridotomy in subsets of primary angle closure disease between the groups

Stage of PACD	Laser energy (mJ)		*P*
	Group 1, Superior LPI	Group 2, Inferior LPI	
PACS	4.2±1.4	2.6±1.0	<0.01*
PAC	4.2±1.6	2.7±1.2	<0.01*
PACG	4.5±1.6	2.8±1.2	<0.01*

PACD=Primary angle closure disease, PACS=Primary angle closure suspect, PAC=Primary angle closure, PACG=Primary angle closure glaucoma, LPI=Laser peripheral iridotomy, *statistically significant (paired *t*-test)

Table 4: Comparison of side-effects post-procedure between the groups

Side-effect (*n*)	Group 1, Superior LPI (*n*=152)	Group 2, Inferior LPI (*n*=152)	*P*
Iris bleeding	27 (17.76%)	21 (13.81%)	0.687
Transient IOP elevation (one-hour post-procedure)	14 (9.21%)	10 (6.57%)	0.541
Iritis (Day one)	88 (57.89%)	66 (43.42%)	0.033*
Linear dysphotopsia	2 (1.3%)	2 (1.3%)	1.000

*Statistically significant (McNemar test). LPI=Laser peripheral iridotomy, IOP=Intraocular pressure

that inferior LPIs required less mean total laser energy to perforate the tissue ($P = 0.05$) than superior LPIs. Similarly, in the present study, it was found that the mean total laser energy and number of shots required to perform LPI was less in the inferior approach, though similar initial laser energy settings were used in both groups. The lesser energy and fewer shots could be attributed to the laser hitting the target area more directly with the inferior approach. Additionally, the iris may naturally be thinner in the inferior region, although we haven't found any evidence to support this hypothesis.

The most frequent complication of LPI is a transient IOP increase. Jiang Y *et al*.[15] reported that LPI in primary angle-closure suspects (PACS) resulted in a significant IOP rise in 9.8% and 0.82% of cases at 1 hour and two weeks, respectively. Eyes in which more laser energy and a higher number of laser pulses were used and those with shallower central anterior chambers were at increased risk for IOP spikes at 1 h after LPI. In the study by Ahmadi *et al*.,[14] inferior LPI resulted in lower IOP elevation following treatment ($P = 0.002$) than superior LPI. However, in our study, there was no significant difference in the IOP rise after LPI between the two groups.

Focal corneal endothelial or lens damage may occur with laser treatment due to the proximity of these structures to the peripheral iris. Laser energy delivered at the time of treatment and the altered fluidics of the eye may have other ramifications, including the hastening of corneal

endothelial cell dysfunction. Focal corneal opacity above the YAG iridotomy site depends on the distance between the endothelium and iris surface and the total Nd: YAG energy used.[16,17] In the present study, no corneal damage was noted over the follow-up period. We believe that proper focusing can minimize this problem.

Studies reported up to 45% of iris bleeding following YAG laser iridotomy.[18,19] In this study, iris bleeding was noted in 27 eyes with superior LPI and 21 eyes with inferior LPI, which was not statistically significant. However, suppose bleeding occurs in undiagnosed coagulopathy cases, during the superior LPI, with a significant amount of bleeding in the anterior chamber, visualization is difficult for further shots as blood covers the iris surface from top to bottom. Nevertheless, with an inferior approach, even if bleeding occurs, the width of the iris in the upper portions is visible for further shots.

Post-laser significant iritis was noted in 51% of eyes (88 eyes in group 1 and 66 eyes in group 2), and superior LPI resulted in a significantly higher incidence of iritis. This could be due to an increase in energy used for superior LPI. In most cases, it settled within 72 hours with post-procedure topical steroid regimen. This observation is similar to the finding by Ahmadi *et al*.,[14] where a lower incidence of post-LPI iritis was seen with inferior LPI.

Patients may also complain of visual aberrations after LPI. The position of the LPI seems to be the major factor that determines whether or not the streak of light develops after the procedure. These visual aberrations may be from the iridotomy hole itself or the size of the perforation and the prismatic effect of the tear film at the lid margin. A larger hole may result in less diffraction of the light, decreasing the likelihood of a visible dysphotopsia and a smaller hole might tend to produce the pinhole effect, creating sharper unwanted images on the retina. Also, it could be from the refraction of light by the tear film. Weintraub and Berke found that dysphotopsia symptoms occurred in some patients even when the LPI was entirely placed under the upper eyelid, proposing a base-up prism effect of the tear meniscus at the edge of the upper eyelid as the cause of dysphotopsia.[20] Because the coverage of the iris by the upper lid margin is higher than the lower lid margin and the likelihood of a dysphotopsia is more likely to occur with a LPI partially or fully covered by the lid margin, inferior placement of LPI is safe and seems to reduce the occurrence of postoperative dysphotopsias. A study by Vera and associates compared dysphotopsia after temporal versus superior LPI and reported that temporal placement of LPI is safe and is less likely to result in linear dysphotopsia than superior placement.[7] However, Srinivasan *et al*.[9] found that the occurrence of visual dysphotopsias did not differ by LPI location. In the present study, two patients complained of linear dysphotopsia in both the groups which was not statistically significant.

Inferior LPIs require fewer shots and less laser power to perforate the tissue. Furthermore, an inferior approach is preferable in patients with dense arcus and thick iris.

The strengths of this study include the inclusion of the entire spectrum of PACD and the study design. Our study has some limitations too. A questionnaire on subjective visual quality and post-procedure pain to evaluate patient satisfaction would have added more information. While the study was single-masked, the investigators were not masked. This could introduce bias, particularly in the assessment of subjective outcomes such as dysphotopsia. A double-masked design (where both patients and investigators are masked) would have been more robust. The study had a 6-month follow-up period, which is relatively short for evaluating long-term outcomes such as the durability of IOP control, the persistence of iridotomy patency, and the incidence of late-onset complications such as cataract and corneal endothelial cell loss. Also, the use of specular microscopy to assess the corneal endothelium and the use of ultrasound biomicroscopy and AS-OCT to evaluate the angle parameters pre- and post-LPI could have been included. Further double-masked studies with a larger sample size and follow-up, representing diverse population based on age, gender, race, and ethnicity may provide more significant results.

CONCLUSION

Both superior and inferior LPIs were equally effective, with no significant difference in visual side effects. Nevertheless, the laser energy required was less in inferior LPIs. Performing inferior LPI may be technically easier, particularly in patients with thicker iris or dense arcus senilis.

Ethical clearance

Institutional ethical committee approval was obtained before commencing the study. A written informed Consent according to the tenets of the Declaration of Helsinki was obtained.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Evaluating the impact of overnight orthokeratology on myopia control in patients with moderate myopia and astigmatism – A prospective study

ABSTRACT

Background: Myopia, a prevalent refractive error, is projected to affect nearly half of the global population by 2050. Traditional corrective measures like spectacles and daytime contact lenses do not address myopia progression. Orthokeratology (Ortho-K), a nonsurgical procedure that reshapes the cornea overnight, has emerged as a promising approach to correct refractive errors and potentially slow myopia progression. This study aims to evaluate the impact of overnight Ortho-K lenses on visual acuity, corneal thickness, and axial length in young adults with moderate myopia, with or without astigmatism. **Methods:** This was a prospective interventional study conducted at a tertiary care hospital in North India over a year. Sixty patients aged 15–30 years with myopia up to -5.0 D and corneal astigmatism up to -1.50 D were included. Baseline measurements of refractive error, corneal thickness, and axial length were taken, followed by follow-ups at 3 months, 6 months, and 1 year. Ortho-K lenses were worn overnight for an average of 6 hours. Statistical analysis was performed using repeated measures ANOVA and *post hoc* paired Student's t-tests. **Results:** The study observed a significant improvement in unaided visual acuity (VA) among participants. At baseline, a large proportion of participants had poor VA, but by the first follow-up, 7.02% achieved 6/6 vision, and this percentage increased to 85.11% by Day 90. The axial length remained stable throughout the study, with minimal fluctuations from the baseline of 24.10 mm, indicating effective control of myopia progression. The LogMAR values showed significant reductions, from 0.757 at baseline to 0.034 by Day 90, highlighting improved visual clarity. The central corneal thickness decreased from 512.23 μm at baseline to 500.24 μm by Day 90, reflecting the reshaping effect of Ortho-K. Changes in nasal, temporal, superior, and inferior corneal thickness were observed, with statistically significant variations in different regions. **Conclusions:** Overnight orthokeratology is an effective nonsurgical option for the temporary correction of moderate myopia in young adults. The treatment resulted in significant visual improvement and measurable changes in corneal thickness and axial length. However, the short follow-up period and lack of a comparative control group necessitate further research, particularly randomized controlled trials, to establish the long-term safety and efficacy of Ortho-K as a myopia management strategy.

Keywords: Axial length, corneal thickness, myopia, nonsurgical correction, orthokeratology, refractive error

INTRODUCTION

Myopia, or nearsightedness, has become an increasingly prevalent refractive error worldwide, particularly among younger populations.[1,2] The global prevalence of myopia has surpassed 28%, and it is anticipated that by 2050, nearly half of the world's population, equating to around 5 billion individuals, will be affected by some level of myopia.[3] This alarming trend calls for the need for effective and noninvasive methods to manage its progression. Traditional corrective measures, such as spectacles and daytime contact lenses, primarily address the symptoms of myopia rather than slowing its progression. In contrast, orthokeratology (Ortho-K), a nonsurgical procedure

Ankuj Tinna, Vikas Sharma[1], Anju Pannu[2], Gaurav Kapoor[3], Vinod K. Baranwal[4]

Department of Ophthalmology, INHS ASVINI, Mumbai, Maharashtra, [1]Department of Ophthalmology, Air Force Central Medical Establishment, Subroto Park, New Delhi, [2]Department of Ophthalmology, Military Hospital Panagarh, West Bengal, [3]Department of Ophthalmology, AFMC, Pune, Maharashtra, [4]Department of Ophthalmology, Brigadier Eye Hospital, Lucknow, Uttar Pradesh, India

Address for correspondence: Dr. Ankuj Tinna, INHS ASVINI, Mumbai, Maharashtra, India.
E-mail: ankuj.tinna@gmail.com

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that involves the overnight wear of specially designed contact lenses to temporarily reshape the cornea, has emerged as a promising approach for both correcting refractive errors and controlling the progression of myopia.[4-7]

Ortho-K lenses work by flattening the central cornea, thereby reducing the refractive error and improving unaided visual acuity (VA) during the day.[8] This method is particularly advantageous for individuals seeking a noninvasive alternative to refractive surgery as well as for those who prefer to be free from corrective lenses during daytime activities. Additionally, emerging evidence suggests that Ortho-K may slow the axial elongation of the eye, which is a key factor in the progression of myopia.[9,10]

Astigmatism, a common coexisting refractive error in myopic patients, poses additional challenges in visual correction and myopia management.[11] The effectiveness of Ortho-K in patients with moderate myopia, with or without astigmatism, warrants thorough investigation. Previous studies have demonstrated the potential of Ortho-K in controlling myopia progression in children and young adults; however, the impact of this treatment on patients with varying degrees of astigmatism remains less clear.

The aim of the study is to evaluate the impact of overnight orthokeratology (Ortho-K) lenses on the duration of clear vision, corneal thickness, and axial length in patients with moderate myopia. Additionally, the study seeks to assess the functional outcomes of Ortho-K treatment, focusing on unaided VA, residual refraction, and changes in corneal thickness and axial length.

MATERIALS AND METHODS

This was a prospective interventional study conducted at a tertiary care hospital in North India over duration of 1 year. The study population consisted of young adults aged 15–30 years with myopia up to -5.0 D, with corneal astigmatism up to -1.50 D with the rule astigmatism, (most of the study participants were students), who attended the Department of Ophthalmology of our institute during the study period. Patients with hypermetropia, dry eyes, Myopia >-5.0 D, Astigmatism >-1.50 D, ectatic corneas, or any other eye diseases/ocular surface disorders and those who underwent post lasik/refractive surgeries were excluded from the study. The number of participants as per age range as well as type of myopia and astigmatism are described in Table 1.

Sixty patients satisfying the inclusion criteria were enrolled in the study. Of those, three (5%) discontinued on first follow-up itself and additional three (5%) chose not to undergo treatment. The study was approved by the Institutional ethics committee, and a written informed consent was provided to all participants.

Table 1: Demographic data

	Total no of participants
Age range	
15-20	15
21-25	32
26-30	13
Type of myopia	
Mild	7
Moderate myopia with astigmatism	11
Moderate myopia without astigmatism	42
Gender	
Male	28
Female	32

Participants were fitted with Lucid Korea's Ortho-K LK®-Lens PREMIER, designed for overnight wear to temporarily reshape the cornea and correct myopia. The lens is made from Boston XO material, known for its high oxygen permeability (a Dk value of 100), ensuring adequate oxygen supply to the cornea during sleep. The total diameter of the lens ranges from 10.0 to 11.2 mm, adjustable in 0.2 mm increments. The optic zone diameter is 6.2 mm, and the lens features a five-curve design, including base curve, reverse curve, alignment curves, and peripheral curve. The central thickness of the lens is approximately 0.22 mm, which were worn overnight for an average of 6 hours over 3 months. Baseline measurements of refractive error, corneal thickness, and axial length were taken using standard subjective refraction techniques, Orbscan for corneal thickness, and IOL Master for axial length. These measurements were repeated during follow-up visits at 3 months, 6 months, and 1 year to assess changes from baseline. The study also included a thorough prefitting evaluation, which involved uncorrected and best-corrected VA assessments, slit-lamp examination, ophthalmoscopy, baseline corneal topography, and tear film analysis. The fitting of Ortho-K lenses was based on the patient's refractive error and corneal topography, and the fit was evaluated using fluorescein staining to ensure proper alignment and tear exchange.

Participants received detailed instructions on lens care, insertion, and removal. They were required to attend follow-up visits with their lenses to monitor the fit and assess any potential side effects. Statistical analysis was performed using SPSS version 19.0, with repeated measures analysis of variance (ANOVA) used to examine changes over time. *Post hoc* paired Student's *t*-tests were used to compare changes from baseline, with a critical probability of 0.05 for ANOVA and 0.01 for *t*-tests to minimize the risk of type 1 error.

RESULTS

The patients' age ranged from 15 to 30 years, with a slight female preponderance. The distribution of uncorrected VA among the study population showed a significant and sustained improvement in uncorrected VA for patients undergoing overnight Ortho-K treatment, with most patients reaching normal or near-normal vision (6/6 to 6/9) by the 3 months, and these improvements persisted by the 1 year follow-up. By 1 year, 85.11% of patients achieved normal vision, indicating that Ortho-K is highly effective in improving uncorrected VA in moderate myopia and astigmatism. There was a rapid initial improvement seen as early as the first follow-up on day 1, with a steep progression over 3 months [Table 2].

The mean axial length remained relatively stable over the follow-up period. At baseline, the mean axial length was 24.10 ± 0.22 mm. By the first follow-up, it showed a minimal reduction to 24.09 ± 0.22 mm ($P = 0.0006$), and this stability was maintained throughout the study. At day 1 and 3 months follow up, the axial length remained at 24.09 ± 0.22 mm ($P < 0.0001$), with no significant elongation by 1 year (24.09 ± 0.21 mm, $P = 0.0303$) [Table 3].

LogMAR values also showed significant improvements, starting from a mean of 0.757 at baseline and progressively decreasing over the follow-ups. By the first follow-up, the mean LogMAR dropped to 0.377 ($P < 0.0001$), followed by further reductions to 0.114 by 3 months ($P < 0.0001$), 0.064 by 6 months ($P < 0.0001$), and 0.034 by 1 year ($P = 0.0003$). The significant reduction in LogMAR demonstrated a steady and meaningful improvement in visual clarity as a result of Ortho-K treatment [Table 4].

Corneal thickness parameters showed notable changes, particularly in the central corneal thickness. At baseline, the mean central corneal thickness was 512.23 ± 19.21 µm. By the first follow-up, it reduced to 507.18 ± 18.94 µm ($P < 0.0001$) and continued to decrease to 502.12 ± 17.60 µm by 3 months ($P < 0.0001$). This reduction was sustained through 6 months and 1 year, with final values of 501.77 ± 18.21 µm and 500.24 ± 17.05 µm, respectively ($P = 0.0016$). Nasal, temporal, superior, and inferior corneal thicknesses showed mixed trends, with some increasing slightly and others stabilizing over time, but most of these changes were statistically significant ($P < 0.0001$ in various follow-ups), suggesting structural changes in the cornea with Ortho-K treatment [Table 5].

DISCUSSION

This study provides a comprehensive evaluation of the effects of overnight Ortho-K in managing moderate myopia and astigmatism, focusing on several key parameters including uncorrected VA, axial length (AL), LogMAR values, and corneal thickness. The results highlight the effectiveness of Ortho-K in both improving VA and controlling myopia progression by preventing axial elongation. Each of these findings is crucial for assessing the long-term efficacy and safety of Ortho-K as a noninvasive intervention for myopia control.

Visual acuity

The significant improvements in uncorrected VA observed over the follow-up period reflect the immediate and sustained

Table 2: Distribution of visual acuity among study population

Baseline uncorrected visual acuity ($n=120$)			1st follow-up on day 1 ($n=114$)			2nd follow-up on 3 months ($n=108$)		3rd follow-up on 6 months ($n=100$)		4th follow-up on 1 year ($n=94$)	
VA	Studied Eye		VA	Studied Eye		Studied Eye		Studied Eye		Studied Eye	
	n	%		*n*	%	*n*	%	*n*	%	*n*	%
6/12	5	4.17	6/6	8	7.02	51	47.22	68	68.00	80	85.11
6/18	11	9.17	6/9	15	13.16	37	34.26	25	25.00	9	9.57
6/24	22	18.33	6/12	45	39.47	20	18.52	7	7.00	5	5.32
6/36	28	23.33	6/18	18	15.79						
6/60	27	22.50	6/24	20	17.54						
5/60	7	5.83	6/36	8	7.02						
4/60	8	6.67									
3/60	12	10.00									
Total	120	100		114	100	108	100	100	100	94	100

Table 3: Distribution of study participants based on mean axial length during follow-up

Parameters	Baseline ($n=120$)	1st Follow-up ($n=114$)	2nd Follow-up ($n=108$)	3rd Follow-up ($n=100$)	4th Follow-up ($n=94$)
Axial Length (mean±SD)	24.10±0.22	24.09±0.22	24.09±0.22	24.10±0.22	24.09±0.21
P		0.0006	<0.0001	0.0001	0.0303

impact of Ortho-K. At baseline, most participants had poor VA, with the majority exhibiting vision worse than 6/24. The rapid improvement noted after just one night of Ortho-K lens wear—where 7.02% of participants achieved 6/6 VA and 13.16% reached 6/9—demonstrates how quickly the reshaping of the cornea can have a positive effect on vision. By the second follow-up at 3 months, nearly half of the participants (47.22%) achieved 6/6 vision, with continued improvements seen over the subsequent follow-ups, culminating in 85.11% of participants achieving 6/6 by 1 year.

This improvement in VA is significant because it allows patients to experience clear vision during the day without the need for corrective lenses. The sustained improvements suggest that Ortho-K not only provides immediate correction but also helps maintain visual clarity over time, making it a valuable option for myopia management, particularly in younger patients or those who want to avoid daytime contact lenses or glasses.

Axial length control

One of the most critical findings of this study is the stabilization of axial length over the follow-up period. Axial elongation is directly linked to myopia progression, with greater axial length associated with higher levels of myopia and an increased risk of complications such as retinal detachment, myopic maculopathy, and glaucoma. At baseline, the mean axial length was 24.10 mm, which is typical for patients with moderate myopia. Over the course of the study, the axial length remained remarkably stable, with only minimal fluctuations that were statistically significant ($P < 0.0001$ to $P = 0.0303$).

Table 4: Distribution of Log MAR during follow-up

Parameters	Baseline	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up
LogMAR (mean)	0.757	0.377	0.114	0.064	0.034
LogMAR (SD)	0.433	0.189	0.117	0.098	0.082
P		<0.0001	<0.0001	<0.0001	0.0003

The ability of Ortho-K to control axial elongation is particularly important for younger patients as their axial length tends to increase with age, leading to worsening myopia. The fact that Ortho-K was able to prevent axial length growth over the 1 year study period suggests that it may play a protective role in slowing myopia progression, thereby reducing the risk of future ocular complications. This is consistent with previous research suggesting that Ortho-K is effective in controlling axial elongation in children and adolescents.[12,13]

LogMAR improvements

The reductions in LogMAR values further support the improvements in VA. LogMAR is a more precise measurement of visual clarity than the Snellen chart, and the significant decrease in mean LogMAR from 0.757 at baseline to 0.034 at the final follow-up demonstrates a clear and sustained improvement in vision. The largest reduction occurred between baseline and the first follow-up (0.757 to 0.377, $P < 0.0001$), with continued improvements over time.

These findings suggest that Ortho-K lenses not only improve the refractive state of the eye but also enhance overall visual clarity, making them an effective treatment for reducing myopic blur. The fact that the LogMAR values continued to improve up to 1 year indicates that Ortho-K's effects on visual clarity are not only immediate but also sustainable with continued lens wear.

Corneal thickness changes

Orthokeratology lenses work by reshaping the cornea to temporarily reduce refractive error, which is reflected in the changes observed in corneal thickness throughout the study. At baseline, the mean central corneal thickness was 512.23 µm. This thickness progressively decreased over time, reaching 500.24 µm by 1 year. The statistically significant reductions in central corneal thickness ($P < 0.0001$ to $P = 0.0016$) are consistent with the known mechanism of action of Ortho-K, where the central cornea is flattened to reduce myopia.

Table 5: Distribution of study participants based on mean corneal thickness parameters during follow-up

Parameters	Baseline *n*=120	1st Follow-up *n*=114	2nd Follow-up *n*=108	3rd Follow-up *n*=100	4th Follow-up *n*=94
Corneal thickness Central (mean±SD)	512.23±19.21	507.18±18.94	502.12±17.60	501.77±18.21	500.24±17.05
P		<0.0001	<0.0001	<0.0001	0.0016
Corneal Thickness Nasal (mean±SD)	585.91±22.94	585.91±23.21	589.42±23.25	593.85±22.74	592.90±22.27
P		0.45	<0.0001	<0.0001	0.16
Corneal Thickness Temp (mean±SD)	573.24±24.26	573.49±24.46	576.90±24.90	581.66±24.88	581.91±25.26
P		0.41	<0.0001	<0.0001	0.017
Corneal Thickness Superior (mean±SD)	599.51±22.37	599.68±22.83	602.56±22.61	606.92±22.74	607.10±22.67
P		0.47	<0.0001	<0.0001	0.014
Corneal Thickness inferior (mean)	578.73±19.21	579.00±18.94	581.67±17.60	591.31±18.21	590.48±17.05
P		0.48	<0.0001	0.056	0.06

Interestingly, while the central corneal thickness decreased, the nasal, temporal, superior, and inferior regions of the cornea showed mixed trends, with some areas thickening slightly over time. For example, the superior corneal thickness increased from 599.51 µm at baseline to 607.10 µm at 1 year follow-up ($P = 0.014$), suggesting that while the central cornea is flattened, other regions may undergo compensatory thickening. This redistribution of corneal thickness is crucial for achieving the desired refractive change while maintaining corneal structural integrity.

The long-term impact of these changes in corneal thickness on corneal health is an important area for further study. While the current study did not report any adverse effects related to corneal thinning, monitoring corneal health over a longer period would be essential to ensure the safety of Ortho-K, particularly in young patients who may use the treatment for extended periods.

A meta-analysis by Li *et al*.[14] found that a reduction in corneal thickness occurs within the first week of Ortho-K.

Park *et al*.[15] evaluated the effectiveness of overnight Ortho-K in correcting moderate to high myopia using the White OK lens® over 1 month. Participants with myopia between –3.00 and –7.50 D and astigmatism ≤ 2.00 D were fitted with a 6-curve OK lens and assessed at weeks 1, 2, and 4 for vision quality, including refraction, uncorrected distance VA, and corneal topography. Of the 46 participants, with a mean age of 23.11 years, 95.35% achieved a successful outcome, defined as a logMAR ≤ 0.1, by week 4. There was a significant reduction in mean sphere from –4.58 D to –0.65 D and noticeable corneal flattening, suggesting the White OK lens is an effective intervention for moderate to high myopia correction with mild astigmatism over a short-term period.

A retrospective cohort study for 12 years by Lee *et al*.[16] reported that Ortho-K was effective in slowing myopia progression and exhibited an acceptable long-term safety profile.

The results of this study have significant clinical implications. First, the rapid and sustained improvements in uncorrected VA suggest that Ortho-K is an effective nonsurgical option for patients with moderate myopia and astigmatism, allowing them to experience clear vision without the need for daytime corrective lenses. This can be especially beneficial for children and adolescents who may be at higher risk of progressive myopia and for individuals involved in sports or outdoor activities where glasses or contact lenses are inconvenient.

Second, the control of axial length growth is a critical factor in preventing the progression of myopia and the development of associated ocular complications. The ability of Ortho-K to stabilize axial length over the 1 year study period supports its role as a potential intervention for reducing the long-term risk of myopia-related complications. This is particularly important in light of the global increase in myopia prevalence, where effective control strategies are needed to reduce the burden of high myopia.

While the results of this study are promising, there are several limitations that should be addressed in future research. First, the study followed participants for only 1 year, which provides valuable short-term data but does not offer insight into the long-term effectiveness and safety of Ortho-K. Longer-term studies, particularly those that follow patients for several years, would be important for understanding whether the effects of Ortho-K on axial length and corneal thickness are sustained over time and whether there are any long-term complications associated with prolonged use. Absence of an age-matched control group is also a limitation of our study.

Additionally, while this study focused on moderate myopia and astigmatism, future studies could explore the effectiveness of Ortho-K in patients with high myopia or more complex refractive errors. Understanding the limits of Ortho-K's efficacy in different patient populations could help optimize treatment protocols and expand its use to a broader range of patients.

CONCLUSION

In summary, this study demonstrates that overnight orthokeratology is a highly effective and noninvasive treatment for improving VA and controlling axial length in patients with moderate myopia and astigmatism. The rapid improvements in VA, stabilization of axial length, and significant changes in corneal thickness support the use of Ortho-K as a valuable intervention for myopia management. Future research should focus on the long-term safety and efficacy of Ortho-K, as well as its potential applications in preventing the progression of high myopia in younger populations.

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Ethical approval
HEC/BHDC/2019-20/14898.

Data availability statement
The data supporting the results reported in the published article will be shared on request.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

The effect of induced fusional vergence on stereopsis

ABSTRACT

Context: Time taken to complete the task with induced fusional vergence. **Aims:** To identify the time taken to complete the task with and without fusional demand with different object sizes and contrast levels. **Settings and Design:** Prospective cross-sectional study. **Subjects and Methods:** In this study, we included the patient between the age of 18 and 30 years. All the patients underwent a complete eye examination. Heterophoria were calculated by using the prism bar cover test. For each participant, prism power equivalent to the blur point of base-in (BI) and base-out (BO) fusional vergence at 40 cm was divided and placed in front of both eyes. At 0, 3, 6, 9, and 12 min after prism introduction, the stereo acuity was measured. Time taken to complete the task was calculated by asking the patient to identify the difference between the two images in both modes of gameplay with and without BI and BO fusional vergence using 4 different contrast level and 3 target size. **Statistical Analysis Used:** The data were analyzed by using SPSS statistical software version 20. Wilcoxon signed-rank test and one-way ANOVA test with *post hoc* analysis were performed to see comparison between multiple groups. **Results:** A total of 20 patients with a mean age of 20.70 ± 3.52 participated in the study. In experiment 1, the stereoacuity was reduced immediately after prism introduction and slowly it got adapted after 6 min and came to the baseline at 12 min. For experiment 2, after the 12 min of adaptation with BI and BO prism is showing the similar results as normal mode of game play. **Conclusions:** The stereoacuity can be regained to baseline after 9 min for BI and 12 min for BO prism. Stereoacuity can be achieved back to the baseline without the orthophoria also.

Keywords: Negative fusional vergence, positive fusional vergence, stereopsis

INTRODUCTION

Stereopsis is the third grade of Binocular vision. Stereo acuity is the smallest detectable depth difference that can be seen in binocular vision, effectively measuring the threshold of depth discrimination. Stereopsis is one of the parameters used to evaluate the interactions of the accommodative and vergence systems.[1,2] Stereoacuity is the smallest amount of horizontal retinal image disparity that gives rise to a sensation of relative depth.[3] The complex two-eyed visual system is designed not simply for redundancy, but primarily to allow both eyes to work together to extract information from the environment. Approximately 60% of the human visual field overlaps, where greater peripheral vision is sacrificed in favor of information provided by binocular disparity, but this results in benefits to functional ability. Stereoacuity is routinely measured clinically, and the tests currently used are accurate in identifying people with good levels of stereoacuity.[4] Disparity detection requires good acuity that is similar in each eye. Stereopsis is not present at birth but develops after the improvement in visual acuity. Visual evoked potentials have demonstrated the development of stereopsis starts around 3 months of age, but with a rapid maturation in the first year of life.[5] Change blindness paradigm in a spatial domain, wherein the visual transient that exists while saccading between the two scenes is thought to render the visual system 5 insensitive and consequently "blind" to the change in the local feature.[6,7] The first candidate for prism adaptation involves higher level strategic remapping controlled by the cognitive system and is the ordinary response to performance error produced

Swanandi S. Gawde, Rajvi Mehta, M. Purushottam Naidu, Rakesh Kaushal, Sankalp Rao

Department of Optometry, ITM University, Navi Mumbai, Maharashtra, India

Address for correspondence: Ms. Swanandi S. Gawde, ITM University, Navi Mumbai - 410 206, Maharashtra, India.
E-mail: swanandig09@gmail.com

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by prismatic displacement, a kind of cognitive learning.[8] When a horizontal or vertical prism is placed before an eye the induced change in heterophoria, or fixation disparity gradually reduces with time. This ability to adapt to a prism, commonly called prism adaptation.[9] The base in (BI) and base out (BO) prism adaptation depending on the viewing distances, the object at distance the adaptation responses are asymmetrical, there being a significantly greater amount of adaptation to BO prism compared with BI, while at near, the responses are virtually symmetrical. The reduced amount of adaptation found to base-out prisms at near may be due to: A reduction in the demand made on the fusional vergence by the action of accommodative convergence. And a decreased demand made on the fusional convergence at near due to the action of proximal convergence.[9,10] Ogle and Prangen suggested that there is an involuntary adaptation reflex that is responsible for adaptation to prisms. It can be divided into two systems, a fast and a slow system, and the latter is responsible for permanent prism adaptation.[11]

SUBJECTS AND METHODS

In this experimental study design, subjects were collected by using simple random sampling technique. We have included the 20 subjects between the age of 18 and 30 years with the best-corrected visual acuity of 6/6 or better on Snellen chart in each eye. They should have heterophoria for near and stereopsis up to 40 s of Arc on Titmus fly stereo acuity test.

The stereo test on Titmus fly stereo acuity test. The subjects with any binocular disorder, history of ocular trauma, or surgery were excluded.

The visual acuity, refractive error, distance phoria, near phoria, negative fusional vergence, positive fusional vergence, and stereoacuity were calculated. The distance and near visual acuity were taken on Snellen's chart. Stereoacuity was tested by using the Titmus fly stereo acuity test.

- Experiment 1: Stereoacuity and dissociated phoria were measured with the help of Maddox rod test. Prism vergences were measured using a prism bar. For each subject, prism power equivalent to the blur point of BI and base-out (BO) fusional vergence at 40 cm was divided and placed in front of both eyes. At 0, 3, 6, 9, and 12 min after prism introduction, the stereoacuity was measured with different time fame one with BI and another with BO fusional vergence[12]
- Experiment 2: The study images made by using Adobe illustrator with contrast grayscale. Distance from the screen to 60 cm is kept between the observer and display unit. The screen has a 1680 × 1050 pixel size. Angular resolution of 3 different size images 5°, 3°, and 1°. Contrast of 4 different level images 100%, 50%, 10%, and 5%. A set of 36 images will be presented to each subject: 12 images for without fusional vergence and 12 images for BI and another 12 images for BO fusional vergence. Set of 4 images contained 5° image size and 100%, 50%, 10%, and 5% contrast and another set of 4 images contained 3° image size and 100%, 50%, 10%, and 5% contrast. A set of 4 images contained 1° image size and 100%, 50%, 10%, and 5% contrast. Time taken to complete the task is calculated for each image individually. Each image contains 6 differences, an individual task is to find the difference between two adjacent images by using the mouse click. We chose the randomized pattern difficulty level for image projection. After both the experiments, data were transformed from Microsoft PowerPoint presentation to Microsoft excel sheet for further analysis.

Data analysis

In this study, we analyzed the data by using Statistical Package for Social Science (SPSS) statistical software version 20. The mean value of stereoacuity of induced positive and negative fusional vergence was compared by using Wilcoxon signed-rank test. The time taken to complete the task with different levels of contrast and target size was correlated by using a one-way ANOVA test with *post hoc* analysis to see comparison between multiple groups.

RESULTS

A total of 20 patients with a mean age of 20.70 ± 3.52 (ranges from 18 to 33 years) participated in the study. In the data, three participants were male and the other 17 participants were female. The mean spherical equivalent of − 0.39 ± 0.80 D and near point of convergence was 9.15 ± 1.75 cm. For the distance cover test, five participants were having orthophoria, 14 were exophoria, and 1 were esophoria. For the near cover test, nineteen participants were exophoria and one was esophoria.

Table 1 contains the mean values of negative and positive fusional vergence were calculated for distance at 6 meter and for near at 40 cm. The mean values of break at near for positive fusional vergence are 17.05 ± 5.32 Prism Diopter and for recovery 12.10 ± 3.80 Prism Diopter. Moreover, the mean values of break and recovery for positive fusional vergence at near are 22.5 ± 6.87 Prism Diopter and 16.20 ± 4.5 Prism Diopter. Experiment 1: We have observed the effect of positive and negative fusional vergence on stereoacuity. Stereoacuity was calculated at baseline and after inducing the BI and BO prism at immediate, 3 min, 6 min, 9 min, and

12 min. The stereoacuity was reduced immediately after prism introduction and slowly it got adapted after 6 min and came to the baseline at 12 min.

Stereoacuity measurements were taken after inducing BI and BO prism according to the negative and positive fusional vergence ranges. There was no statistically significant difference that was noticed immediately after inducing BI and BO prisms. Moreover, there was no statistically significant difference between BI and BO induced prisms with different time intervals 3 min, 6 min, 9 min, and 12 min [Table 2 and Figure 1].

Experiment 2: A total of 20 participants were enrolled in experiment 2. All participants were undergone to spot the difference in game play. Time taken to find the 6 differences in each image was calculated depending on the different contrast levels with 3 different sizes.

In Figure 2, we have calculated the time taken to complete the task with different target sizes 5, 3, and 1 in 100% contrast level. In normal binocular vision and BI-induced prisms, there is a statistically significant decrease in time taken to complete the task with target size 3 as compared with target size 5. In comparison with normal mode of game play and after induction of BI and BO prisms, there is no statistically significant difference noticed to complete the task with different target sizes in 100% contrast level [Table 3].

In Figure 3, we have calculated the time taken to complete the task with different target sizes 5, 3, and 1 in 50% contrast level. In normal binocular vision and BI-induced and BO-induced prisms, there is no statistically significant change in time taken to complete the task were noticed with different target sizes. In comparison with normal mode of game play and after induction of BI and BO prisms, there is no statistically significant difference that was noticed in time taken to complete the task with different target sizes with 50% contrast level [Table 3].

In Figure 4, we have calculated the time taken to complete the task with different target sizes 5, 3, and 1 in 10% contrast level. In normal binocular vision and BI induced prisms, there is a statistically significant decrease in time taken to complete the task with target size 3 ($P = 0.010$) as compared with target size 5 ($P = 0.011$). In comparison with normal mode of game play, time taken to complete the task with BO-induced prism is significantly lesser than normal mode of game play in 10% contrast level with target size 5 [Table 3].

Table 1: Negative and positive fusional vergence value for distance and near

	Blur (Prism D)	Break (Prism D)	Recovery (Prism D)
NFV (distance)	5.5±5.68	10.5±4.79	6.65±4.18
NFV (near)	14.4±4.51	17.05±5.32	12.10±3.80
PFV (distance)	11.65±9.27	18.65±10.21	13.85±8.98
PFV (near)	19.35±5.32	22.5±6.87	16.20±4.5

NFV=Negative fusional vergence, PFV=Positive fusional vergence

Table 2: Stereoacuity measurement after inducing base in and base out prisms at different time intervals in minutes

	Induced BI	Induced BO	*P*
Immediate	316.5±310.83	234.5±232.91	0.4134
3 min	170±191.61	165±222.46	1
6 min	75±41.74	109.5±168.29	0.5505
9 min	58.5±36.31	64±42.23	0.5898
12 min	45±10.51	59±49.19	0.5248

BI=Base in, BO=Base out

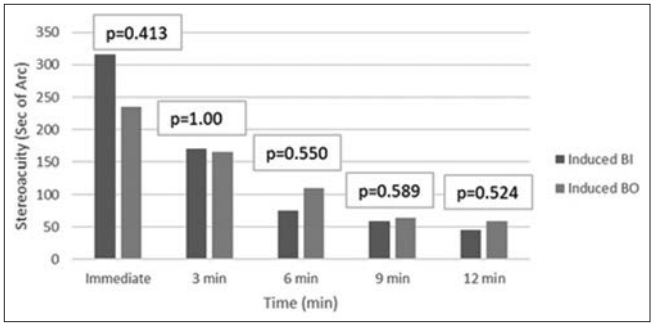


Figure 1: Stereo acuity measurement at different time intervals in minutes

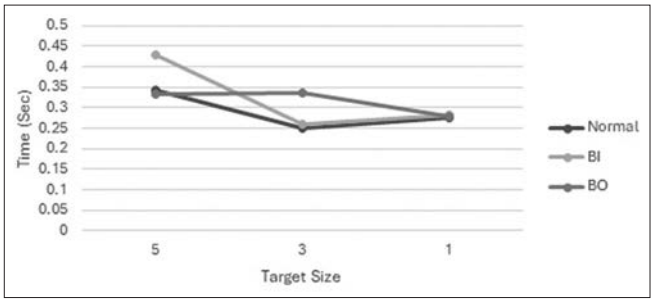


Figure 2: Time taken to complete the task with different target sizes in 100% contrast level

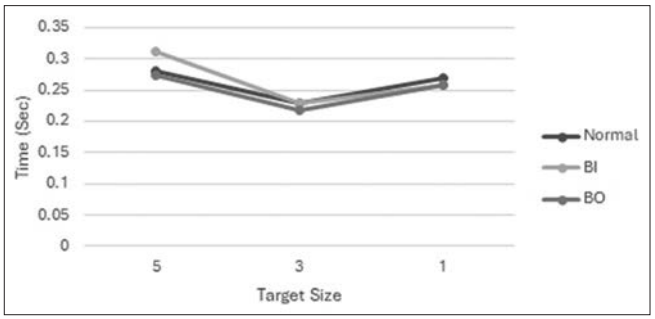


Figure 3: Time taken to complete the task with different target sizes in 50% contrast level

In Figure 5, we have calculated the time taken to complete the task with different target sizes 5, 3, and 1 in 5% contrast level. In normal binocular vision and BI-induced and BO-induced prisms, there is no statistically significant change in time taken to complete the task were noticed with different target sizes. In comparison with normal mode of game play and after induction of BI and BO prisms, there is no statistically significant difference that was noticed in time taken to complete the task with different target sizes with 5% contrast level [Table 3]. As the difficulty of the task increases the time taken to complete the task also increases but does not show a statistically significant difference between them. After the 12 min of adaptation with BI and BO, prism is showing the similar results as normal mode of game play.

DISCUSSION

This study investigated the effect of BI and BO prism on stereoacuity and magnitude of horizontal phoria in 20 participants. Moreover, looking for the effect of horizontal phoria on different task identification of different contrast levels with different target sizes. The results indicate that time required for stereoacuity to return to preprism level was 9 min for BI and 12 min for BO prism. The time taken to come back to its baseline value is significantly different because there is difference between stereoacuity and heterophoria. In a previous study, the stereoacuity came back to the baseline after 6 min with BO-induced prism and 9 min with BI-induced prism adaptation.[12] One could be the reason that to check the stereoacuity used TNO test random dot stereo test. In our study, we have used the Titmus fly gross stereoacuity test. In our study, time taken to come back to baseline level is more for BO induced prism.[13] The earlier study by Henson and North reported that the BO prism adaptation is quicker as compared with BI prism.[14] During the procedure kept the 6-prism diopter only in front of one eye for horizontal phoria. In our study, we are taking blur value from positive and negative fusional vergence for prism induction and splitting the prism amount in front of both eyes. The study conducted by Spencer *et al*. proved that; BO prism could not be adapted with 12 BO prismatic glasses up to 9 min.[12] Earlier study reported that, with different target sizes with different contrast levels, time taken to complete the task was significantly smaller in fusion mode of game play as compared to nonfusion mode of game play. Moreover, 10% and 50% contrast levels with all larger as well as smaller target sizes required more time to complete the task. In our study, time taken to complete the task with target size 3 with all four contrast levels showed lesser time to complete the task as compared with other small and larger target sizes.[15] Relatively, to make luster appear, binocular viewing is more feasible as compared with monocular viewing.[16] The induced exo fixation disparities adapt well with binocular visual acuity as compared with monocular visual acuity.[17] In this study, there is no significant pattern of adaptation of prisms found with eso and exo fixation disparities.

Table 3: Time taken to complete the task with target size 5, 3, and 1 with contrast level 100%, 50%, 10%, and 5%

Target size	Contrast (%)	BV	BI (*P*)	BO (*P*)
5	100	0.34±0.10	0.43±0.29 (0.144)	0.33±0.11 (0.409)
5	50	0.28±0.10	0.31±0.17 (0.288)	0.27±0.08 (0.405)
5	10	0.31±0.09	0.32±0.10 (0.399)	0.26±0.06 (**0.037**)*
5	5	0.28±0.09	0.26±0.05 (0.272)	0.26±0.08 (0.250)
3	100	0.25±0.08	0.26±0.08 (0.292)	0.34±0.27 (0.078)
3	50	0.23±0.06	0.23±0.05 (0.466)	0.22±0.06 (0.218)
3	10	0.23±0.06	0.23±0.07 (0.413)	0.23±0.06 (0.451)
3	5	0.24±0.06	0.26±0.08 (0.267)	0.24±0.06 (0.471)
1	100	0.27±0.06	0.28±0.06 (0.330)	0.28±0.09 (0.445)
1	50	0.27±0.08	0.26±0.07 (0.368)	0.26±0.06 (0.289)
1	10	0.28±0.07	0.27±0.07 (0.355)	0.27±0.06 (0.334)
1	5	0.26±0.09	0.28±0.08 (0.285)	0.25±0.09 (0.298)

BI=Base in, BO=Base out, BV=Binocular Single Vision, *0.037: Statistically significant

CONCLUSIONS

This study concluded that the pattern of prism adaptation with BI and BO were similar for stereoacuity. Time taken to complete the task is lesser with a medium size target with the angular resolution of 3°. In addition, maximum

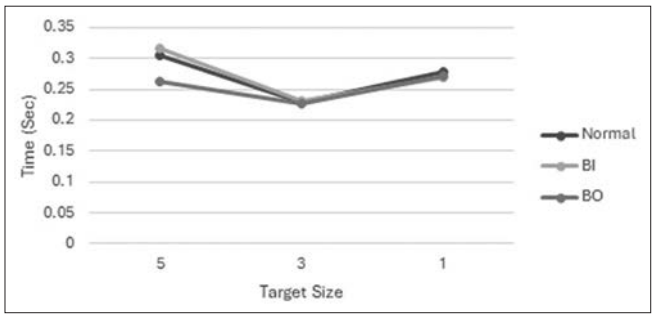


Figure 4: Time taken to complete the task with different target sizes in 10% contrast level

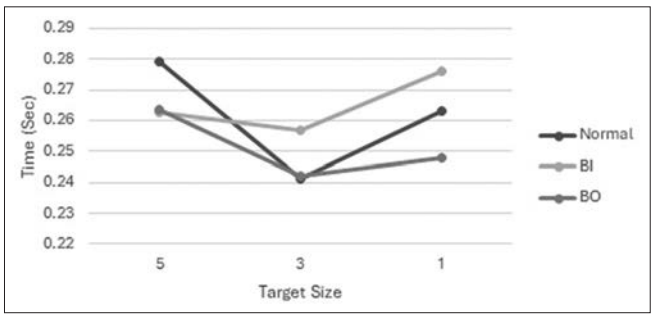


Figure 5: Time taken to complete the task with different target sizes in 5% contrast level

time taken to complete the task with smaller target size with angular resolution of 1° and larger target size with the angular resolution of 5° in all four levels of contrast. The stereoacuity can be regained to baseline after 9 min for BI and 12 min for BO prism. Stereoacuity can be achieved back to the baseline without the orthophoria also. It is the good indicator for prism adaptation.

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Conflicts of interest
There are no conflicts of interest.

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Original Article

Pseudoexfoliation with cataract – Frequency, clinical profile, and challenges during cataract surgery

ABSTRACT

Purpose: To study the frequency, clinical profile, surgical difficulties, and visual outcome in patients of pseudoexfoliation (PEX) scheduled for cataract surgery. **Methods:** A prospective, interventional, hospital-based study was conducted on 100 eyes from 100 patients of PEX syndrome consecutively undergoing manual small incision cataract surgery. All patients underwent complete ophthalmologic evaluation, that is, slit-lamp examination, tonometry, and ophthalmoscopy before the surgery. At the end of the surgical procedure, the intraoperative difficulties were noted. Postoperative follow-up at 1 week and 6 weeks was done to assess visual acuity. **Result:** We observed in our study that the mean age of patients with PEX was 73.2 ± 8.67. Fifty-seven patients had unilateral presentation, while 43 patients had bilateral presentation. The PXF material was distributed on the iris in 31% cases, followed by lens with 23% and pupillary margin with 11%. Hypermature cataract was the most commonly observed cataract with 41%. Intraoperative difficulties were reported in 39 cases, with poor pupillary dilation being the most common problem accounting for 20 cases. **Conclusion:** Cataract with PEX is a challenging scenario to operate upon, but good postoperative visual outcomes can be achieved with manual small incision cataract surgery by careful preoperative evaluation of risk factors and surgical plan, knowledge, and the ability to manage the complications.

Keywords: Cataract, manual small incision cataract surgery, pseudoexfoliation

INTRODUCTION

Pseudoexfoliation (PEX) syndrome is characterized by the accumulation of microscopic, grayish-white, amyloid-like protein fibers on intraocular structures.[1,2] It is commonly associated with dense nuclear cataracts, and patients with PEX are at a higher risk of developing complications during and after cataract surgery.[3,4] The reported prevalence of PEX in the Indian population ranges from 0.69% to 3.8%.[2] Cataracts in PEX patients tend to be more advanced than average, and phacodonesis due to zonular weakness may be present.

This study aims to evaluate the frequency, clinical signs, intraoperative challenges, and postoperative visual outcomes in patients with PEX undergoing cataract surgery at our institute.

METHOD

This prospective, interventional study was conducted between June 2023 and May 2024 at a tertiary eye care center in India. The study received approval from the Institutional Ethics Committee and Institutional Review Board and adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrolment.

Patients aged over 50 years, of either gender, who were diagnosed with cataract and PEX syndrome were consecutively included in the study. The following patients were excluded: Those with corneal degeneration or opacities that hinder anterior segment evaluation; patients with cataracts secondary to uveitis, trauma,

Ankita Jakhar, Anju Kochar, Nabab Ali Khan, Arif Khan, Shaheen Farooq, Manoj Kumari, Priyanka Sunda

Department of Ophthalmology and Sardar Patel Medical College and Hospital, Bikaner, Rajasthan, India

Address for correspondence: Dr. Ankita Jakhar, Department of Ophthalmology and Sardar Patel Medical College and Hospital, Bikaner - 334 001, Rajasthan, India.
E-mail: ajayjakhar73@gmail.com

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or systemic diseases; and patients who did not provide consent.

All enrolled patients underwent a detailed slit-lamp examination, during which the following signs were assessed:

- Conjunctiva: Congestion
- Cornea: Presence of edema, pigmentation, and exfoliation material
- Anterior chamber: Flare, cells, depth, exfoliation material, and pigment dispersion
- Iris: Pattern, transillumination defects, and iridodonesis
- Pupil: Size, reaction to light, presence of exfoliation material, and response to mydriatics
- Lens: Presence of exfoliation material, cataract type, phacodonesis, subluxation, or dislocation

Pupil dilation was routinely performed to observe the classic three zones of exfoliation material on the anterior lens capsule. Intraocular pressure (IOP) was measured in all patients using noncontact tonometry (NCT) as part of the preoperative evaluation. Fundus examination was carried out using direct ophthalmoscopy and slit-lamp biomicroscopy to assess for glaucomatous optic disc changes.

In patients undergoing cataract surgery, axial length (A-scan) and keratometry (K-readings) were recorded, and intraocular lens (IOL) power was calculated using the SRK-II formula. Routine preoperative investigations included blood sugar testing, urine analysis for albumin and sugar, and blood pressure measurement.

RESULTS

During the study period, a total of 2234 patients were evaluated at our center. Of these, 100 patients (4.47%) were diagnosed with PEX syndrome and met the inclusion criteria. For each patient, only one eye was included in the study specifically, the eye with more advanced cataract or greater clinical significance. During the study period, a total of 2234 patients were evaluated at our center. Of these, 100 patients (4.47%) were diagnosed with PEX syndrome and met the inclusion criteria. For each patient, only one eye was included in the study specifically, the eye with more advanced cataract or greater clinical significance.

The mean age of patients with PEX was 73.2 ± 8.67 years. The highest frequency of PEX was observed in the 71–80-year age group, accounting for 50 cases (26 males, 24 females), followed by the 61–70-year group with 21 cases (10 males, 11 females), as shown in Table 1.

In this study, the majority of PEX patients were from rural areas, as presented in Table 2. Of the 100 cases, 57 patients had unilateral pseudoexfoliation, placing them at risk of developing it in the fellow eye as age progresses. The remaining 43 patients had bilateral involvement. Regarding systemic comorbidities, 23% of patients had diabetes mellitus, 17% had hypertension, 7% had a history of cerebrovascular accident (CVA), 5% had hearing loss, and 1 patient had a psychiatric illness.

In terms of cataract morphology, 41 patients presented with hypermature cataracts, 30 with mature cataracts, 21 with nuclear sclerosis, four with cortical cataracts, three with posterior subcapsular cataracts, and one with a posterior polar cataract.

Intraoperative difficulties were encountered in 39 cases, as detailed in Table 3. The most common issue was poor pupillary dilation in 20 cases, for which intracameral adrenaline was used. Zonular dehiscence was the second most frequent complication, occurring in six cases. Other complications included Rhexis extension in three cases (necessitating conversion to capsulotomy), posterior capsular rupture in

Table 1: Age group distribution of study population

Age (in years)	Gender				Total	
	Male		Female			
	No.	%	No.	%	No.	%
51–60	6	11.76%	6	12.24%	12	12%
61–70	10	19.60%	11	22.45%	21	21%
71–80	26	50.98	24	48.98%	50	50%
>80	9	17.65	8	16.33%	17	17%
Total	51	51%	49	49%	100	100%
Mean±SD	73.63±8.92		72.76±8.49		73.2±8.67	

Table 2: Demographic distribution

Age (in years)	Rural		Urban		Total	
	No.	%	No.	%	No.	%
50–70	25	33.33%	8	32%	33	33%
71–90	49	65.34	16	64%	65	65%
>90	1	1.33	1	4%	2	2%
Total	75	75%	25	25%	100	100%

Table 3: Surgical difficulties

Surgical difficulties	No.	%
Poor pupil dilation	20	20%
Zonular dehiscence	6	6%
Rhexis extension	3	3%
PCR	4	3%
Pupil catch	1	1%
Vitreous loss	3	3%
Retained lens matter	2	2%
Total	39	39%

four cases, vitreous loss in three cases, retained lens matter in two cases, and pupil catch in one case.

The distribution of PEX material on ocular structures is summarized in Table 4. The most common sites were iris in 31%, lens capsule in 23%, pupillary margin in 11%, and on corneal surface in 9%. Regarding intraocular pressure (IOP), 58 patients had IOP between 16 and 20 mmHg, 35 had IOP less than 15 mmHg, and 7 patients presented with elevated IOP >21 mmHg. Preoperatively, 98% of patients had a best-corrected visual acuity (BCVA) less than 6/18. Postoperatively, 76% of patients achieved BCVA better than 6/12, as shown in Table 5.

DISCUSSION

In our study, the frequency of PEX syndrome was 12% in the 51–60-year age group, increasing to 17% in those aged ≥81 years [Table 1]. We included patients over 50 years of age as PEX and associated hard cataracts are more commonly seen in this demographic. A similar study by Bhargavi Parth *et al*. (2023)[5] reported the highest incidence of PEX in the 61–70-year group (50 cases), followed by the 51–60-year group (36 cases). In a hospital-based study by Joshi RS. *et al*. (2019),[6] most patients with PEX (35.8%) were ≥81 years old.

The sex distribution in our study was male: female = 1:1.11, consistent with population data indicating no significant gender predilection. Similar findings were reported by H. Arvind *et al*. (2003)[7] and Lamba P.A. *et al*. (1984).[8]

A significant associated factor for PEX in our cohort was rural residence. This may be attributed to greater outdoor activity and increased sunlight exposure, which have been linked to PEX development. Our findings are supported by the study of Vijaya L. *et al*. (2016).[9]

Table 4: Deposition of pseudoexfoliation material on ocular structure

Distribution on ocular structure	No. of cases	Percentage
Cornea	9	9%
Iris	31	31%
Lens	23	23%
Pupillary margin	11	11%
Iris, lens, and pupillary margin	26	26%

Table 5: Comparison among pre- and postoperative pseudoexfoliation patients

Visual acuity	Preoperative		Postoperative	
	No.	%	No.	%
6/6 – 6/12	2	2%	76%	76%
6/18 – 6/24	37	37%	9	9%
6/36– 6/60	36	36%	–	–
>6/60	25	25%	–	–
Total	100	100%	85	85%

Unilateral PEX was seen in 57% of patients, putting them at future risk of bilateral involvement as age advances. Bilateral PEX was present in 43%. The Blue Mountains Eye Study (1999)[10] and Reykjavik Study[11] have shown that unilateral PEX often progresses to bilateral disease over time.

Regarding systemic associations, 23% of patients had diabetes mellitus, 17% had hypertension, 7% had a history of cerebrovascular accident (CVA), 5% had hearing loss, and 1% had psychiatric illness. Since our study population was elderly, it was difficult to establish a direct correlation between these systemic conditions and PEX. However, similar associations were reported by Anastasopoulos E *et al*. (2015)[12] and Yildirim N *et al*. (2017).[13] PEX is known to be associated with an increased prevalence of cataract, though the exact mechanism is unclear. Hypothesized contributors include ocular ischemia, oxidative stress, and reduced antioxidant protection due to lower ascorbic acid levels in aqueous humor.[14]

In our study, hypermature cataracts were present in 41% of cases, followed by mature (30%) and nuclear cataracts (21%). The high incidence of hypermature cataracts may reflect delayed presentation for surgery, particularly in rural populations where there is a belief that cataract surgery is only necessary after full maturation. This contrasts with Shivkumar C *et al*. (2022),[15] who found immature cataracts more prevalent. Our findings were supported by Govetto *et al*. (2015)[16] and Joshi RS *et al*. (2019),[6] while Arvind H *et al*. (2003)[7] reported nuclear cataract as the most common type.

Intraoperative complications occurred in 39% of cases, the most common being poor pupillary dilation (20%). This was managed with intracameral adrenaline and sphincterotomy when required,[17] as similarly noted by Al Saleh S.A. *et al*.[18] and Shivkumar *et al*.[15] Zonular dehiscence, the second most common complication (6%), was managed by creating a continuous curvilinear capsulorhexis (CCC) using a bent 26-gauge needle, minimizing pressure on the zonules. Hydrodissection was done cautiously. Similar incidence rates were reported by Avramides *et al*.[19] (13.1%), Lumme *et al*.[20] (14.8%), and Ong *et al*.[21] (6.1%).

Rhexis extension occurred in three cases and was managed by converting CCC into a capsulotomy using generous viscoelastic. Posterior capsule rupture (PCR) occurred in

four cases, of which three had vitreous prolapse. Anterior vitrectomy was performed, followed by careful aspiration of soft lens matter. In two cases with adequate capsular support, PMMA IOLs were implanted. In the other two, iris-claw IOLs were used. Drolsum *et al*.[22] reported a PCR rate of 9.6% in PEX patients.

Other complications included pupil capture in one case and retained lens matter in two cases. Distribution of PEX material was observed primarily on the iris (31%), lens capsule (23%), and pupillary margin (11%), with corneal deposition seen in 9% of cases. These findings align with Joshi R.S. *et al*. (2019)[6] but contrast with Idakwo *et al*. (2018),[23] who observed PEX primarily on the lens periphery and pupillary margin. The variation may reflect differences in disease stage and timing of presentation.

All surgeries were performed via manual small-incision cataract surgery (MSICS) with IOL implantation. Postoperative visual acuity improved significantly, with 76% achieving VA better than 6/12. Nine patients had VA less than 6/18, and 15 patients (15%) were lost to follow-up by 6 weeks. The favorable outcomes in our study may be attributed to experienced surgeons, accurate biometry, availability of essential equipment, and trained staff. Poor outcomes were associated with older age, intraoperative complications, and iris-claw lens implantation. These results are in agreement with studies by Gogate P. *et al*. (2011)[24] and Venkatesh R. *et al*. (2005).[25]

However, the 15% loss to follow-up at 6 weeks represents a limitation. Despite efforts to ensure follow-up, patient-related factors (e.g., geographic distance, economic constraints) contributed to attrition. This may introduce bias and limit generalizability, especially for late complications. Future studies with longer follow-up periods and strategies to minimize attrition are needed to better assess long-term outcomes in PEX patients undergoing cataract surgery.

CONCLUSION

Cataract still remains the world's leading cause of blindness and visual impairment in the elderly population, despite the decreasing number of people affected. If age is the main risk factor for cataract progression, pseudoexfoliation syndrome (PXF) represents an independent additional hazard for the development of cataract and indication for surgery. Studies, like ours, provide critical insights on frequency and surgical difficulties in PEX patients, guiding public for early surgery in eyes with visually significant cataracts rather than later surgery and to achieve enhanced patient outcomes and to reduce the impact of this debilitating ocular condition and aids in the detection of glaucoma using PEX as a marker.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Eyes wide open: The keratitis spike in a recent measles outbreak in North Kerala - A cross sectional study

ABSTRACT

Purpose: To highlight the resurgence of measles, once considered under control, and to report the emerging trend of corneal involvement in affected individuals, which poses new challenges to public health and clinical management. **Design:** Cross sectional descriptive study **Methods:** Comprehensive evaluation was done in 30 clinically diagnosed measles patients. **Results:** The mean age was 28+/- 9 years. The most common eye symptoms were redness, foreign body sensation and blurred vision. 91% had known h/o vaccination against measles. About 70% had involvement of cornea with small punctate epithelial dot like lesions in 66.7% and large dot like lesions in 25% cases. The treatment for keratitis included topical steroids with lubricants. **Conclusion:** Despite widespread vaccination, a notable proportion of measles cases have occurred in individuals who have received the vaccine, particularly among young adults. Concurrently a substantial set of these cases has been associated with corneal involvement, presenting a clinical challenge and necessitating a deeper understanding of the underlying mechanism.

Keywords: Keratitis, measles, north Kerala

INTRODUCTION

Blindness and low vision, particularly in children, remain major public health challenges, with preventable causes like vitamin A deficiency, measles, and cataracts decreasing due to socioeconomic improvements such as better sanitation, water supplies, and vaccination coverage.[1] Measles, caused by the highly contagious measles virus (MeV) of paramyxo virus family, is a systemic infection characterized by fever, cough, coryza, and the hallmark maculopapular rash.[2] Despite the availability of an effective vaccine, measles remains a significant global health concern, particularly in regions with suboptimal vaccination coverage.[3,4] Measles, once thought to be under control, has resurged in recent years, posing significant challenges to public health systems worldwide.[5] While measles primarily affects the respiratory tract and lymphatic system, the virus can also disseminate hematogenously, leading to systemic complications affecting various organs and tissues.[6] Notably, ocular manifestations of measles, although less common than respiratory or neurological complications, can have significant implications for visual health. The involvement of the eye in measles infection, termed measles-associated ocular complications, encompasses a spectrum of pathologies, including conjunctivitis, uveitis, retinitis, and keratitis.[2,7-9] Of particular concern is the development of measles keratitis, characterized by inflammation of the cornea, which can lead to pain, photophobia, and vision impairment. The pathogenesis of measles keratitis involves direct viral invasion of corneal epithelial cells and immune-mediated inflammation, resulting in tissue damage and visual disturbances.[10,11] Investigating the incidence, clinical features, and outcomes of measles-associated keratitis will provide valuable insights into the pathogenesis and clinical course of this complication.

Remya Edachery, Pushpangadan Peringeth, Preethi Nair, Binoo Divakaran[1]

Consultant in Cataract and General Ophthalmology Services, Payyanur Co-Operative Hospital, Payyanur, [1]Department of Community Medicine, Government Mediacl College, Kannur, Kerala, India

Address for correspondence: Dr. Remya Edachery, Consultant in Cataract, Pediatric Ophthalmology, Strabismus and Neuro Ophthalmology, Payyanur Co-operative Hospital, Kannur, Kerala, India.
E-mail: remyae2003@gmail.com

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MATERIALS AND METHODS

This cross-sectional study was conducted at a secondary eye care hospital in North Kerala over five months, from October 2023 to February 2024. The study population consisted of patients who were admitted with clinical features suggestive of measles and presented with any symptoms or signs of ocular involvement. These patients were promptly referred for a comprehensive eye evaluation.

History taking

A detailed history was obtained from each patient, including:

- **Onset of General Symptoms:** The timing of fever, rash, cough, and gastrointestinal symptoms was recorded.
- **Onset of Ocular Symptoms:** Patients were questioned about the onset and progression of any eye-related symptoms.
- **Vaccination History:** The vaccination status against measles was ascertained through direct inquiry with the patient or their parents, given the lack of documented vaccination records. The recall method was used to determine whether the patient had received the measles vaccine.
- **Exposure History:** Any history of contact with confirmed or suspected measles cases was documented.

Ophthalmic examination

All patients underwent a thorough ophthalmic evaluation, which included the following:

- **Slit Lamp Examination:** A detailed slit lamp examination of the anterior segment of the eye was performed to assess for signs of conjunctivitis, keratitis, or other ocular abnormalities. Specific attention was given to the presence of conjunctival inflammation, corneal involvement, and any other anterior segment pathology.
- **Ocular Surface Staining:** Fluorescein staining was utilized in all cases, allowing for the identification of superficial punctate erosions, corneal epithelial defects, and other types of staining patterns.
- **Fundus Evaluation:** Undilated evaluation was done in all cases, with dilated evaluation in selected cases.

Laboratory investigations

To support the clinical diagnosis of measles and assess the overall health status of the patients, the following laboratory tests were conducted:

- **Complete Blood Count (CBC):** A CBC was performed on all patients to evaluate their hematological status, including white blood cell count, which could indicate an underlying infection or inflammatory response.
- **C-Reactive Protein (CRP):** CRP levels were measured to assess the presence and extent of inflammation.
- **Serological Testing:** In cases where measles was suspected but not definitively diagnosed through clinical presentation, serological testing for measles-specific IgM antibodies was conducted. This test helped confirm the diagnosis of measles, especially in atypical cases.

The collected data, including clinical features, vaccination history, ocular findings, and laboratory results, were systematically recorded and analyzed.

RESULTS

Age-wise distribution

A total of 30 patients formed the study group. Their ages ranged from 7 to 44 years, with a mean of 28 (±9) years; females comprised 57% of the total patients. The age and sex wise distribution of the studied population, shown in Figure 1 below, reveals that among the different age groups, the highest proportion (46%) belonged to the 20–29 age group, followed by the 30–39 age group (32%). Males accounted for the highest proportion (67%) in the 20–29 age group, while females (44%) in the 30–39 age group.

Among the 23 patients whose vaccination history was known, 21 (91%) had been vaccinated against measles. Also, among those who were aware of whether they had contact with a case of measles or not, 22% reported that they had contact with a known case. The number of days after onset of rash in the studied group varied from 1 to 10 days, with a mean duration of 4 (±2) days.

From Figure 2 above, it is seen that all the cases of measles had fever with rash; other symptoms that were possessed by the patients are depicted above. The eye-related symptoms present in the studied group, depicted in Figure 3 below, show that redness was the most common symptom, followed by foreign body sensation.

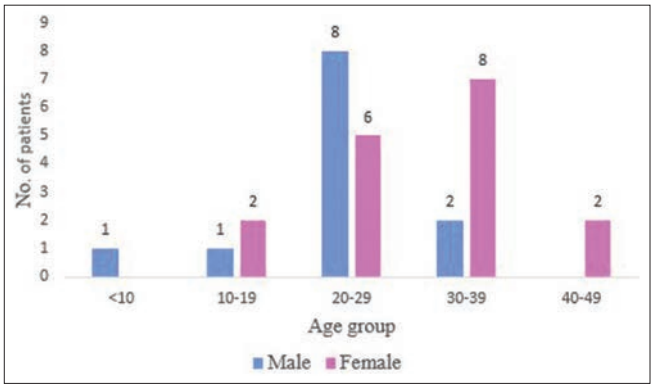


Figure 1: Age and sex wise distribution

The ocular findings in the patients suffering from measles are given in Figure 4.

The corneal involvement is shown in Figure 5.

The laboratory findings in the studied group are shown in Table 1.

Treatment details are listed in Table 2.

Measles IgM was positive in 3 cases (10.7%).

DISCUSSSION

In this study, a significant number of measles cases were observed despite a high rate of reported vaccination, raising concerns about possible vaccine failure. This finding suggests that a booster dose of the measles vaccine may be necessary to enhance immunity. However, it is important to acknowledge that the vaccination history in our study was obtained through patient or parental recall, as documented records were unavailable for most patients, who were between 20 and 40 years of age. Consequently, recall bias cannot be entirely ruled out. The World Health Organisation's South-East Asia Regional Office (WHO-SEARO) had set a target for the elimination of measles is by 2020.[12] To achieve this goal, it is essential to accurately determine vaccination status, measure antibody levels, and maintain active surveillance of measles cases.

The most recent measles outbreak in India was reported in Maharashtra in 2017, with children being the most affected group.[13] In contrast, our study focuses on the ocular findings in a group of immunocompetent adult patients with measles who were admitted to a secondary eye care hospital. Among the 23 patients whose vaccination history was available, 21 had been vaccinated against measles. The high incidence of measles despite this suggests that vaccine failure may have occurred.

All patients in our study presented with fever and rash. Conjunctival inflammation, affecting both the bulbar and palpebral conjunctivae, was observed in 70.8% of cases, with 8.3% exhibiting follicles in the palpebral conjunctiva. These findings align with those of a 2020 study, which reported conjunctival involvement in 65.6% of measles cases among 61 patients.[14]

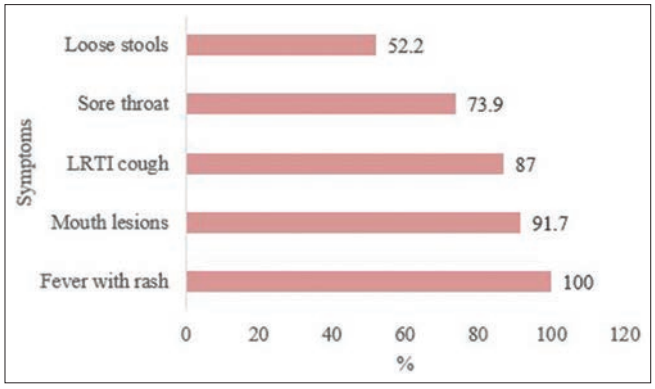


Figure 2: Symptoms of measles

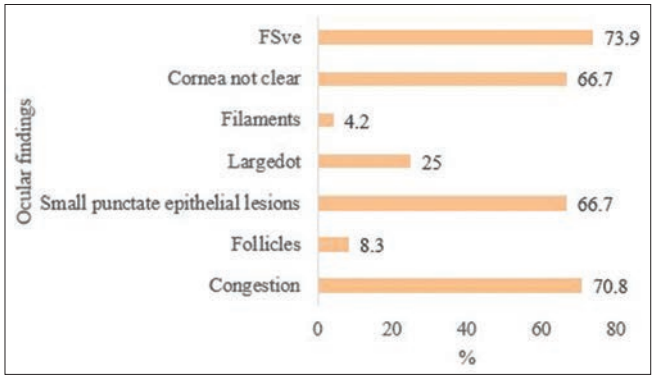


Figure 4: Eye-related findings

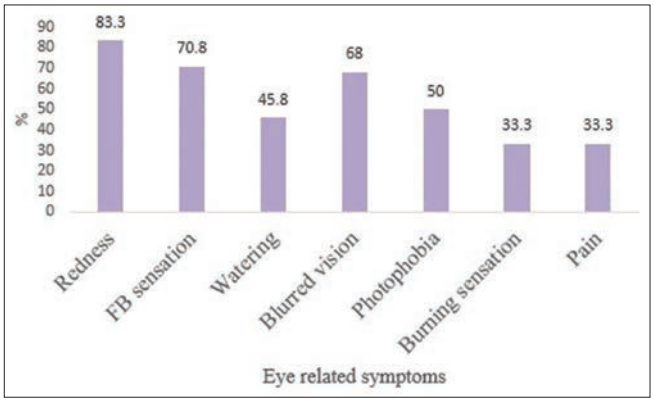


Figure 3: Ocular symptoms of measles

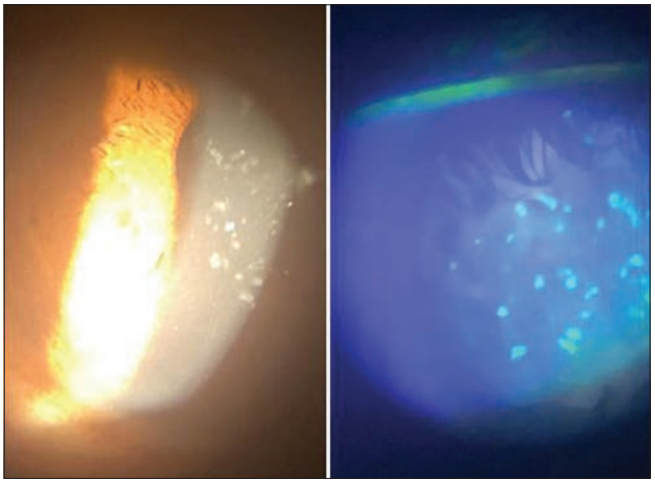


Figure 5: Corneal involvement without and with fluorescein staining

Table 1: Blood Parameters of the Studied Group

Variable	Minimum	Maximum	Mean	Std. Deviation
Hb	10.4	16.7	13.1	1.8
Total count	3090	9200	5446.8	1731.9
Neutrophil	61	89.3	74.8	7.3
Lymphocyte	7.6	35	19.6	6.6
Eosinophil	0.6	15	2.7	3.7
Monocyte	0.4	7.4	3.1	1.9
Basophil	0.1	6.1	1.2	1.8
C-reactive protein	0.5	50.2	18.4	13.6

Table 2: Treatment Details of the Study Group

Treatment	%
Lubricant	64.3
Antibiotic	10.7
Topical steroid	7.1
IV cephalosporin	71.4
Vit A	50
Systemic steroid	53.6

Pavlopulos *et al.*[15] identified four types of corneal lesions were through photographic analysis: small punctate epithelial lesions staining only with rose Bengal, small or coalesced epithelial defects, large or tiny filaments, and target lesions. Target lesions were characterized by concentric zones of staining with both rose Bengal and fluorescein, forming a distinctive pattern. The keratitis was confined to the corneal epithelium and resolved gradually without complications. Notably, our study found a high rate of corneal involvement, with 66.7% of patients exhibiting corneal changes on slit lamp examination and 73.9% testing positive for fluorescein staining. The types of staining observed included superficial punctate erosions, small and large punctate opacities, and filaments. These patients were closely monitored for secondary complications. Similar studies have reported significant corneal involvement, such as a 51% rate of keratitis in a study of measles in Turkish military personnel.[14] The higher percentage of corneal involvement in our study could be attributed to differences in viral strain and population characteristics. Although most cases of corneal and conjunctival inflammation resolved fully, 7.1% of patients required treatment with low-potency steroids.

In our study, 50% of patients received vitamin A as part of their treatment regimen, based on the attending physician's preference. However, there is no conclusive evidence from clinical trials to support the efficacy of vitamin A in preventing blindness in measles.[16] Interestingly, three of our patients exhibited corneal involvement without concurrent conjunctival inflammation, suggesting that thorough ocular evaluation should be performed in all measles patients. Future research should explore the relationship between antibody titres and the occurrence of keratitis.

Overall, our study found that young, immunocompetent patients did not experience any long-term ocular sequelae following measles. Further research is needed to better understand the factors contributing to vaccine failure and the ocular manifestations of measles, especially in adult populations.

CONCLUSION

This outbreak underscores the critical need for comprehensive epidemiological and laboratory investigations in suspected measles cases, regardless of vaccination status. Ocular involvement in measles is well-documented, typically manifesting as conjunctivitis or keratitis, though it can sometimes occur without noticeable symptoms. While general ophthalmologists often manage these eye conditions, the management of keratitis requires particular caution. Initiating steroid treatment without a proper slit lamp examination and ongoing monitoring can lead to complications such as corneal thinning and increased intraocular pressure. Therefore, ophthalmologists need to be actively involved in the care of measles patients, even in the absence of overt eye symptoms, to ensure appropriate management and prevent potential complications.

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There are no conflicts of interest.

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David Hubel and Torsten Wiesel: The duo that deciphered the visual brain



Figure 1: David Hubel and Torsten Weisel in their basement laboratory (credits: Canadian Medical Hall of Fame)

One of the most exciting discoveries that happened in the field of Neuroscience is the unravelling of the mysteries of the visual brain. This edition brings out the story of the collaboration of David Hubel and Torsten Wiesel who deciphered the neurobiology of vision through their animal experiments and the implications this discovery had on further explorations in visual processing, neuroplasticity and modifying the clinical approach to many diseases like amblyopia [Figures 1 and 2].

The mechanism by that the brain processed sensory data from our environment into cohesive visual images was largely unknown prior to the work of Hubel and Weisel, though some foundational insights were provided by the work of Ramón Y Cajal's work on neuronal interconnections.[1] It was known that individual retinal receptors transmit numerous messages conveying information about small units of the visual field. Hubel and Wiesel went on to explain how the cerebral cortex reconstructs these messages to allow the brain to "see" the image.

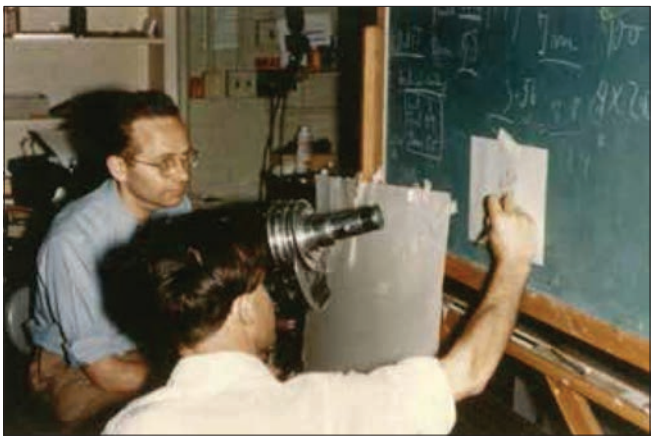


Figure 2: Hubel and Wiesel mapping a receptive field in cat visual cortex using a crude projector and screen (credits: Harvard Medical Library in the Francis A. Countway Library of Medicine.)

Dr. David Hunter Hubel was born on February 27, 1926, in Windsor, Ontario. He did Honors in Mathematics and Physics (1947, McGill University), and then applied to Medical School, where he was fascinated by Biochemistry and studies on the brain. Due to his interest in the studies of the brain, he mustered courage and arranged a meeting

Sanitha Sathyan
Vettam Eye Hospital, Kochi, Kerala, India

Address for correspondence: Dr. Sanitha Sathyan, Vettam Eye Hospital, Kochi, Kerala, India.
E-mail: dr.sanitha@gmail.com

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with the famous neurosurgeons Wilder Penfield and Herbert Jasper, who were famous for their work on epilepsy at the Montreal Neurological Institute, a part of the McGill University. Dr. Jasper promptly offered him a summer job in his Physiology laboratory.

After receiving MD degree in 1951, Hubel continued his training at McGill, with an internship, a year of Neurology residency, and a fellowship in clinical electroencephalography with Dr. Jasper. In 1954, David moved to the United States for a second year of Neurology residency at Johns Hopkins Institute. He volunteered for the Army, and was assigned to the Walter Reed Army Institute of Research in Washington DC. In 1955, around the age of 30 years, David had his first opportunity to conduct his own research.

Dr. Torsten Nils Wiesel was born in 1924 in Uppsala, Sweden. His family lived at the Beckomberga Hospital, a large mental hospital in Stockholm, where his father was the chief psychiatrist. Torsten graduated from the Karolinska Institute in Stockholm in 1954. He taught in the Karolinska Institute's Department of Physiology and worked in the Child Psychiatry unit of the Karolinska Hospital. In 1955, he began to pursue his interest in visual physiology in association with Prof. Stefen Kuffler at Johns Hopkins University Medical School. Later in his career, he joined as the Vincent and Brooke Astor Professor Emeritus in Rockefeller University, New York.

At Walter Reed, National Institutes of Health (NIH) in Bethesda, David had the opportunity to collaborate with Michelangelo Fuortes, a spinal cord neurophysiologist, who compared the flexor and extensor reflexes in decerebrate cats. For David, who had no prior experience in animal research, this provided a thorough grounding in electrophysiology. When David was pondering on his own research project, Mike suggested placing wires in the cortex of cats and recording from them while they were awake. That attempt failed, but the idea captured David's imagination and he began developing techniques for brain recording from animals while awake. He first tried a tough tungsten microelectrode, and then developed an electrode advancer. The advancer required so many versions, and through the course of his experiments he learned to operate the lathe and made the new electrodes himself.

David and Torsten first met when Torsten visited Walter Reed to learn how to make David's tungsten electrodes. Torsten was then working in Prof. Stephen Kuffler's laboratory in the Wilmer Institute at Johns Hopkins. David was planning to join the Physiology Department at Johns Hopkins at the invitation of Vernon Mountcastle, but it was not available at that point. To accommodate David at Johns Hopkins, Kuffler suggested that David spend time in his laboratory collaborating with Torsten. In 1958, David moved to the Wilmer Institute, which marked the beginning of a scientific partnership destined to last more than a quarter of a century. David and Torsten decided to take forward the investigations that Kuffler had done on the cat retina and the visual cortex. In 1959, when Kuffler moved from the Wilmer Institute at Johns Hopkins to Harvard Medical School, David and Torsten followed him to be among the first members of what eventually became the Department of Neurobiology at Harvard.

As they began their collaboration, David and Torsten set up their laboratory at Havard and began to stimulate the cat's retina by light and dark spots as Kuffler had conducted by using the projection ophthalmoscope. It turned out that they had great difficulty in activating the cortical visual neurons with spots of light. Here comes a serendipitous finding that changes their trajectory of experiments. For a single neuron, they were able to obtain only faint responses to spots of light in a part of the visual field; but when they changed the slide in the ophthalmoscope, there occurred a burst of activity which was produced by the line at the edge of the slide. They then realized that the neurons got excited by lines more than by spots. Subsequently, they discovered that different neurons preferred different orientations, and across a sample of neurons all orientations were represented. This was a preview of the observations in his landmark studies that was to describe the directionality and type of the stimulus that incited a response.

In 1959, David and Torsten had their first publication in the *Journal of Physiology* titled "Receptive fields of single neurons in the cat's striate cortex," which reported the orientation selectivity of primary visual cortex.[2] In 1962 they published their ground breaking paper in that they differentiated the classes of visual neurons, described their columnar organization, demonstrated that neurons within a column preferred similar orientations and put forward the idea of ocular dominance.[3] Subsequent to the cat experiments, they switched to studying the monkey visual cortex and made detailed drawings on the sequence of visual processing in the cortex, the topographical mapping of the cortex and the color opponent organization in the lateral geniculate body.

About three years later, they began to investigate the impact of congenital cataracts on the development of visual mechanisms in the brain. Initially they made several recordings from kittens at successive ages of their development. They noticed that shortly after the kitten's

eyes opened, many neurons in the primary visual cortex did show directional orientation like that of adults. Then they tested the effects of visual deprivation by sewing of one eye in new born kittens to simulate monocular deprivation, like unilateral cataracts in new born infants. After a few months they noticed that those kittens with monocular deprivation had reduced responses along with anatomical changes in the neurons of the lateral geniculate body and visual cortex receiving input from the deprived eye. But those neurons receiving input from the normal eye remained intact. Through a series of experiments, they concluded that the monocular deprivation was most severe when it was present before the eye opened, less severe if they were open for a few months and normal if the suturing was done in adulthood. They also paved way for the evolution of the concept of neuronal plasticity. The results of their experiments were published in a series of papers spanning over twenty-five years and made a quantum leap in the field of visual neurophysiology and their riveting insights channeled further explorations in remarkable ways.

Through these innovative experiments, Hubel and Wiesel established two fundamental points about the developing visual system: one that the neuronal connections in the visual brain are largely existent before the eyes open and two, that the organization of these connections deteriorate if deprived of visual input during a critical period after birth, which was later elucidated to be four to eight weeks after eye opening. These novel experiments and their astounding results spawned a new field of research about the molecular mechanisms of visual plasticity and inspired generations of scientists. David and Torsten won the Nobel Prize for Physiology/Medicine in 1981, along with Roger Sperry, for his independent work on cerebral hemispheres [Figure 3].



Figure 3: Torsten Wiesel, Roger Sperry, and David Hubel in Stockholm, 1981. (Credits: Harvard Medical Library in the Francis A. Countway Library of Medicine.)

The collaboration of these two giants in the field of Neuroscience was also path breaking in many aspects. Hailed as one of the most successful and longest partnerships in the history of biological sciences, their respect for each other was immense as was their realization that they brought complementary abilities for a common good. They shared a common understanding of what they wanted to aim for, how to transform differences of opinion to pearls for intellectual stimulation and to nurture together their love for scientific discipline and innovative spirit. Over the long period of their bonding, they had realized that they had reached their studies on visual cortex at the right time, with the right techniques and had the responsibility to take it to a fruitful point of completion. The story of their combined work is summarized in the book, Brain, and Visual Perception (OUP USA; 1st edition, 2005).

David spent the rest of his life at Harvard as the John Franklin Enders University Professor of Neurobiology and continued to work on many aspects including the functional correlates of the sub-modalities of vision like form, contrast, and color. Torsten moved to Rockefeller University, and worked on the connections within striate cortex.

In addition to winning the Nobel Prize, David was elected to the leading societies of the world including the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and the Royal Society. He was honored by many honorary lectures, award, and honorary degrees.

Torsten Wiesel is the member of the Royal Swedish Academy of Sciences, Serbian Academy of Sciences and Art. He has won numerous awards, presented numerous lectures, and bestowed with several honorary degrees.

Hubel passed away at 87, in 2013. Torsten Wiesel, at 101 years of age, is still active as a mentor for young scientists and as a propounded of Human Rights.

Hubel and Wiesel's work was an epoch marking contribution, which had a great impact on our understanding of the visual brain. Their observations influenced the thought processes of many generations of scientists working in the field of Neurophysiology, Behavior Psychiatry etc., and had a huge impact on the clinical care in Neurology and Ophthalmology.

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Case Series

Eye: A window to the brain

ABSTRACT

The present case report aims at reviewing the topographical localization of the lesions/area affected by stroke by means of analyzing the presenting ocular motor abnormalities in an emergency medical setup. Three cases are described, wherein the patient presented with an aggregation of discrete eye abnormalities classically aiding in the localization of lesions in the brain.

Keywords: Brain, lesion, pupil

CASE HISTORY

The first case is of an 18-year-old girl who presented with acute onset of binocular diplopia from 1 week noticed on waking up from sleep, especially when looking up and down. There was associated left-sided headache and left eye pain. There was no history of projectile vomiting, transient visual obscurations, diminution of vision, redness, or photophobia. There was no associated head trauma or any prior medical condition or fever.

The patient did not report any neurological symptoms. Her best corrected visual acuity was 6/6, N6 in both eyes with a correction of -1.25 dc at 180. Ocular motility evaluation revealed a -4 limitation of elevation and -2 limitation of depression in both eyes [Figure 1]. There was presence of convergence retraction nystagmus, with Colliers sign in both eyes. There was light near dissociation in the left eye. We went ahead with the neuroimaging in this patient with a clinical diagnosis of Parinaud's syndrome. Magnetic resonance imaging (MRI) brain revealed a tiny acute nonhemorrhagic infarct in the midbrain around peri aqueductal gray matter. MRI orbit was normal. The patient was extensively investigated for any thrombophilic disorders, autoimmune diseases causing vasculitis, and complete cardiac evaluation for any source of emboli, but all were unyielding.

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The definitive cause of infarct in this young patient could not be discerned. The patient was treated with low-molecular-weight heparin and antiplatelet agents. Improvement in depression after 2 weeks but elevation limitation had remained. Further follow-ups were only by telephonic conversation due to COVID pandemic when the parents reported marked improvement and resolution of diplopia.

The second case is of a 75-year-old male with complaints of blurring of vision in both eyes past 1 year and drooping of the left eye past a year with limitation of movements in both eyes. There was past history of stroke a year ago, following which the complaints started. He was a known diabetic and hypertensive on oral medications for the same. His visual acuity was counting fingers at 2 m in both eyes, not improving. Anterior segment evaluation showed grade 3 nuclear sclerosis in both eyes. The intraocular pressure measured by applanation tonometry was 12 mmHg in both eyes.

Pooja Kumari, Harsha Pagad

Department of Ophthalmology, Padmashree Dr. D.Y. Patil Medical College and Hospital, Nerul, Navi Mumbai, Maharashtra, India

Address for correspondence: Dr. Pooja Kumari, Department of Ophthalmology, Padmashree Dr. D.Y. Patil Medical College and Hospital, Nerul, Navi Mumbai, Maharashtra, India.
E-mail: ps154557@gmail.com

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Figure 1: Case 1: 9 Gaze demonstration



Figure 3: Case 2: 9 gaze demonstration

Pupillary evaluation was as follows: The right eye pupil was round, reactive to light. The left pupil was mid-dilated [Figure 2]. The anisocoria increased in bright illumination. There was no afferent pupillary defect. The fundus examination was unremarkable. External examination showed the presence of bilateral mild ptosis. There was 30 degree left exotropia on Hirschberg corneal reflex test. Extraocular motility examination revealed -3 limitation of elevation in the right eye and -4 limitation of adduction,

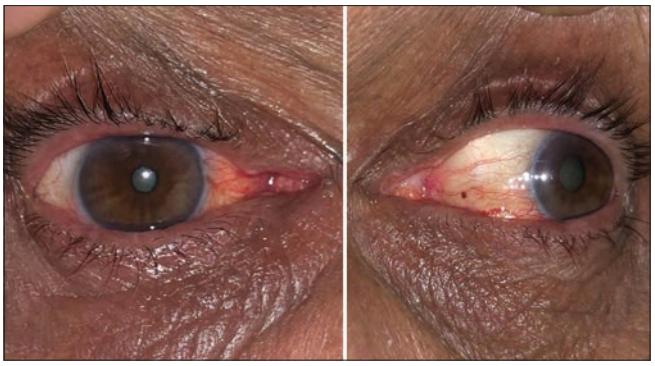


Figure 2: Pupil RE: CCRTL. LE: Mid-dilated fixed

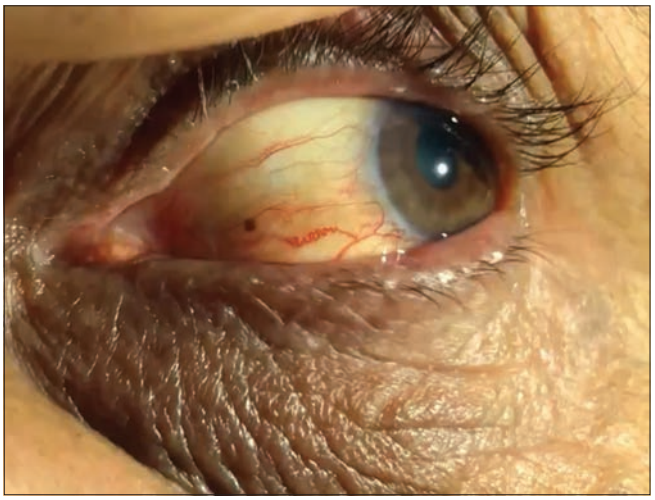


Figure 4: Intorsion caused by superior oblique on looking down

elevation, and depression in the left eye, suggestive of a nuclear third nerve palsy [Figures 3 and 4].

MRI brain dated a year back showed well-defined focal areas of hyperintensity on T2W1 in the midbrain, suggestive of acute infarct [Figure 5].

The third case is of a 70-year-old male who presented with sudden onset of weakness in upper and lower limbs and binocular diplopia on looking to the left side. His best corrected visual acuity was 6/9 in right eye and 6/36 in left eye. Pupils were miotic with sluggish reaction to light. The patient was pseudophakic in both eyes. Dilated fundus evaluation was normal. Extraocular motility examination showed limitation of adduction in right eye with abduction limitation in left eye, suggestive of left gaze palsy [Figure 6]. MRI brain done was s/o acute nonhemorrhagic infarct at the pontomedullary junction [Figure 7]. MR Angiography showed narrowing in the proximal part of the basilar artery just distal to its origin. The patient was a known diabetic on oral medications. So, a diagnosis of Millard–Gubler syndrome (MGS) was made with ipsilateral gaze palsy and contralateral hemiparesis.

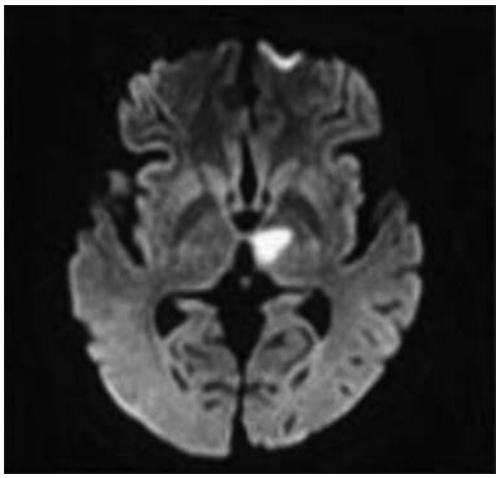


Figure 5: MRI Brain: Well-defined focal areas of hyperintensity on T2WI in mid-brain (L>R) suggestive of acute infarct



Figure 6: Case 3: 9 gaze demonstration



Figure 7: MRI Brain: Acute nonhemorrhagic infarct at the pontomedullary junction

DISCUSSION

Case 1: Parinaud syndrome

French ophthalmologist Henri Parinaud first described Parinaud syndrome in the late 1800s. Parinaud described it in a series of case reviews of patients with disturbances of associated eye movements and gaze paralysis. He attributed the cause of this condition to a lesion of the quadrigeminal area. This condition is variously known as the Sylvian aqueduct syndrome, dorsal midbrain syndrome, pretectal syndrome, and Koerber–Salus–Elschnig syndrome.[1]

The classic triad of conjugate up gaze paralysis, convergence–retraction nystagmus, and light-near dissociation was only present in 65% of the cases. Pineal neoplasms remain an important etiological consideration. Conservative management approaches for ocular symptoms are sufficient in most cases, although surgical treatment of up gaze palsy can be a useful option in refractory cases.[2]

Case 2: The third cranial nerve palsy

Third nerve palsies can result from lesions located anywhere from the oculomotor nucleus to the termination of the third nerve in the extraocular muscles within the orbit and may be the herald manifestation of underlying neurological emergencies such as intracranial aneurysm, pituitary apoplexy, and giant cell arteritis.[3]

Nuclear third nerve palsy can result from ischemia, infective causes, or tumors.

The topographic arrangement of oculomotor subnuclei within the midbrain is responsible for the varying clinical presentations in nuclear, fascicular, or infranuclear lesions.[4]

Case 3: Millard–Gubler syndrome

MGS is also known as facial abducens hemiplegia syndrome or the ventral pontine syndrome. It is a classical crossed brainstem syndrome characterized by a unilateral lesion of basal portion of the caudal *pons* involving fascicles of abducens (VI) and the facial (VII) cranial nerve, and the pyramidal tract fibers.[5]

Components of MGS include ipsilateral weakness of the eye on abduction (VI nerve), ipsilateral facial muscle weakness (VII nerve), contralateral hemiparesis, or hemiplegia of upper and lower extremities (pyramidal tract involvement).

CONCLUSION

The various parts of the brain like cortex, basal ganglia, cerebellum, and brainstem are involved in the generation

and control of eye movements. The signals of this complex neural network finally converge on the ocular motoneurons of the brainstem. Infarct or hemorrhage at any level of the oculomotor system may give rise to a broad spectrum of eye movement abnormalities. These eye movement abnormalities when recognized at the right time will have high localizing value.

Our case series proves this beyond doubt. All our patients had classic eye movement abnormalities which aided in topographical localization of brain lesions even before the results of neuroimaging were available. Recognition of the patterns and characteristics of abnormal eye movements observed is important in understanding the roles of each neural structure and circuit in ocular motor control as well as in localizing the offending lesion.

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Conflicts of interest

There are no conflicts of interest.

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Case Report

Corneal lamellar patch graft: A remedy for hypotony maculopathy and leaking bleb

ABSTRACT

Trabeculectomy with antifibrotic agents such as Mitomycin C has merits but comes with the risk of bleb-related complications such as bleb leaks and hypotony maculopathy. This can be managed with several techniques, including conservative and surgical approaches. Corneal lamellar patch graft offers multiple advantages over other surgical techniques such as scleral patch graft and amniotic membrane graft. We report a patient who presented with a leaking thin cystic avascular bleb, intraocular pressure of 3 mmHg, and hypotony maculopathy. The patient was initially managed conservatively and later managed surgically with bleb excision by bleborhexis and clear corneal lamellar patch graft. Timely recognition and intervention thus help in preventing sight-threatening complications.

Keywords: Bleb leak, corneal lamellar patch graft, hypotony maculopathy, mitomycin C, trabeculectomy

INTRODUCTION

Trabeculectomy with Mitomycin C is used worldwide as a convenient and effective method to reduce intraocular pressure (IOP) in glaucomatous eyes that cannot be controlled with maximum tolerated medications. The introduction of antifibrotic agents as an adjunct to trabeculectomy has resulted in lower postoperative IOPs. The use of these antifibrotic agents is associated with demerits such as bleb leaks and hypotony, which can be sight-threatening.[1]

"Statistical" hypotony is defined as IOP more than 3 standard deviations below the mean (<6.5 mmHg), and the World Glaucoma Association defines hypotony as IOP less than 5 mmHg along with possible clinical complications that could compromise vision.[2] Severe complications associated with leaking blebs are blebitis or bleb-related endophthalmitis. Successful resolution of leaking avascular filtering blebs often requires surgical revision, though many nonsurgical treatments are available. Various surgical approaches with varying success rates have been described, including conjunctival advancement with or without excision of the pre-existing bleb, free conjunctival grafts, and amniotic membrane grafts.[1]

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CASE REPORT

A 51-year-old female presented to us with a history of defective vision in the left eye of 1-year duration. Her best corrected visual acuity in the left eye was 6/9, IOP was 18 mmHg with maximal medical therapy, closed angles on gonioscopy, and a cup: disc ratio of 0.9 with advanced visual field loss. This patient underwent an uneventful phaco-trabeculectomy with 0.2 mg/mL Mitomycin C. IOP with Goldmann Applanation tonometry was measured to be 8, 10, 8, and 8 mmHg at 2 weeks, 1 month, 3 months, and 6 months follow-up, respectively. At her 1-year follow-up, she presented with a leaking thin cystic avascular bleb [Figure 1] and an IOP of 3 mmHg. Her best corrected visual acuity dropped to 6/24 from 6/9, and fundus

Devendra Maheshwari, Priya H. M., Madhavi R. Pillai, Techi D. Tara

Department of Glaucoma, Aravind Eye Hospital, and Post Graduate Institute of Ophthalmology, Tirunelveli, Tamil Nadu, India

Address for correspondence: Dr. Devendra Maheshwari, Department of Glaucoma, Aravind Eye Hospital, S. N. High Road, Tirunelveli Jn. - 627 001 Tamil Nadu, India.
E-mail: drdevmaheshwari@gmail.com

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examination revealed choroidal folds suggestive of hypotony maculopathy associated with disc edema [Figure 2e]. Optical coherence tomography (OCT) also confirmed this clinical finding [Figure 2f].

The patient was prescribed topical steroids with cycloplegics along with oral steroids. Despite conservative management, the patient's clinical condition did not show any improvement after 2 weeks. Hence, surgical management with bleb revision and lamellar corneal patch graft was performed.

After conjunctival peritomy, bleb excision by bleborhexis[1] technique was done, and an underlying scleral defect with frank leak was noted [Figure 3a and b]. A clear corneal lamellar patch graft was placed over the scleral defect and was anchored to the sclera with one 9-0 nylon box suture and four 9-0 nylon cardinal sutures, followed by watertight conjunctival closure with 10-0 vicryl sutures [Figure 3c and d]. Postoperatively, clear cornea, uniformly elevated diffuse bleb, and a well-formed anterior chamber were noted on the first postoperative day, and IOP picked up to 16 mmHg. The visual acuity improved to 6/12. Subsequently, at her 3-month follow-up, best corrected visual acuity was 6/6, IOP was 12 mmHg, and fundus examination and OCT revealed complete resolution of hypotony maculopathy [Figure 2g].

DISCUSSION

The occurrence of bleb leaks and hypotony have increased as a result of the introduction of various antifibrotic agents such as Mitomycin C and 5-fluorouracil as an adjunct to trabeculectomy. Some of the severe complications associated with bleb leaks following MMC trabeculectomy include bleb-related infections, blebitis, and endophthalmitis.[3,4] The treatment options for hypotony associated with bleb leaks can range from conservative to surgical approaches.

Cases resistant to the conservative approach often require a surgical approach, which involves surgical excision of the bleb and patch grafting using autologous conjunctiva, autologous or preserved sclera, amniotic membrane, and preserved cornea. Bleborhexis is a technique in which the overhanging fibrosed thin cystic conjunctival bleb is peeled off the cornea smoothly to leave a uniform clear corneal surface.[1] Conjunctival advancement with excision of the pre-existing bleb is superior to conjunctival advancement alone because the presence of the pre-existing bleb leads to an increased incidence of recurrent bleb leaks as a result of retained epithelial inclusions, as well as to the development of bleb dysesthesia. Only a patch graft can help maintain ocular integrity in cases of full-thickness scleral melt or fistula or in cases of non-closure of the leaking bleb with sutures. In

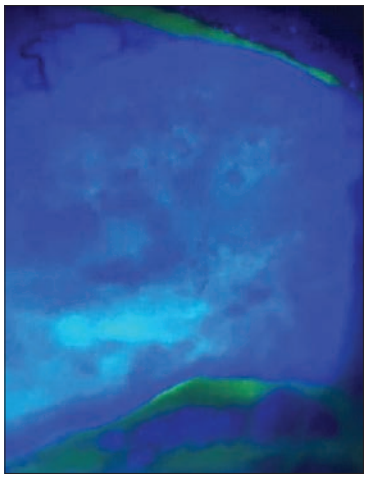


Figure 1: Figure showing a sweating bleb under cobalt blue filtered light after fluorescein staining

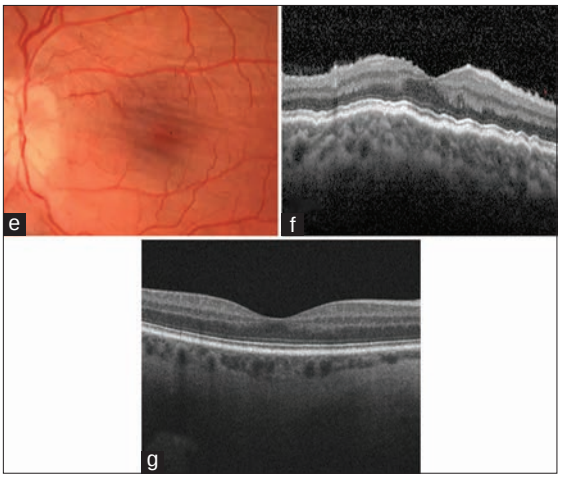


Figure 2: (e) Fundus photo showing choroidal folds and disc edema -hypotony maculopathy (f) OCT Macula showing retinal folds – hypotony maculopathy (g) Normal OCT Macula 3 months post procedure

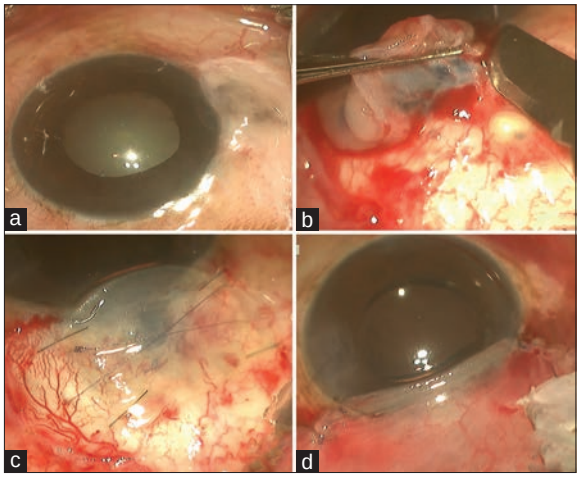


Figure 3: (a) Bleb excision by bleborhexis (b) Scleral defect with frank leak (c) Corneal lamellar patch graft anchored with one box suture and four cardinal 9-0 nylon sutures (d) Watertight conjunctival closure with 10-0 vicryl sutures

such cases, the use of conjunctiva or AMG has an increased likelihood of breakdown of overlying epithelium.[5] A donor scleral patch graft carries a higher risk of flap necrosis and exogenous infection.[6] Corneal lamellar graft has constructive advantages, contributing to a better graft-host fit. Corneal graft is superior to scleral graft as there is less vascularization and scar formation. It also has an added advantage that it maintains the contour of the eye with minimal disturbance of the tear film and thus offers better cosmesis.

CONCLUSION

Surgical bleb revision with clear corneal lamellar patch graft is a useful and effective technique in managing bleb leak with associated refractory hypotony maculopathy and offers faster healing, better patient comfort, and good cosmesis.

Declaration of patient consent

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There are no conflicts of interest.

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Case Report

Bearing the brunt: A Case of traumatic enucleation in a bear encounter

ABSTRACT

In a bear attack aftermath, a 35-year-old female farmer suffered severe facial trauma, resulting in traumatic enucleation of the right eye. Ocular and maxillofacial assessments revealed extensive injuries. Enucleation was chosen as a management option due to optic nerve avulsion and potential systemic complications, highlighting the complexity of wildlife-induced ocular injuries.

Keywords: Bear maul, ocular trauma, traumatic enucleation

INTRODUCTION

Deforestation has compelled animals to venture from the heart of the forests toward the forest perimeters. This proximity between the forest's edge and human settlements has led to frequent interactions between humans and wildlife, notably bears, thereby heightening the vulnerability of people to bear attacks. The typical method of bear assault predominantly involves frontal attacks with rapid, high-velocity clawing motions.[1] Ocular involvement in such incidents is rare but poses a significant challenge management due to the complexity and extent of injuries sustained.

CASE PRESENTATION

A 35-year-old female, working as a farmer, was returning home from the farms when she was suddenly ambushed by a bear emerging from the nearby bushes. The attack resulted in severe bleeding from her face, prompting an urgent transfer to the nearby PHC from where the patient was referred to a tertiary medical hospital. Notably, there was no history of seizure attacks or neurological deficits observed. During the local examination, multiple sutured lacerations [Figure 1b] were identified on her face and forehead, particularly around the eye region. Additionally, the patient described an abrupt loss of vision in her right eye following the incident.

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Ophthalmic examination unveiled significant findings. The right eye exhibited proptosis with a complete loss of vision (traumatic enucleation) [Figure 1a]. Additionally, there were signs of restricted ocular movements, periorbital edema, ecchymosis, fixed-dilated pupil, and the presence of a traumatic cataract. Left eye had a full-thickness split in the lower eyelid; ocular movements were restricted.



Figure 1: a Traumatic enucleation; b sutured lacerations over the maxillofacial area

Malvika Sharma, Dhruval A. Khurana[1], Nancy Sharma

Department of Ophthalmology, Government Medical College, Jammu, [1]Department of Ophthalmology, Aditi Eye Hospital, Gujarat, India

Address for correspondence: Dr. Nancy Sharma, Government Medical College, Jammu, India.
E-mail: nancee.shandilya@gmail.com

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However, the trauma vision remained relatively intact, measuring at 6/12.

Radiological assessment through NCCT of the head revealed

- Proptosis of the right eye with evident optic nerve injury, specifically in the anterior intraorbital section, indicating a probable avulsion. Retrobulbar blood and air foci were visible, yet there was no indication of globe rupture.
- Comminuted fractures of the lateral orbital wall of the right eye and the lamina papyracea of the left orbit.
- Bilateral comminuted and displaced fractures involving nasal bones.
- Minimally displaced fractures of the anterior and medial walls of the maxillary sinus.

MANAGEMENT

Upon the patient's ER presentation, consultations were sought from OMFS (Oral and Maxillofacial Surgeons) for the assessment of maxillofacial injuries, and any identified lacerations were promptly sutured. A follow-up review was advised once the vital signs had stabilized. Additionally, opinions were sought from general medicine experts to ensure systemic stability of the patient's vital parameters.

Given the irreversibility of the optic nerve avulsion (bad visual prognosis) and the risk of systemic ophthalmic complications in the other eye, the patient and her family were counseled, and after obtaining informed consent, enucleation was performed.

DISCUSSION AND CONCLUSION

In India, bear maul injuries account for only 0.1% of animal attacks, despite being the most frequent injuries caused by wild animals. Among the reported injuries, a majority occurred during individuals' routine morning activities such as defecation, wood collection, and cattle grazing, characterized by sudden encounters with bears.[2] There is limited literature on total globe enucleation. Traumatic globe avulsion, commonly caused by traffic accidents, falls, or assaults, is a rare occurrence.[3]

Several theories propose mechanisms for traumatic enucleation. Morris *et al*.[4] suggest that a wedge-shaped object entering medially may cause enucleation by cutting the optic nerve against the nasal wall. Another theory involves orbital fractures compressing the orbit, forcing globe luxation. Retrobulbar posterior-to-anterior force causing globe displacement and subsequent optic nerve injury is also proposed. In this case, a decreased orbital volume from displaced fractures of the lateral orbital wall was the reason and the optic nerve injury resulted from a sudden and forceful high-speed blunt trauma. Notably, in this case, traumatic enucleation resulted from a bear attack, representing an uncommon cause for such an event.

Globe avulsion classifies as incomplete when only the optic nerve is affected and complete when all extraocular muscles and the optic nerve are disrupted (traumatic enucleation). In incomplete cases, preserving the globe is preferred unless its vascular supplies are compromised. However, for traumatic enucleation, surgeons commonly recommend removing the entire globe and adjacent components due to the impossibility of functional and anatomical rehabilitation[5] and so was done here too.

After the enucleation of the traumatic eye, the patient underwent regular reviews to monitor the fellow eye for any signs of sympathetic ophthalmia; fortunately, there were no such indications. In between, the patient was also referred to the OMFS department for the management of the facial fractures.

Declaration of patient consent

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Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Case Report

Vanishing act: The peril of a freely mobile foreign body hidden in the eyelid

ABSTRACT

Intraorbital foreign bodies because of trauma in children often present various challenges in clinical practice. We present the unique case report of a 10-year-old male child with a history of trauma by pencil during a fight with another student in school and presented 5 months later with a graphite foreign body in the left upper eyelid. Ultrasound B scan confirmed the presence of the foreign body in the eyelid. The foreign body was freely mobile in the subdermal preseptal orbital fat. Surgery was performed under general anesthesia and a 6 mm graphite pencil lead was removed successfully. Follow-up USG-B scan confirmed no residual piece. Small size, free mobility, breakability of foreign body, and minimal size of surgical incision were some of the challenges of surgery.

Keywords: Foreign body, foreign body removal, pencil tip

INTRODUCTION

Intraorbital foreign bodies (IOFB) are quite common in the pediatric population. Both high-velocity, as well as low-velocity injuries, can occur since children are playful and do not know about the nature of the objects in hand. An IOFB is an object that lies within the orbit but outside the globe.[1] Orbital foreign bodies may damage the intraorbital structures and may lead to serious complications if not identified and removed in time. Foreign bodies may be either metallic, inorganic, or organic.[2] The foreign bodies should be removed rather than leaving them *in situ* as a lot of delayed complications have been reported by several authors.[3] There is no defined method of removal of IOFB as they greatly vary in location and size. Organic foreign bodies cause excessive inflammation and reaction and should be removed as soon as possible. Inorganic and metallic foreign bodies may remain inert for a long time, but they may cause fibrosis or migrate leading to damage of major orbital structures.[4] IOFB in the eyelid may lead to difficulty in blinking and granuloma formation. IOFB in fornix may lead to recurrent conjunctivitis, hemorrhage, scleral tear, entropion, etc.[5] Corneal lacerations occur as a result of penetrating injuries. Retinal and vitreous foreign bodies may cause fibrosis leading to tractional retinal detachment and lodge on the macula to cause a macular hole or diminution of vision.[6]

CASE PRESENTATION

We present a unique case of graphite foreign body in the left upper eyelid of a 10-year-old male child. The child came to the ophthalmology outpatient services complaining of something in his left upper eyelid, which he could feel with his fingers. On examination, we could not feel anything on palpation, but the child could maneuver it above the upper lid with his fingers to enable us to palpate a hard linear mass about half a centimeter which was freely mobile subdermally. It got easily displaced in subdermal fat and was hard to locate. On detailed questioning of parents and child about the history of trauma, the child revealed the history of a fight

Sonia Bhargav, Anshul Garg, Tarun Arora[1]

Department of Ophthalmology, Bhagat Phool Singh Government College for Women, Sonipat, Haryana, [1]I Cure Eye Centre-Janakpuri, New Delhi, India

Address for correspondence: Dr. Anshul Garg, House No 1031, Amardeep Colony, Kaimri Road, Hisar - 125 001, Haryana, India.
E-mail: ani.3219@gmail.com

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with a fellow student in school 5 months back during which he was hit by a pencil. We then suspected the mass to be a foreign body, most likely the pencil tip graphite. On careful examination, we noticed an entry site on the skin below the left eyebrow with mild dark discoloration [Figure 1]. Ocular movements were normal and there was no sign of trauma to the eyeball. The dilated fundus examination was unremarkable. Visual acuity was 6/6 in both eyes. Since the foreign body was superficial, an ultrasound B scan was done which revealed a highly echogenic linear shadow measuring 4.4 mm in length in preseptal subdermal fat in the left upper eyelid just below the eyebrow. The foreign body was lying so superficial in the subdermal fat and so easily maneuvered by the child, that it could be easily visualized with a routine USG B scan that penetrates only 5–10 mm into the eye. Graphite being an inert substance did not cause any inflammation in the eyelid despite staying in the tissue for 5 months. Free mobility of the foreign body prevented it from lodging at a single place and formation of granulation tissue. Based on these findings, the patient was taken up for foreign body removal under general anesthesia. The surgery was challenging not only because the foreign body was very small but also because the child would no longer be able to help us localize it under the effect of anesthesia. Moreover, we aimed to make the smallest possible incision leaving the least scar. The child was asked to maneuver the foreign body in the upper eyelid, which was marked before the anesthesia was induced. After induction of anesthesia, cleaning, and draping, the foreign body was held in place carefully by a bud by the assistant, where a nearly 7 mm incision was given below the eyebrow. The dissection was carried out neatly in a single plane and a foreign body was found and removed taking care not to break or crush it with forceps. Since the foreign body was very superficial, the skin was sutured in a single layer with 6.0 silk [Figure 2]. After removal of the foreign body, it was measured to be 6 mm in length and 1–2 mm in diameter [Figure 3].

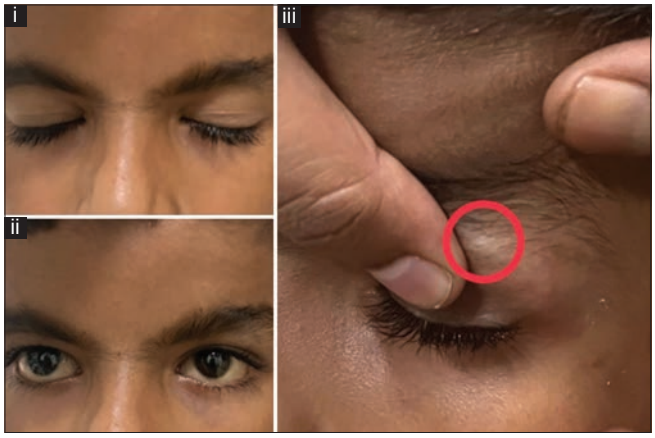


Figure 1: (i and ii) The photograph of the child before maneuvering the foreign body (iii) the entry site showing mild discoloration

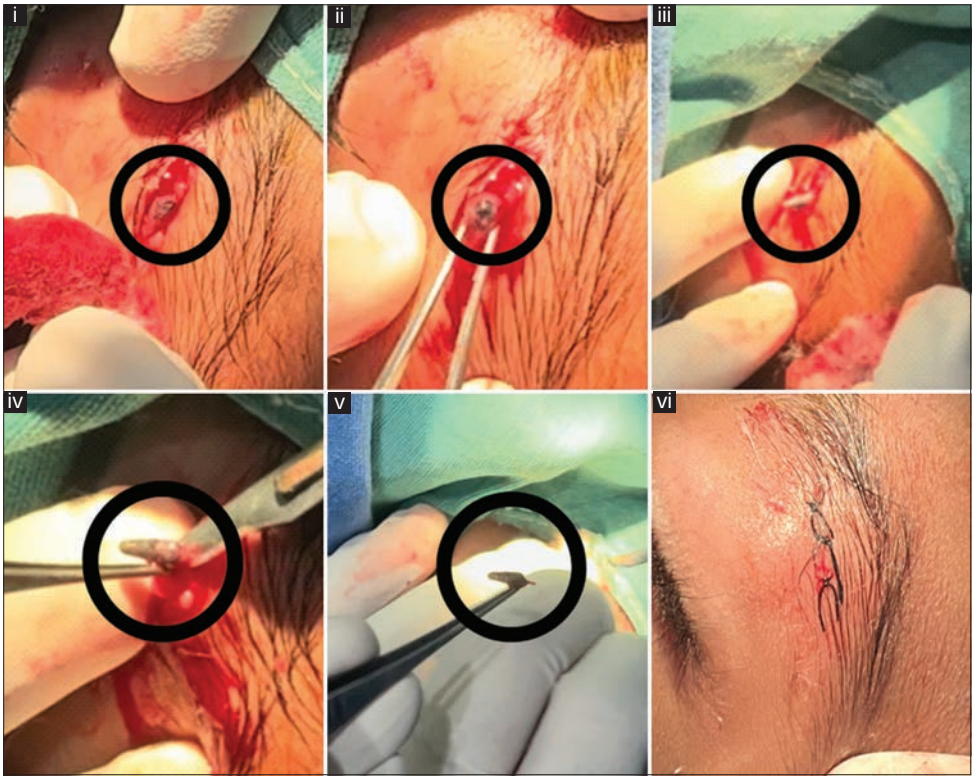


Figure 2: (i) 7 mm incision given below the left eyebrow (ii) foreign body located and held with forceps (iii and iv) neat dissection of the foreign body from the subdermal fat (v) removed foreign body clearly showing graphite pencil tip removed in toto (vi) closure of skin incision with silk 6-0

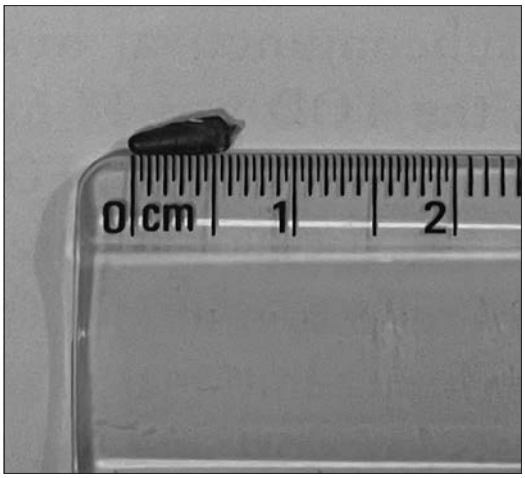


Figure 3: Foreign body as measured after removal, roughly 6 mm in length

DISCUSSION

IOFD in the pediatric population is uncommon because of the absence of occupational risks in children, but they often go unnoticed and ignored. It is very important to recognize the foreign bodies in time and remove them as soon as possible. Risk-benefit assessment should always be performed by ophthalmologists in all these cases whether to carry out surgery or not. Given the sharp nature of the objects, it is very important to educate both children and parents about the complexities that are associated with IOFB. For instance, in this case, if the removal of the foreign body was not carried out it could have eventually penetrated through the orbital structures or damaged the levator palpabrae superioris aponeurosis, muller muscle causing lagophthalmos or ptosis. Furthermore, there are always chances of granuloma formation in these cases and recurrent infections could occur. The ophthalmologist should have sound knowledge of how to locate the foreign body and a rational decision should be made on the removal technique along with minimizing the radiation damage due to various imaging modalities. To our knowledge, this is the first reported case of a freely mobile graphite foreign body in the eyelid. The varied foreign bodies in the orbit can be approached by proper clinical suspicion, thorough history taking, and a series of diagnostic tests.[7] Children should be kept at close follow-up to monitor long-term complications.

CONCLUSION

IOFB in the pediatric population can have sight-threatening effects, a meticulous history along with proper management is always necessary in all these cases.

Declaration of patient consent

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Financial support and sponsorship

Nil.

Conflicts of interest

Nil.

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Case Report

Sudoriferous cyst near inner canthus of eye: A case report

ABSTRACT

We present a rare and unique case of Sudoriferous cyst of the orbit in an adult patient. The unique feature of the cyst is that it presented spontaneously, without any local trauma in an adult whereas the usual presentation is after minor local trauma. There have been reports of presentation in children as congenital cases. Our patient is a 64-year-old male, who noticed a small nodule near the inner canthus of his left eye a year ago. It gradually increased in size over 5–6 months as a painless mass. After a complete clinical assessment, surgical excision of the complete mass was performed under local anesthesia and sent for histopathological examination. The histopathology revealed a single cyst lined by double layered cuboidal epithelium. The lining epithelium is periodic acid Schiff (PAS) positive suggesting its apocrine nature. This confirmed the diagnosis of a sudoriferous cyst.

Keywords: Apocrine, periodic acid Schiff stain, sudoriferous cyst eyelid

INTRODUCTION

Sudoriferous cysts of the eyelid arise from sweat glands. They are also called Hidrocystoma. "Sudoriferous" means carrying or producing sweat. They are thin-walled transparent vesicles at the margin of the lid, lined by 1–2 layers of atrophic cuboidal or flattened epithelial cells containing watery fluid or with an empty lumen. Sweat glands are uniformly distributed in the skin with a higher density over axillae, perianal, and genital regions. In the eyelids, they occur as modified sweat glands and are called Moll's glands.

The unique feature of the cyst is that it presented spontaneously, without any local trauma in an adult whereas the usual presentation is after minor local trauma.

CASE HISTORY

A 64-year-old, male patient, presented with the chief complaint of a mass near the inner canthus of his left eye. It began as a small painless nodule one year ago. During the past 3 months, the nodule increased in size to the present size of a peanut. He also reported that it was painful to touch. There was no history of local trauma or any other ocular disorders. He offered no history of similar disorders elsewhere.

The examination findings included a swelling of 2 cm diameter, globular shape, with intact overlying skin near the medial canthus in the left eye [Figure 1]. On palpation, it was cystic in consistency and non-tender. It was fixed to the skin but not to the underlying tissue. There was no discharging sinus or fistula. The transillumination test was positive indicating its cystic nature. Intraocular examination was normal for both eyes. A differential diagnosis of inclusion cyst/retention cyst and the sebaceous cyst was considered. An X-ray was taken to rule out any involvement of the underlying bone.

Surgical management was offered to the patient [Figure 2]. Local anesthesia was induced by giving perilesional local

Pramod K. Sahu, Akshita Sharma, Surbhi Gupta, Nitika Beri, Shimpa Kundan

Department of Ophthalmology, UCMS and GTB Hospital, Delhi, India

Address for correspondence: Dr. Akshita Sharma,
Department of Ophthalmology, UCMS and GTB Hospital,
New Delhi - 110 095, India.
E-mail: akshita_sharma05@yahoo.co.in

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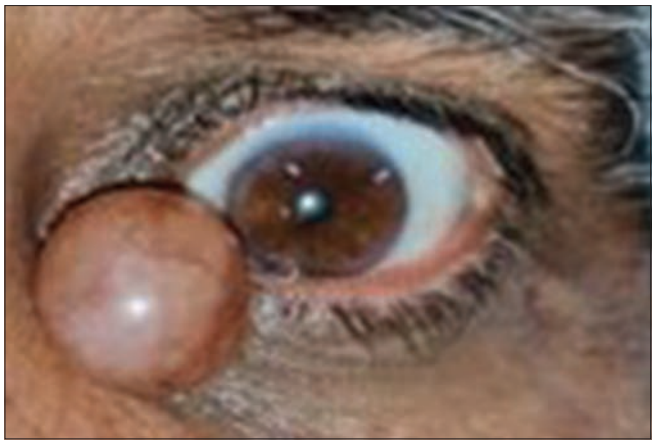


Figure 1: Preoperative photograph showing the mass near the inner canthus of left eye with eyelids open

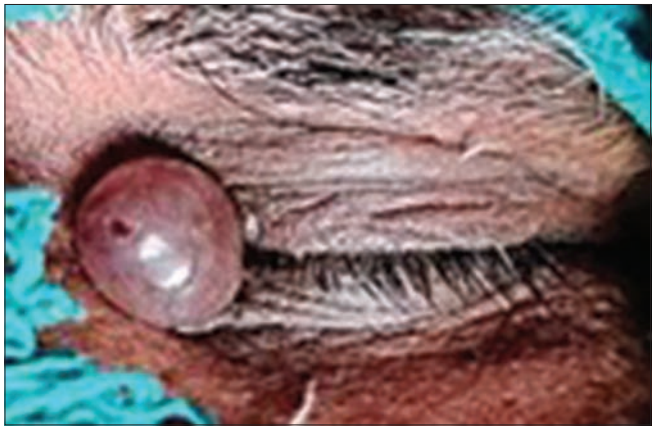


Figure 2: Preoperative photograph showing the mass near the inner canthus of left eye with eyelids closed



Figure 3: Gross appearance of intact cyst after excision

infiltration with 2% xylocaine. The overlying skin was incised taking care not to puncture the cyst. The cyst was removed intact as shown in the picture. The wound was closed primarily with a 6.0 Vicryl suture. The cyst was bilocular on gross inspection and was sent for histopathological examination.

The gross examination showed that the cyst was 1.4 × 1.2 × 1.1 cm in size [Figure 3]. On the cut section, thin clear fluid came out. The wall thickness was 0.1 cm. The histopathological examination revealed a single cyst lined by double-layered cuboidal epithelium, resembling a sweat gland containing serous fluid. The cells show decapitation and are Periodic acid Schiff stain positive. Based on these findings, a final pathological diagnosis of a Sudoriferous cyst was established.

DISCUSSION

Sudoriferous cysts are rare, benign cystic lesions involving the sweat glands, most commonly seen in the head and neck region. Congenital and post-traumatic orbital sudoriferous cysts are well documented in the literature. However, orbital sudoriferous cysts of spontaneous origin have been rarely reported.[1] The congenital sudoriferous cysts have been hypothesized to occur as a result of the sequestration of epithelial cells that form the glands of Moll, during embryogenesis.[2] To date, only 3 cases of spontaneous origin sudoriferous cysts have been reported in adults.[3]

Hidrocystomas, or sudoriferous cysts, are cutaneous cysts of sweat gland origin.[1,4,5] There are two types of sudoriferous cysts, eccrine and apocrine. Decapitation of the apical part of lining cells as seen in our case is the distinguishing feature of the apocrine type. The decapitation of the apical portion of lining cells occurs to form part of the secretion of the apocrine gland while the remaining cells remain viable. It may also show focal proliferation of lining epithelium, PAS-positive granules in the apical cytoplasm of lining cells and express a special marker called "Gross cystic disease fluid protein". Their differentiation from the eccrine type is difficult to establish histologically.[6]

In the eccrine type, there is no loss of cell structure. Eccrine hidrocystomas are small translucent, fluid-filled cysts that arise from the ducts of sweat glands. They often enlarge in conditions that stimulate perspiration. They can be solitary or Smith type and multiple or Robinson type. Both apocrine and eccrine varieties can be found on the face though the apocrine variety is less common in the periorbital or ocular adnexal region.[7]

Apocrine hidrocystomas are benign cysts and arise from the apocrine glands of Moll that are modified sweat glands of the eyelids. They are typically found in the head and neck region and have also been reported to occur in the orbit. Apocrine hidrocystomas tend to be larger, solitary, darker in color and are not affected by temperature-induced sweating.[8,9] The presence of bone remodeling or bony changes on the X-ray image indicates the long-standing nature of the lesion. In our case, there was no evidence of bone remodeling indicating that the sudoriferous cyst was probably of adult origin.

The differential diagnosis of orbital cystic lesions includes implantation cyst, lacrimal duct cyst, conjunctival cyst, dermoid cyst, and haemangioma. Our case is an adult male who presented with a spontaneous onset, solitary, cystic lesion near the inner canthus with no radiological evidence of bony changes. Histopathological changes showed no evidence of lacrimal duct tissue, conjunctival tissue, or dermoid elements, which rules out the above differential diagnosis. In the case of a conjunctival inclusion cyst, the wall is lined with stratified columnar epithelium. A cyst of lacrimal duct origin has a double-layered epithelium, PAS-positive cells but the apical decapitation is not seen. Therefore, our case was diagnosed as an apocrine sudoriferous cyst of the eyelid.

There are a few special tests for apocrine cells that include human milk fat globulin-1 (1.10.F3) monoclonal antibody and cytoplasmic granules containing epidermal growth factor (EGF) are available only in special centers. Most of the reported cases have employed hematoxylin and eosin staining for the detection of apocrine features.

CONCLUSION

Spontaneous sudoriferous cysts, though earlier reported to be only of childhood origin, may also be of adult origin. They are common in the lids, and their occurrence in the periorbital region is extremely rare. This diagnosis should be considered when dealing with orbital cysts in adults.

Key message

Spontaneous sudoriferous cysts, though earlier reported to be only of childhood origin, may also be of adult origin. They are common in the lids, and their occurrence in the periorbital region is extremely rare. This diagnosis should be considered when dealing with orbital cysts in adults.

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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Case Report

Double trouble – A twin rarity in the same patient

ABSTRACT

Detecting a rare finding is always a source of excitement in a clinician's practice. This in turn leads to unearthing and learning more about the disease detected. The following case report is a manifestation of the very same excitement felt on not detecting one, but rather two rarities in the same patient. On extensively searching published literature, no such combination of the twin rarities mentioned in this case report has been detected before and this is the first case report to do so.

Keywords: Coloboma, pigmented paravenous retinochoroidal atrophy, embryonic fissure

INTRODUCTION

Retinochoroidal coloboma is a relatively common finding in the population. It is typically located in the inferior aspect of the fundus, along the line of closure of the embryonic fissure. Superior retinochoroidal colobomas are rare, and a scientific explanation for their occurrence has yet to be established. Pigmented paravenous retinochoroidal atrophy (PPRCA) is also a rarely encountered clinical entity, with its etiopathogenesis still to be conclusively proven and this disease is hardly even mentioned about in ophthalmology textbooks.

Both superior retinochoroidal coloboma and PPRCA are extremely rare conditions typically seen in isolation. This case report presents a patient in whom both of these rare conditions were found to coexist.

CASE REPORT

A 42-year-old male presented with complaints of defective near vision. His best corrected distance visual acuity was 6/6 plano in both eyes while near vision was N6 in both eyes with a +1.25 Dioptre sphere. His right eye fundus showed a retinochoroidal coloboma, approximately 1 disc diameter in size, located just above the superior pole of the disc [Figure 1]. Optical Coherence Tomography (OCT) through the lesion confirmed its colobomatous nature [Figures 2 and 3] and visual field showed a region of absolute scotoma just beneath the normal blind spot [Figure 4]. The left eye fundus showed an area of hyperpigmentation along the inferotemporal vascular arcade [Figures 5 and 6] and OCT through the lesion showed increased hyperreflectivity, and reduced thickness of both the choroid and the retina [Figure 7]. The visual field of the left eye showed an absolute scotoma superonasally from the point of fixation, which corresponded to the area of hyperpigmentation observed clinically [Figure 8]. The remainder of the ocular examination in both eyes were within normal limits.

DISCUSSION

The morphological development of the eye begins with a pair of evaginations protruding from either side of the cranial end

Allen Mathew

Department of Ophthalmology, Government Medical College, Kollam, Kerala, India

Address for correspondence: Dr. Allen Mathew, Kavumpurathu House, Koovapally P.O., Kanjirapally, Kottayam - 686 518, Kerala, India.
E-mail: allenmathew23@gmail.com

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Figure 1: Right Eye Fundus Picture showing a superior retinochoroidal coloboma

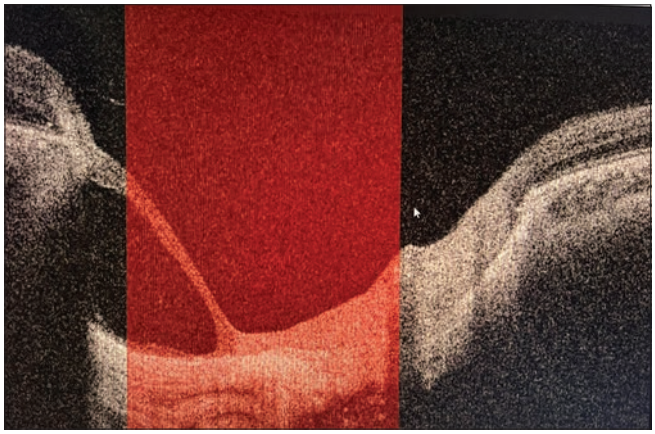


Figure 3: OCT taken just above the disc showing the morphology of the coloboma

of the neural tube. These protrusions, known as optic vesicles, expand outwards and grow toward the surface ectoderm of the developing embryo. Upon contact with the surface ectoderm, the optic vesicle invaginates onto itself, forming the optic cup. To provide for the entry point of vasculature needed by the developing eye, a transient fissure forms on the inferior surface of the optic cup, called as the embryonic fissure, fetal fissure, or choroidal fissure. The fusion of this fissure begins in the 5th week of gestation and is completed by the 7th week of gestation. An incomplete closure of this fissure results in a retinochoroidal coloboma. The inferior location of this fissure gives the pathological basis as to why retinochoroidal colobomas affect the inferior portion of the fundus.

However, this theory of development of the eye loses ground and is fails to explain why occasionally retinochoroidal colobomas are observed superiorly in the fundus.

The posterior segment of the developing eye is thought to receive 2 vascular supplies. The well-known hyaloid vasculature



Figure 2: OCT through the right eye optic disc showing normal disc morphology

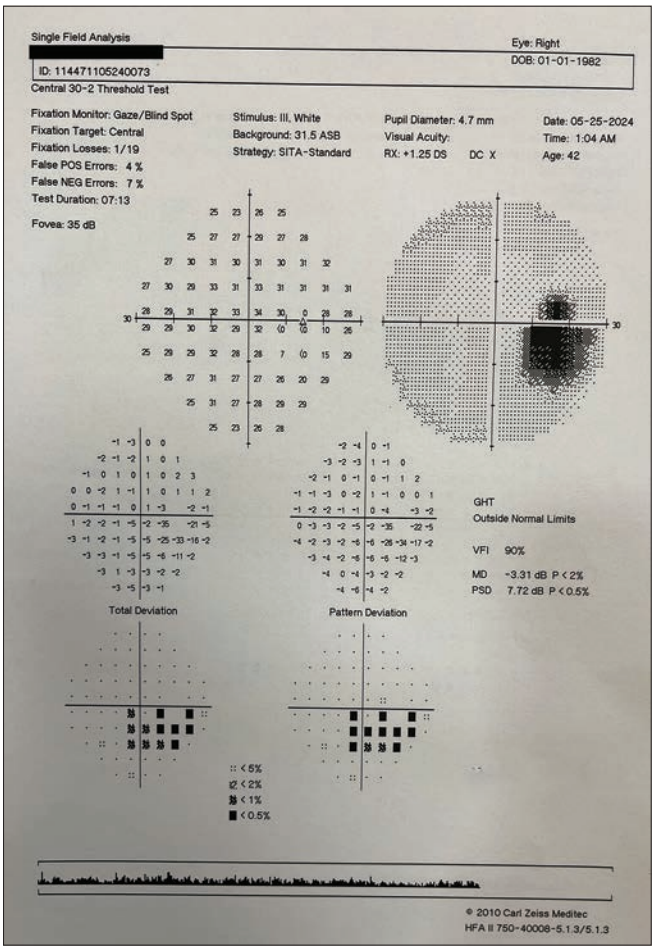


Figure 4: Right Eye Visual Field showing absolute scotoma just beneath the blind spot

enters the developing eye through the embryonic fissure. The development of the second vasculature system, i.e. the choroidal vessels, poorly understood. Studies have revealed the presence of a transient fissure known as the superior ocular sulcus in fish, chick and mouse.[1] This superior ocular sulcus is suggested to serve as a conduit for the entry of the second vasculature i.e. the choroidal vessels, into the eye.[1]



Figure 5: Left eye fundus photo showing an area of hyperpigmentation along the inferotemporal vascular arcade

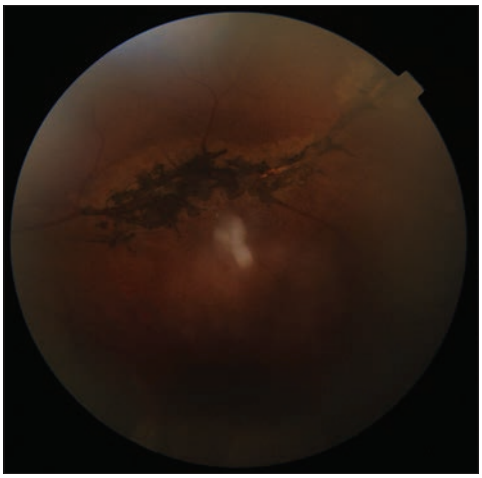


Figure 6: Complete extent of the hyperpigmentation along the inferotemporal arcade

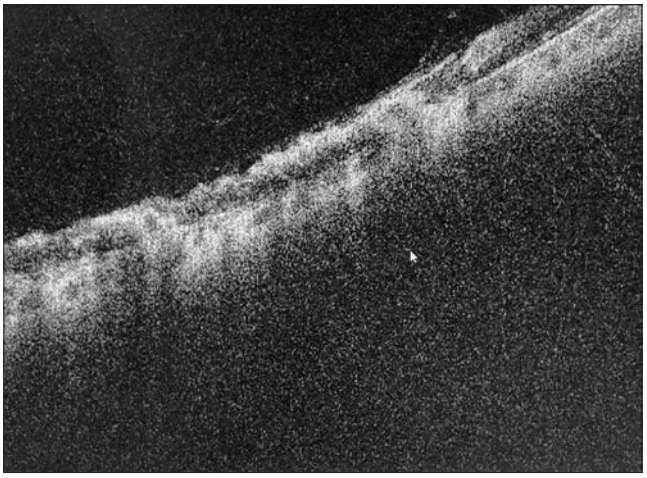


Figure 7: OCT through the area of hyperpigmentation in the left eye

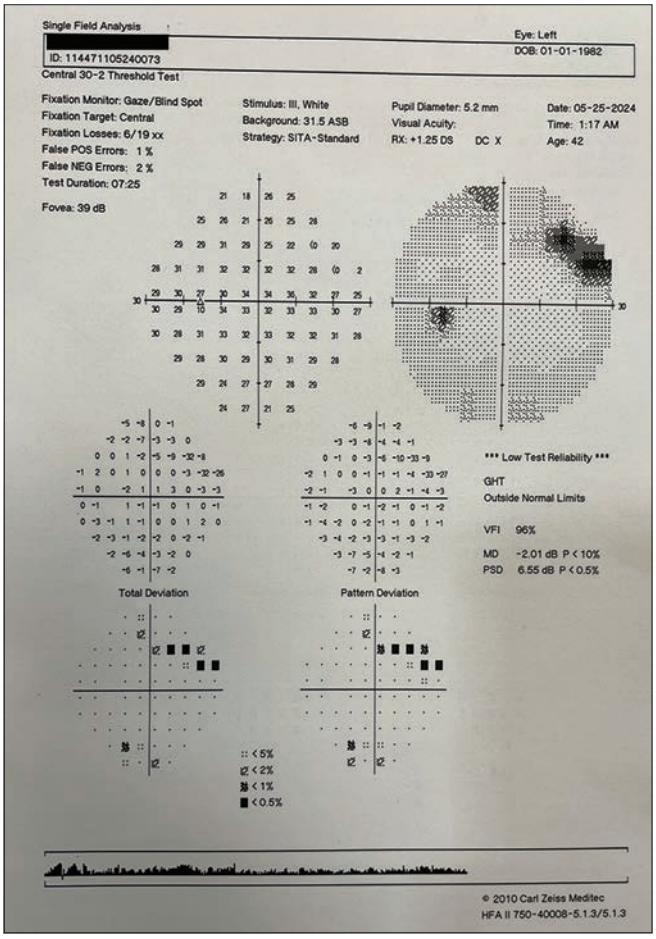


Figure 8: Left Eye Visual Field showing an area of absolute scotoma superonasally

Superior ocular sulcus closure defects, leading to superior colobomas, have been noted in zebrafish, and they are found to be lacking in Bone Morphogenetic Protein (BMP) receptor and T-box transcription factor 2 (TBX2) signalling.[1] Exome sequencing in humans with superior colobomas have also identified similar variants in BMP receptors and TBX2.[1] These findings give prudence to the possibility of a superior fissure in the developing human eye, and superior colobomas might be having its origin due to a defective closure of this fissure.

PPRCA is a disease characterized by atrophy of the choriocapillaris, RPE degeneration and pigmentation along the retinal veins. PPRCA was first described by Hewitson-Brown in 1937 in a 47-year-old man with alopecia areata.[2] It is typically a bilateral, symmetric, non-progressive or slowly progressive disease which is usually detected incidentally in asymptomatic patients.[3] The unilateral, unifocal type of PPRCA is extremely rare, with only a single case being reported in literature to date.[3] The etiopathogenesis of this disease is unclear with the various proposed mechanisms being hereditary, inflammatory and developmental in nature. Infections such as tuberculosis, syphilis, measles and rubeola, as well as inflammatory conditions like sarcoidosis and Behcet's disease have been

seen in association with PPRCA. A few familial cases of PPRCA have also been reported, but no implicating genes have been identified.[4] To support the possibility of a developmental anomaly as the cause for the disease, few cases of macular coloboma with PPRCA have been identified.[5] In the early stages of the disease, the thickness of the choroid is reduced, thinning of the outer retinal layers is noted and the retinal pigment epithelium (RPE) is unaffected.[6] In the later stages, the RPE also gets affected.[7] Vision is rarely affected in PPRCA. The anterior segment, lens and the vitreous is normal. The fundus of an affected individual generally shows pigment accumulation – which can be bony corpuscle like pigmentation, clumps of pigment or fine pigmentary changes – and retinochoroidal atrophy specifically along the retinal veins which generally begins at a certain distance from the optic disc and with the intervening fundus having a normal appearance. Fundus autofluorescence reveals hypoautofluoroscence in the affected area due to loss of RPE. OCT shows increased hyperreflectivity with shadows in areas of pigment clumping. Fluorescein angiography (FA) shows window defects with hyperfluorecence in affected areas due to loss of RPE whereas indocyanine green angiography shows hypocyanescence in the affected areas due to choriocapillary atrophy.[8] There is no specific treatment for PPRCA.

Only a single case report of PPRCA with macular coloboma has been reported to date, and this case report is the second to report a coloboma alongside with a PPRCA.[5] This is the first case report of an atypical unilateral unifocal PPRCA been reported along with a retinochoroidal coloboma – and that too an atypical superior retinochoroidal coloboma – and this case report is the first to do so.

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Conflicts of interest

There are no conflicts of interest.

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Case Report

A rare case of uniocular central retinal artery occlusion post laminotomy with lumbar decompression surgery

ABSTRACT

Presenting a rare case of Unilateral Central Retinal Artery Occlusion (CRAO) following spinal surgery. CRAO following spinal surgery is a rare complication. Central retinal arterial occlusion (CRAO) is an ophthalmic emergency characterized by the sudden blockage of the central retinal artery, the primary blood vessel supplying the retina. This blockage leads to rapid, painless, severe vision loss in the affected eye. One of the leading causes of CRAO is an embolus that obstructs the artery, from the carotid artery or the heart. The blood flow interruption to the retina results in ischemia, causing damage to retinal cells. Unfortunately, the prognosis for visual recovery in CRAO is limited, making early diagnosis critical in managing this serious eye condition.

Keywords: Central retinal artery occlusion, rare, spinal surgery, vision loss

INTRODUCTION

Central retinal artery occlusion (CRAO) is one of the cause for sudden, painless and unilateral loss of vision. It is considered an emergency as vision loss is severe and can be permanent. CRAO following spinal surgery is a rare but serious complication, with only a few cases reported worldwide.

CASE REPORT

A 58-year-old male, with a history of oral tobacco consumption, underwent C5-6 and C6-7 laminotomy, along with L3-4 and L4-5 percutaneous stenoscopic lumbar decompression. The surgery lasted five hours, with the patient was in a prone position and stable blood pressure measured at 140/80 mmHg without any intraoperative complications, and he had no prior comorbidities such as hypertension or diabetes.

Upon regaining consciousness from anesthesia, the patient reported experiencing vision loss in his left eye and was subsequently referred for an ophthalmology consultation the following day. An ocular examination revealed that his visual acuity was limited to light perception in the left eye, accompanied by a Grade 1 Relative Afferent Pupillary Defect (RAPD). The patient had previously undergone cataract surgery and was pseudophakic in both eyes, with no complaints of decreased vision before the procedure. Fundus examination showed a normal optic disc with a cup-to-disc ratio of 0.3:1 [Figure 1], but revealed a pale fundus with a cherry-red spot was noted. The right eye examination was normal [Figure 2].

The patient received an ocular massage and was prescribed Brimonidine eye drops, to be administered thrice daily. This treatment approach was chosen as the initial management plan, considering the patient was non-ambulatory and required careful monitoring.

Sneha Punjabi, Divya Vaidya, Harsha Pagad, Archana Tadwalkar

Department of Ophthalmology, Padmashree Dr. D. Y. Patil Medical College and Hospital, Navi Mumbai, Maharashtra, India

Address for correspondence: Dr. Divya Vaidya, Department of Ophthalmology, Padmashree Dr. D. Y. Patil Medical College and Hospital, Nerul, Navi Mumbai - 400 706, Maharashtra, India.
E-mail: divyavaidya13@gmail.com

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Figure 1: Left eye fundus photo

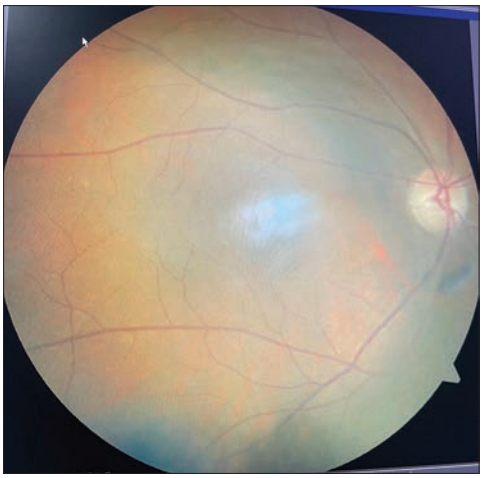


Figure 2: Right eye fundus photo

A subsequent MRI of the brain showed mild generalized age-related cerebral atrophy and chronic ischemic changes in the bilateral frontoparietal and periventricular white matter.

At the follow-up visit one week later, the patient's visual acuity had not improved, and Grade 1 RAPD was still present. Fundus examination showed a pale optic disc, indicating secondary optic atrophy, with narrowed arteries, a hyperpigmented macula, and a "cattle trucking" sign indicative of slow, segmental blood flow. Intraocular pressure in the left eye was normal at 10 mmHg. Optical Coherence Tomography (OCT) provided valuable insights into the retinal structure, exhibiting hyperreflectivity in the inner retinal layers, indicative of retinal edema. Conversely, the outer retinal layers presented hyporeflectivity, suggesting fluid accumulation. Furthermore, the imaging results displayed a shadowing effect attributed to the overlying edema, obscured some of the features of the underlying retina [Figures 3 and 4]. These findings were consistent with central retinal artery occlusion.

DISCUSSION

Postoperative visual loss, which occurs following non-ocular surgery is a rare but disastrous complication, with an estimated incidence of 1 in 125,234 patients undergoing non-cardiac surgery, as observed by Warner *et al*.[1]

Singh *et al*.[2] studied ophthalmic complications associated with perioperative anaesthesia and cited literature indicating that spinal fusion surgeries are associated with CRAO.

Patient risk factors and comorbidities may be risk factors for developing CRAO. These include chronic hypertension, diabetes mellitus, smoking, vascular disease, and other disorders that result in increased blood viscosity.[3] Although these risk factors have been determined from studies in various clinical settings, their exact influence on patients undergoing spinal surgery remains unknown and needs further study.

Bradish and Flowers reported the first case of CRAO following a prone position after an orthopaedic procedure. They suggested that CRAO was due to a combination of hypotensive anesthesia and extrinsic pressure on the eye of a patient with osteogenesis imperfecta in 2004.[4]

In patients with arteriosclerotic risk factors, deliberate hypotension, maintained for prolonged surgeries, may be the inciting cause.[5,6]

Walick and colleagues, in 2007, experimented to concluded that intraocular pressure is more elevated when patients are positioned in the prone Trendelenburg position.[7] Kaur *et al*.,[8] in 2021, monitored ocular pressure changes during spine surgery in the prone position and concluded that ocular pressure was significantly elevated at the end of the surgery when compared to baseline pressures.

A prolonged prone position during spinal surgery can lead to raised intraocular pressure, on the eye, especially due to patient malposition of the patient. This can cause injury to the orbital structures and serious ocular complications. Although postoperative vision loss can occur in the absence of globe compression, it is crucial for both the surgeon and anesthetist must be aware of the need to avoid mechanical injury to the globe.

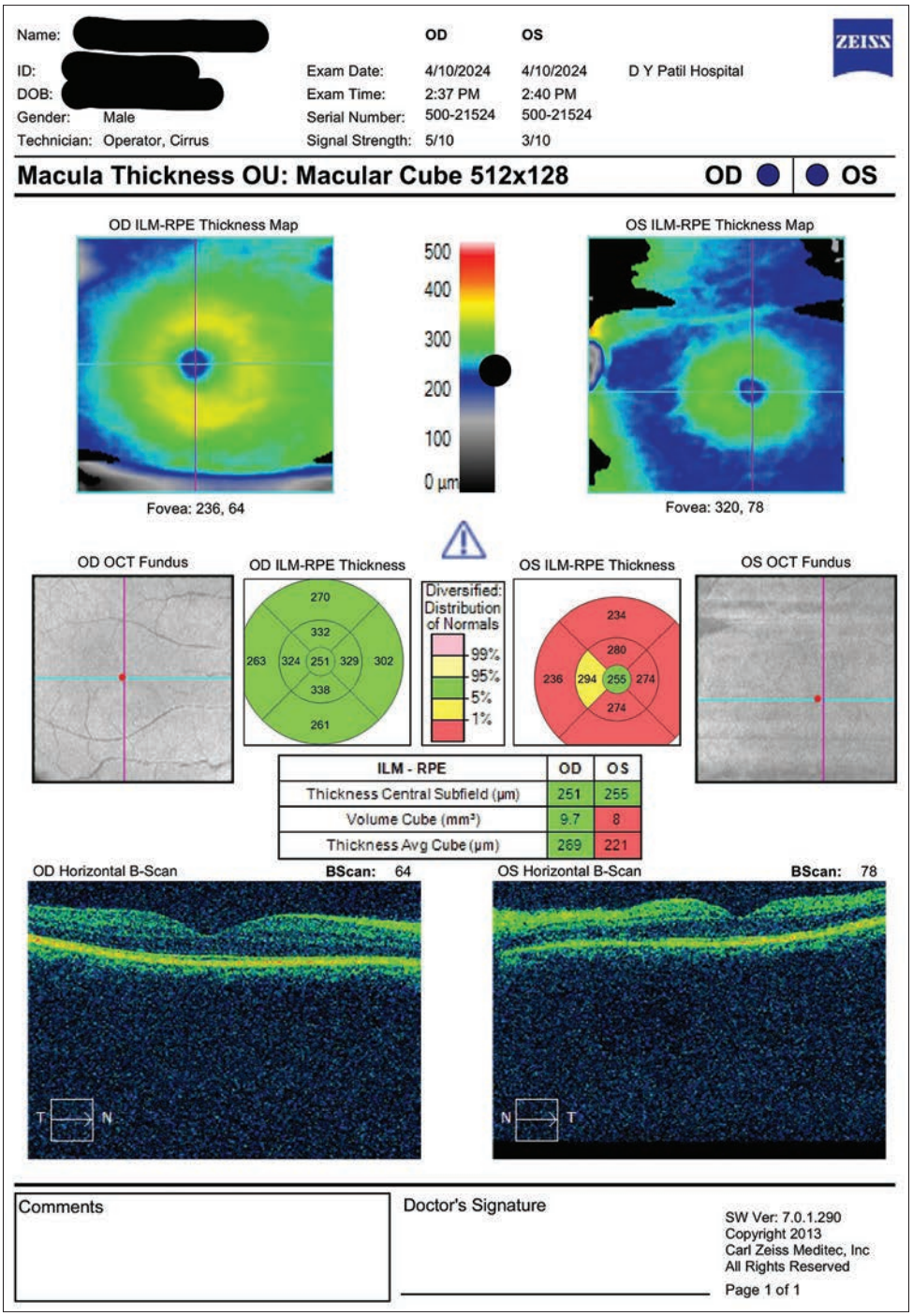


Figure 3: Oct macula cube

The increase in intraorbital pressure associated with hypotension, shock, anemia, prolonged operative time, and bradyarrhythmia are considered major risk factors, according to a study, for developing CRAO[9]

CONCLUSION

Central retinal artery occlusion following spinal surgery is a rare but vision threatening complication. Patients should be counselled about the complication before surgery as it can lead to permanent loss of vision and adequate informed consent should be obtained. Early diagnosis and prompt intraoperative preventative measures are critical for managing this serious eye condition effectively.

Financial support and sponsorship

Nil.

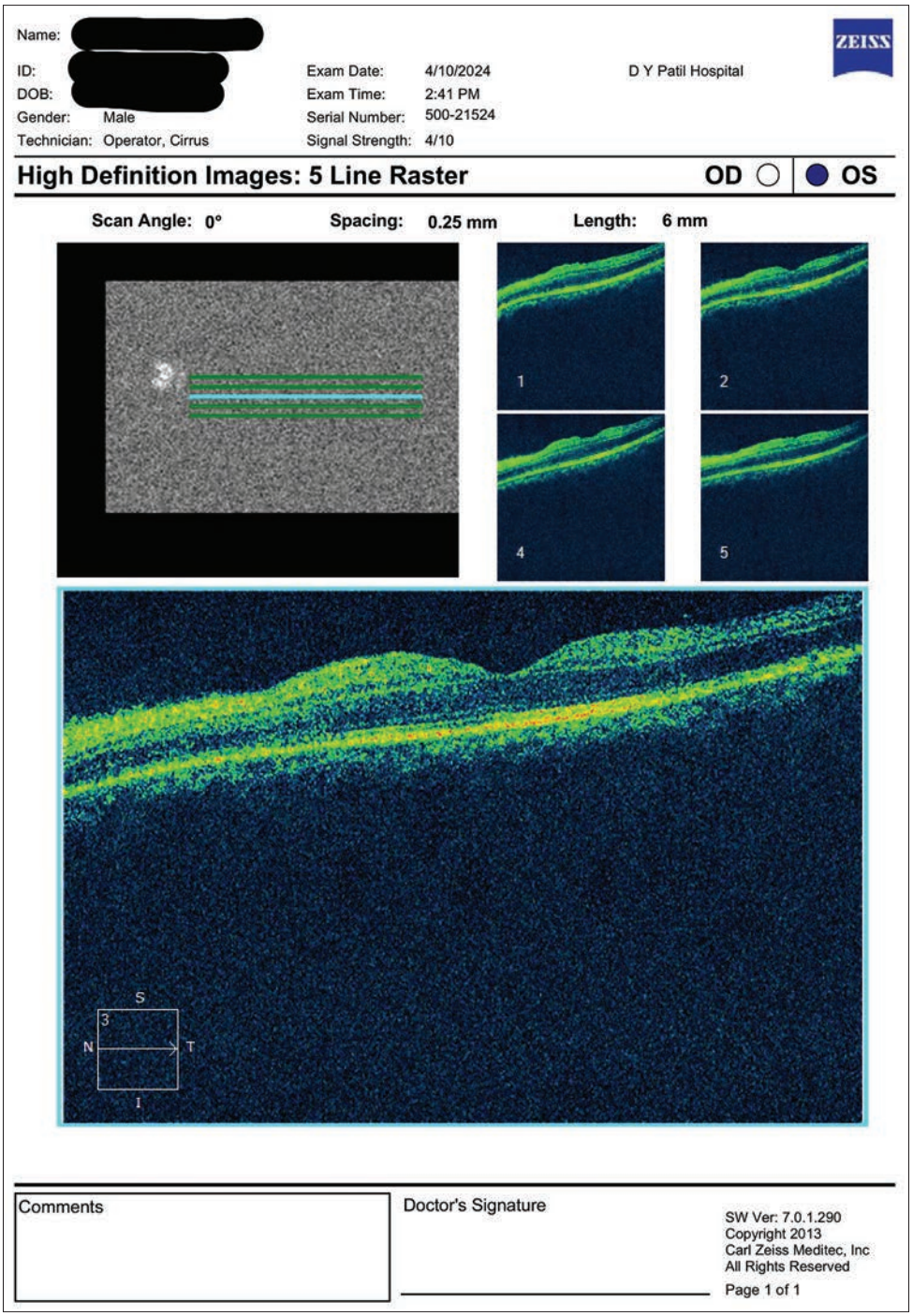


Figure 4: Left eye 5 line oct

Conflicts of interest

There are no conflicts of interest.

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Artificial intelligence in cataract surgery: Smart screening, precision planning, and cataract coaching

ABSTRACT

Artificial intelligence (AI) is rapidly transforming cataract surgery, the world's most frequently performed procedure, by enhancing precision, efficiency, and patient outcomes across the entire care pathway. In preoperative planning, machine learning algorithms for intraocular lens (IOL) power calculation, such as the Hill-RBF and Kane formulas, have demonstrated superior accuracy over traditional methods, achieving mean absolute errors below 0.30 D, particularly in complex cases. Deep learning models are also enabling automated cataract screening and grading from various imaging sources with high accuracy (up to 98%), and AI assistants are being developed to aid in complex surgical decision-making with high consistency (96.26%) compared to experts. Intraoperatively, AI analyzes surgical videos for workflow recognition, instrument tracking, and objective skill assessment, distinguishing between junior and senior surgeons and providing real-time risk prediction for complications with probabilities as high as 92%. Postoperatively, AI facilitates telemedicine follow-ups through automated clinical assistants like Dora and predicts late complications such as posterior capsule opacification with up to 92.2% accuracy. Despite this promise, significant challenges remain, including data scarcity (especially for MSICS), the need for external validation, and critical medicolegal and ethical concerns surrounding data privacy, algorithmic bias from nondiverse datasets, liability, and the "black-box" nature of many models. The future lies in leveraging AI for enhanced surgical training with real-time feedback, bridging global healthcare disparities through accessible screening tools, and developing advanced multimodal models. Realizing AI's full potential will require robust collaboration to address these limitations and build frameworks that ensure accountability and trust.

Keywords: AI surgery, artificial intelligence, cataract, cataract coach, cataract screening, Dr. Dora, eye surgery, Ladas formula, machine learning, phacoemulsification, robotic cataract surgery

INTRODUCTION

Cataract surgery is the most frequently performed procedure worldwide, addressing the leading cause of reversible visual impairment globally.[1] The confluence of high surgical volume and the imaging-rich nature of ophthalmology has made our specialty a leading domain for the implementation of artificial intelligence (AI).[2]

AI, particularly leveraging techniques such as machine learning (ML), deep learning (DL), and convolutional neural networks (CNNs), offers unprecedented capabilities in data analysis, pattern recognition, and predictive modeling.[3] The integration of AI promises to enhance surgical precision, improve patient outcomes, and increase efficiency for healthcare practitioners.[4] This article explores the specific applications of AI throughout the cataract care pathway, addresses the critical limitations and medicolegal complexities involved, and discusses the exciting future prospects of these technologies.

John Davis Akkara

Department of Glaucoma, Cataract and Refractive Surgery, Westend Eye Hospital, Kochi, Kerala, Department of Glaucoma, Cataract and Refractive Surgery, Chaithanya Eye Institute, Kochi, India

Address for correspondence: Dr. John Davis Akkara, Department of Glaucoma, Cataract and Refractive Surgery, Westend Eye Hospital, Kochi, Kerala, India.
E-mail: JohnDavisAkkara@gmail.com

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Various applications of AI in cataract

AI applications span the entire spectrum of cataract management: preoperative evaluation,[5] intraoperative guidance, and postoperative monitoring.

Preoperative planning and diagnosis

- **Intraocular Lens (IOL) Power Calculations:** A primary success area for AI in cataract surgery is IOL power calculation. Modern machine learning algorithms, such as the Hill-RBF, Kane, Ladas, XGBoost, Karmona, and ZEISS AI formulas, incorporate large clinical datasets to refine predictions dynamically.[6] These formulas have demonstrated superior accuracy and personalization compared to traditional formulas. For complex cases, such as highly myopic eyes and even very short eyes, specific AI formulas have significantly improved prediction accuracy, achieving mean absolute errors (MAEs) below 0.30 D and reducing the risk of hyperopic surprises.[7] The automated nature of systems, like the ZEISS AI IOL calculator, can streamline workflows and reduce transcription errors.
- **Patient Information Materials:** AI large language models[8] have been used to generate and improve readability[9] of information available to patients regarding cataract surgery, local anesthesia,[10] and perioperative care. It was noted that current general purpose LLMs sometimes gave wrong or misleading information, so supervision is necessary.[8,11]
- **Diagnosis and Screening for Cataract:** In terms of diagnosis and screening, AI systems can automate the classification and grading of cataracts. Deep learning convolutional neural networks (CNNs) analyze slit-lamp,[12] retro-illumination, smartphone,[13] ASOCT,[14] or fundus images to detect and grade cataracts based on systems like LOCS III. For instance, the diagnostic accuracy of the "CC cruiser" ML platform, developed for grading and diagnosis (including pediatric cataracts), has been validated with high accuracy, up to 98% in some datasets. The AS-OCT-based analysis attempted to predict the visual acuity as well.[14] Wei *et al.*[15] used retina OCT to predict the postoperative visual acuity. The Tamil Nadu e-Governance Agency (TNeGA) developed a smartphone app, e-Paarvai, to detect cataract from smartphone photos. It is presently available only to government doctors, but the sensitivity of detection is only 25% and needs a lot of improvement.[16]
- **Decision Making Regarding Cataract Surgery:** AI can also aid in complex surgical decision-making, particularly for highly myopic cataract patients, where a preliminary AI model achieved consistency of 96.26% with expert "gold standard" decisions in an internal dataset.[17] Furthermore, AI systems can enhance preoperative safety management by using deep learning models for facial recognition, laterality confirmation, anesthesia assessment,[18] and IOL parameter verification, thereby reducing the risk of "never-events" like wrong-site surgery.[19]

Intraoperative guidance and training

During the surgery, AI can help in augmenting training, decision-making, and optimizing surgical efficiency [Figure 1].

- **Workflow Analysis and Phase Recognition:** AI algorithms can classify the different phases of cataract surgery (e.g., incision, capsulorrhexis, phacoemulsification, lens insertion) by analyzing surgical videos.[20] Systems, like DeepPhase and Touch Surgery Enterprise, use deep learning (DL) mechanisms to recognize surgical phases and estimate workflow. Algorithms focused on phase recognition have achieved high performance metrics, with ROC AUC values up to 0.990 and accuracies up to 0.978.
- **Instrument Tracking and Skill Assessment:** Automated tool detection and tracking systems monitor tool usage, contributing to real-time feedback and objective assessment of technical skills. Studies using ML-mediated analysis, such as PhacoTracking[21] and PhacoTrainer,[22,23] generate valuable data on surgical movements,

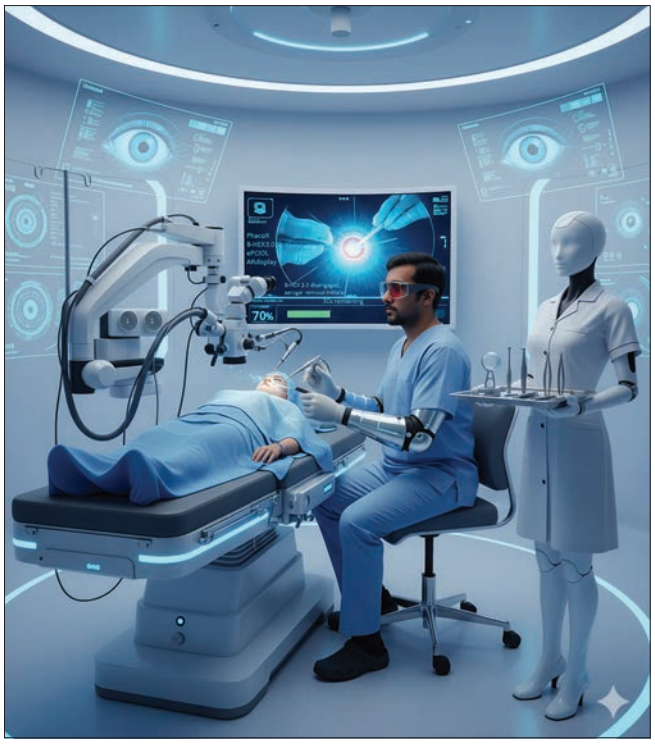


Figure 1: AI-generated image depicting an eye surgeon of the future operating with robotic arms with a handheld cataract extraction device. Visualization is with 3D augmented reality glasses which do not need an external screen. Surgeries are expected to take only 100 seconds. The robotic nurse is ready with instruments for the next few cases

instrument path length, and time of procedure. This helps to identify differences between junior and senior surgeons, optimize surgical efficiency, and avoid complications.[24]

- **Real-Time Risk Assessment:** Some AI models are capable of real-time analysis, and thus provide intraoperative guidance,[25-27] to predict potential complications in real-time by focusing on specific characteristics during surgery. For example, a system was able to predict events leading to problems with a 92% probability using integrated risk indicators calculated from identifying phases and the degree of risk. This capability to evaluate surgical technique in real-time during critical steps, like continuous curvilinear capsulorhexis (CCC) and phacoemulsification (Phaco), is invaluable for training and minimizing complications.

Postoperative care and monitoring

AI tools extend into postoperative management by optimizing follow-up care and preventing late complications.

- **Telemedicine Follow-up:** Autonomous AI clinical assistants, such as Dora[28] (an AI-powered automated telephonic clinical assistant designed in the UK by Ufonia), have been successfully used to conduct telemedicine follow-up assessments approximately three weeks post-cataract surgery in the UK[29] and Canada.[30] Dora (named after Greek Physician Metrodora) can call patients, ask questions, understand responses, and accurately recognize symptoms requiring a clinical review. Studies provide preliminary evidence for the safety, acceptability, feasibility, and cost benefits of using such conversational agents for postoperative triage, expanding clinical capacity.
- **Late Complication Prediction:** Artificial neural networks (ANNs) have been applied to detect and predict the progression of posterior capsule opacification (PCO) with up to 92.2% accuracy.[31] Other models, such as TempSeq-Net, utilize convolutional neural networks (CNNs) to analyze sequential slit-lamp images to predict the progression of ophthalmic complications. AI can also estimate the risk of IOL dislocation.[1]

Medicolegal issues and ethical considerations

The rapid deployment of AI introduces complex ethical and medicolegal challenges that demand careful attention.

- **Data Privacy, Security, and Bias:** The immense volume of data necessary to train DL algorithms raises significant concerns regarding data security and patient privacy, necessitating compliance with regulations such as GDPR (General Data Protection Regulation) and HIPAA (Health Insurance Portability and Accountability Act). Furthermore, AI models are susceptible to algorithmic bias if the training datasets are not representative. Many current AI IOL formulas, for instance, have been validated primarily on Caucasian populations. Failure to use heterogeneous datasets risks perpetuating or amplifying existing healthcare disparities, such as those related to ethnicity.
- **Accountability and Liability:** A critical challenge is the attribution of responsibility when an AI-generated decision or output leads to an error or patient harm. While AI developers may attempt to assume contractual liability for autonomous systems (like in the IDx-DR case), clinicians retain ultimate responsibility for patient care decisions. Real-world case studies demonstrate that errors can result from a complex interplay of human factors (e.g., staff circumventing verification protocols) and technical limitations (e.g., delayed IOL database updates in safety systems). Regulatory frameworks must evolve to address liability fragmentation and enforce protocol adherence.
- **Transparency and Trust:** Many AI models operate as "black-box" systems, limiting both clinician and patient understanding of the diagnostic rationale. Integrating interpretable AI models is essential to bridge the gap between algorithmic outputs and clinician trust, enabling us to validate AI findings against clinical expertise. Moreover, clear communication is necessary for informed consent, ensuring that patients understand the AI's role and limitations in their care, especially since overly simplified explanations risk masking genuine limitations.

Limitations

Despite AI's strong promise, several limitations hinder its widespread implementation in cataract surgery.

1. **Dataset Scarcity and Specificity:** There is a general lack of publicly available, high-quality datasets for cataract surgery analysis. Specifically, the two existing major public datasets primarily cover phacoemulsification. This severely limits the development of algorithms for Manual Small-Incision Cataract Surgery (MSICS), which is still the surgery of choice in high-volume settings in low- and middle-income countries.
2. **Generalizability and Reproducibility:** Many developed models lack external validation across diverse populations and imaging devices. The general lack of publicly shared codebases or pretrained models makes the replication and validation of study results difficult.
3. **Lack of Standardization:** There is a lack of standardized deep learning analysis metrics and a common consensus regarding the recognized phases or complications across studies analyzing surgical videos, making comparative research challenging.

4. **Clinical Maturity:** While promising, many proposed intraoperative AI tools still focus on emerging technologies without clear clinical application, remaining largely hypothetical or requiring further development to achieve clinically acceptable accuracy levels.

Future prospects

The future of AI in cataract surgery lies in improving personalized care, democratizing access, and revolutionizing surgical education.

1. **Enhanced Surgical Training and Real-Time Feedback:** AI is highly promising for enhancing surgical training programs. Future models will likely provide near real-time feedback during procedures to improve surgical techniques and identify errors before complications occur. This can be achieved by integrating AI with virtual reality simulation platforms. Research aims to expand data collection beyond the microscopic surgical field video to include information on surgeon hand/finger movements and foot pedal depression, allowing for a dramatically streamlined and objective assessment of surgical skill. Further in the future, surgeon may just be supervising the robotic surgeon and may even do tele-robotic surgeries across the world in areas of need.
2. **Bridging Global Healthcare Disparities:** Given that timely diagnosis is crucial, especially for congenital cataracts, AI-assisted telemedicine platforms hold the key to overcoming geographical barriers and improving accessibility to care in developing countries and rural populations. Large-scale AI screening using smartphones and further evaluation with affordable slit-lamp and fundus photographs will be increasingly important in these underserved regions.
3. **Advancing Modeling and Integration:** The adoption of advanced neural networks, such as vision transformers, is expected to improve model generalizability across different datasets, potentially overcoming current limitations in heterogeneous data. Future models will move toward multimodal data integration, combining traditional biometric data with imaging, clinical history, and potentially genetic profiles, to create highly precise diagnostic and prognostic models. Furthermore, the methodology developed for cataract IOL calculation may be applied to other areas of refractive surgery, such as LASIK.

CONCLUSION

AI has demonstrated unparalleled potential in transforming the management of cataracts, specifically through improved IOL calculation accuracy, sophisticated diagnostic platforms, and innovative tools for surgical training and postoperative triage. AI models leveraging large datasets have shown superior performance in refractive outcomes. DL models effectively estimate surgical phases, track instruments, and predict complications.

However, realizing this transformative potential necessitates addressing core challenges: ensuring the ethical management of data regarding security and privacy, demonstrating high clinical performance across diverse and heterogeneous populations, and establishing robust frameworks for accountability and transparency to maintain clinician and patient trust. By fostering ongoing collaboration between clinicians, scientists, and industry, AI can position cataract surgery at the forefront of precision medicine, leading to long-term benefits in accessibility, efficiency, and patient care.

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Conflict of interest

There are no conflicts of interest.

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Photo Essay

Retinal fairy lights: Benign flecked retina multimodal imaging

ABSTRACT

Benign familial flecked retina is characterized by widespread bilateral yellow-white fleck-like lesions that extend to the extreme periphery of the retina except the foveal area. A 14 year old girl who came for routine eye check up was evaluated. The anterior segment examination showed normal findings. Fundus examination showed bilateral symmetrical diffuse yellow-white flecks, more concentrated in the mid-periphery, sparing macula, with no evidence of pigment clumping or pigment alteration. Both parents and only sibling of proband were examined and did not reveal any abnormality. Here we describe multimodal imaging features of benign flecked retina that helps in accurate diagnosis and thus in prognostication as compared to other disorders which may have an associated visual impairment. Additionally, we have documented Optical Coherence Tomography Angiography (OCTA) which is a newer, non invasive imaging modality that enables depth resolved images of the retinal and choroidal microvasculature.

Keywords: Flecked retina, fundus autofluorescence, optical coherence tomography

INTRODUCTION

A rare form of retinal dystrophy known as benign familial flecked retina is characterized by widespread bilateral yellow-white fleck-like lesions that extend to the extreme periphery of the retina but spare the foveal area. It is generally a rare autosomal recessive disorder; however, it can also be sporadic (sporadic cases are more rare).[1] It has no electrophysiologic abnormalities and has an asymptomatic clinical presentation.[1]

The disorder is believed to be linked to recessive mutations in the gene that codes for group V phospholipase A2 (PLA2G5).[2] It was first described by Sabel Aish and Dajani in 1980.[3]

The flecks are characterized by their well-defined, sinuous boundaries and flat surfaces. No other observations related to choroidal alterations (vascular prominence) or retinal pigment epithelium (RPE) (pigmentation) were made.[4]

Fundus albipunctatus, fundus flavimaculatus, familial drusen, retinitis punctata albescens, and fleck retina of Kandori are among the other flecked retinal disorders.[5] Night blindness, central visual issues, abnormal electroretinograms (ERGs), and abnormal perimetry can all be linked to these illnesses. In contrast, the patient with benign familial fleck retina does not exhibit any symptoms, and the ERG is normal.[6]

Diagnostic procedures include enhanced depth optical coherence tomography B scan (EDI-OCT), fundus photography, fundus autofluorescence (FAF), and ERG.[7]

Here, we present a case (photo essay) of benign familial fleck retina with high-resolution fundus images, OCT, and optical coherence tomography angiography (OCTA) images of a 14-year-old girl who came for routine ophthalmic evaluation.

Thamana Salim, Aiswaria P, Harshali Kamat[1]

Departments of Ophthalmology and [1]Vitreoretina and Uvea, Sreenethra Eye Care, Thiruvananthapuram, Kerala, India

Address for correspondence: Dr. Thamana Salim, Department of Ophthalmology, Sreenethra Eye Care, Bakery Junction, Nandavanam Road, Thiruvananthapuram, Kerala, India.
E-mail: thamanasalim@gmail.com

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CASE REPORT

A 14-year-old girl was evaluated during a routine eye check-up. She was using glasses for the past 3 years. She had no complaints of night vision difficulties. Her best-corrected visual acuity (BCVA) was 6/6 and N6 in both eyes (OU). On examination, her anterior segment of both eyes was within normal limits.

Fundus examination revealed a normal disc with yellow-white flecked lesions sparing the fovea and more concentrated in the midperiphery [Figure 1]. Wide field fundus images and green light fundus autofluorescence (FAF-G) images were obtained with the Zeiss Clarus 500 fundus camera. FAF revealed hyperautofluorescence of the fleck lesions [Figure 2]. OCT line scan through the macula showed normal foveal contour in both eyes [Figure 3]. OCT through lesions revealed RPE thickening and elevation causing saw tooth appearance causing elevation of the inner segment-outer segment (IS-OS) line and external limiting membrane (ELM) in the region of flecks sparing fovea [Figure 4]. Full-field ERG revealed normal rod and cone responses [Figure 5].

OCTA of the macula shows a well-preserved vascular network in both the superficial and deep capillary plexus with a symmetric well-defined foveal avascular zone. The outer retina to choriocapillaries (ORCC) is avascular. The choriocapillaries is intact, and there is no indication of neovascularization or flow voids [Figure 6].

She was born to a non-consanguineous marriage. Her parents and siblings were screened and did not reveal any abnormalities.

DISCUSSION

Fundus conditions characterized by multiple yellowish-white lesions of varying sizes and configurations without vascular or optic nerve abnormalities were termed "flecked retinas." It was first described by Krill and Klien (1977).[5] Originally, this group consisted of four diseases: (1) fundus albipunctatus, (2) fundus flavimaculatus, (3) familial drusen, and (4) fleck retina of Kandori.[5] In a consanguineous Arab Palestinian family, Sabel Aish and Dajani (1980) observed a possible fifth category, familial benign fleck retina, inherited as an autosomal recessive condition. Of 10 siblings, three girls and four boys were affected. The fundi were massively involved with lesions that appeared as discrete, bright white, or yellow flecks situated behind the retinal vessels. The macula was always free.

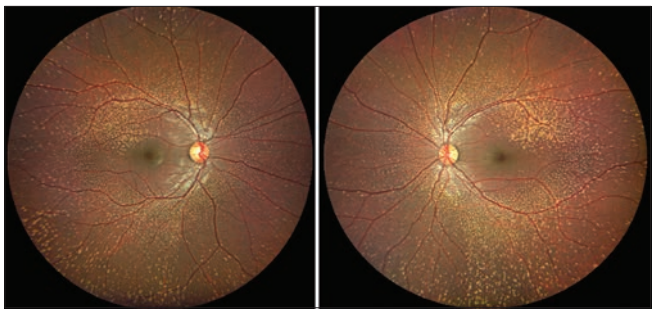


Figure 1: High-resolution fundus images showing normal disc and vessels with bilateral symmetrical diffuse yellow-white flecks, extending from the posterior pole to the periphery, more concentrated in the midperiphery, sparing macula, with no evidence of pigment clumping or pigment alteration

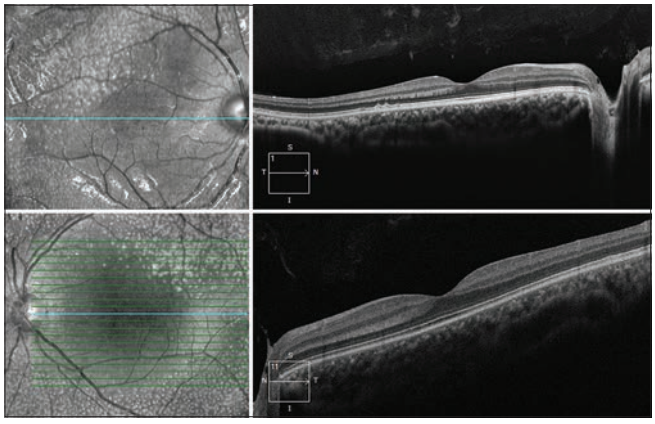


Figure 3: OCT line scan through macula shows normal foveal contour in both eyes

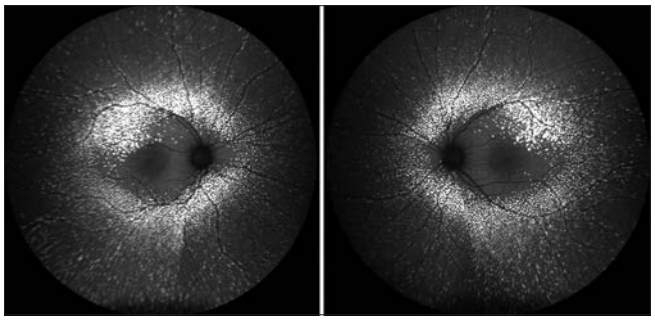


Figure 2: Fundus autofluorescence showing bilateral hyperautofluorescent lesions corresponding to yellow-white lesions seen on fundus examination, sparing macula, with normal background autofluorescence

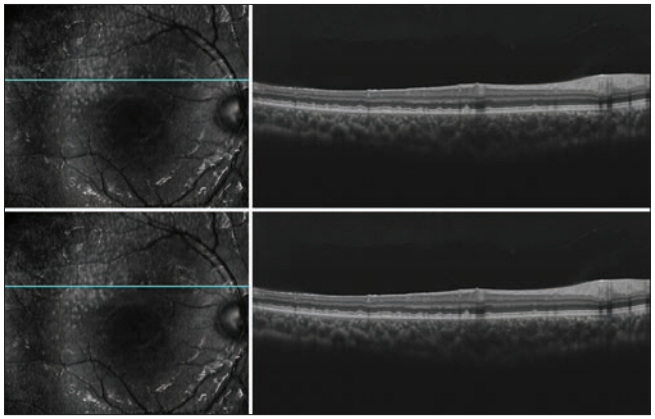


Figure 4: Line scan through lesions shows hyper-reflectivity at the level of RPE elevating (ELM) as well as inner segment-outer segment (IS-OS) junction without disrupting it, giving saw tooth appearance in both eyes

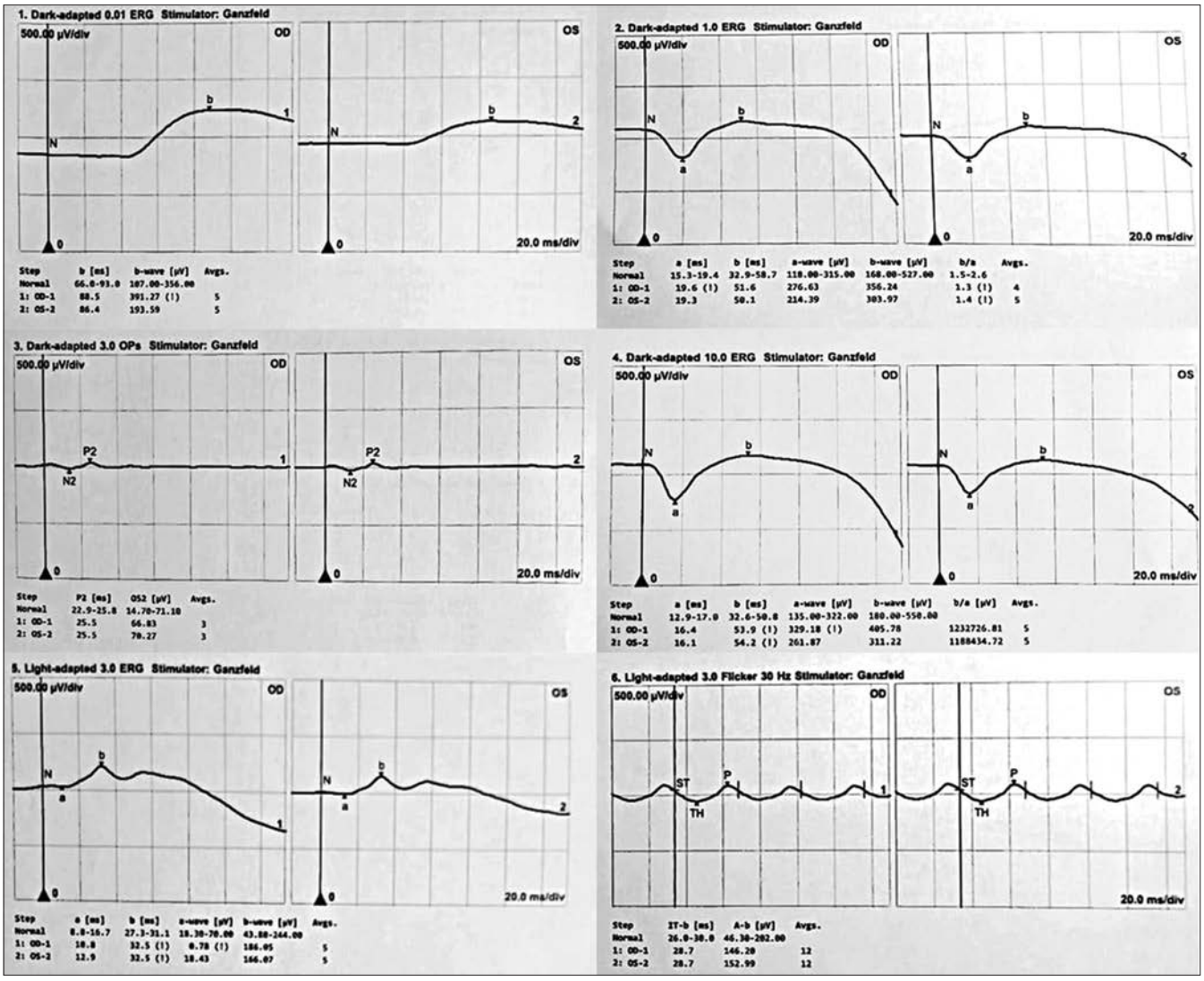


Figure 5: Electroretinogram showing normal scotopic, photopic, and combined responses

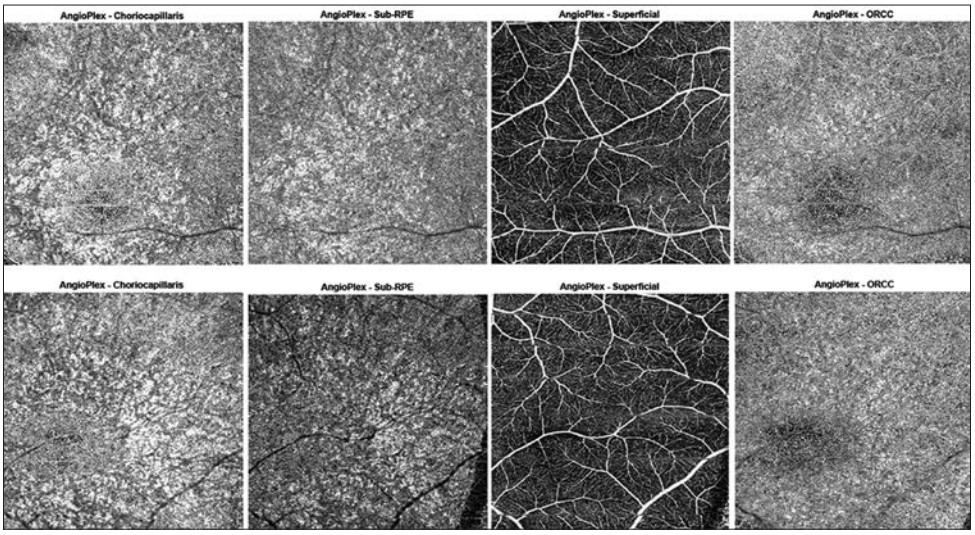


Figure 6: Optical coherence tomography angiography (OCTA) shows no flow void areas in both eyes

Many other conditions can be, however, included in this vague definition. These include primary hereditary ocular diseases, such as retinitis punctata albescens or Bietti's crystalline dystrophy, neuro-ophthalmologic syndromes, such as Kjellin's syndrome, secondary retinal flecks brought on by metabolic disorders, such as Alport's syndrome, cystinosis, oxalosis, or membranoproliferative glomerulonephritis, and iatrogenic retinopathy brought on by tamoxifen and diseases, such as vitamin A deficiency.[5] Accurate diagnosis requires not only meticulous inspection of the fundus but also a thorough psychophysical evaluation of the patient and occasionally of his family.

Fundus albipunctatus is an autosomal recessive disorder characterized by several extensive yellow-white punctate lesions at the level of the RPE and night blindness. Usually seen in the first decade of life. Either nyctalopia is present, or an aberrant retinal appearance is observed during a routine eye test. Visual acuities and visual fields are usually normal. FAF reveals a low autofluorescent signal. Hyper-reflective lesions at the level of the RPE are detected on spectral domain optical coherence tomography (SD-OCT). Characteristic abnormalities on electrophysiology and dark adaptometry facilitate the diagnosis. Our patient, however, was asymptomatic and did not have any abnormalities on the electroretinogram(ERG).

Stargardt disease is an autosomal recessive retinal dystrophy, associated with mutations in the ABCA4 gene characterized by the presence of yellow-white flecks that are scattered throughout the posterior pole. Macular atrophy is common, while in our case, the macula was spared and she had normal visual acuity. The usual age of presentation is between 6 and 20 years. Some patients have good central vision with minimal or no macular involvement at presentation and may be diagnosed as fundus flavimaculatus. Stargardt disease and fundus flavimaculatus are parts of the phenotypic spectrum of the same disorder, and the same genetic etiology is frequently observed. Patients rarely complain at presentation of poor night vision or field constriction although rod function can be abnormal.

Kandori fleck retina is a rare, genetic retinal dystrophy disorder characterized by irregular, sharply defined, yellowish-white lesions of variable size that are distributed mainly in the nasal equatorial region of the retina, with a tendency to confluence, that are not associated with any vascular or optic nerve abnormalities. It may start to appear from childhood to adulthood. They frequently manifest as mild and stationary night blindness. The phenotype of flecks in one case was different and was equally distributed in all quadrants.

Retinitis punctata albescens is a variant of retinitis pigmentosa characterized by multiple retinal white dots rather than pigment deposition. Usually begins in early life. Patients present with nyctalopia and/or peripheral vision problems, and decreased visual acuity may also occur. On fundoscopy, white spots similar to the ones observed in fundus albipunctatus are observed. Vascular attenuation, visual field loss, and a more severe electrophysiologic phenotype are key distinguishing features which were essentially absent in our patient.

Bietti's crystalline dystrophy is an autosomal recessive disorder characterized by progressive chorioretinal degeneration, nyctalopia, reduced visual acuity, visual field constriction which again was absent in our patient, and multiple yellow-white crystalline deposits at the retina, in circulating lymphocytes and, occasionally, at the corneoscleral limbus. The onset of impairment is during the second or third decade of life. Retinal crystals are observed predominantly at the posterior pole, in the superficial and deep retinal layer. When full-field ERG testing is performed, both cone and rod systems are found affected even in the early stages of disease, while in our case, ERG was normal.

Benign fleck retina is an autosomal recessive condition associated with a distinctive retinal appearance and no apparent visual or electrophysiologic deficits. Affected individuals are asymptomatic, but fundus examination reveals a striking pattern of diffuse, yellow-white flecks extending to the far periphery, sparing the foveal region which matched that of our patient. The flecks are located at the level of the RPE and can be present in early infancy. FAF reveals multiple hyperautofluorescent lesions corresponding in location with the flecks. On SD-OCT, discrete deposit accumulation located posterior to the photoreceptor IS-OS junction but without disrupting it is observed. Normal full-field and pattern ERGs confirm the diagnosis.

OCTA is a newer, non-invasive imaging modality that enables depth-resolved images of the retinal and choroidal microvasculature.[8] It is an effective research tool for studying the pathobiology of retinal diseases including inherited retinal disorders.[8] The image produced by OCTA algorithms is often divided into four zones: the outer retina, the choriocapillaris, the superficial, and deep retinal plexus. There do not seem to be any vascular abnormalities contributing toward or secondary to the development of flecks as inferred from normal OCTA. Also, the use of OCTA conducted over time will help in understanding the natural history of disease and any change in flow pattern over time can be correlated with any change in the morphology of flecks.

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.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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Photo Essay

An enigmatic partially sine-pigmento pupillary strand

ABSTRACT

Persistent pupillary membrane (PPM) is embryologically derived from the anterior vascular sheath due to its nonregression during intrauterine development. Though visually insignificant in most cases, if dense, it can lead to diminished vision. It can be a source of hyphema if vascularized. This photoessay describes an isolated partly pigmented PPM strand in a young patient which presented as an incidental finding.

Keywords: Non-regression, partially pigmented, persistent pupillary strand

PHOTO ESSAY

Persistent pupillary membrane (PPM) is embryologically derived from the anastomosis between circulus arteriosus minor along the iris collarette and tunica vasculosa lentis on the lateral lens surface. It undergoes regression by the phagocytic action of macrophages by around 5 months of gestation. A PPM occurs due to macrophage dysfunction and incomplete regression.[1]

This is the case of a 23-year-old male presented for routine eye checkup. He had unaided visual acuity of 6/6 in both eyes. On slit-lamp examination, his right eye showed a PPM strand attached to iris collarette at 8 O'clock and 1 O' clock. It was pigmented for around half the total length, while the other half was nonpigmented with demarcation point being at the center of the pupil [Figure 1]. This is a rare presentation as PPM is an entirely pigmented entity.

Duke Elder has classified PPM into[2]-

1. PPM solely attached to iris
2. PPM with irido-lenticular adhesions or "chicken tracks", where clumped iris melanocytes are attached to anterior lens capsule (ALC)
3. PPM with corneal adhesion.

Another clinical finding closely resembling PPM is accessory iris membrane (AIM), a rare congenital anomaly in which normal iris tissue strands form a virtual second pseudopupil with no muscular activity [Figure 2].

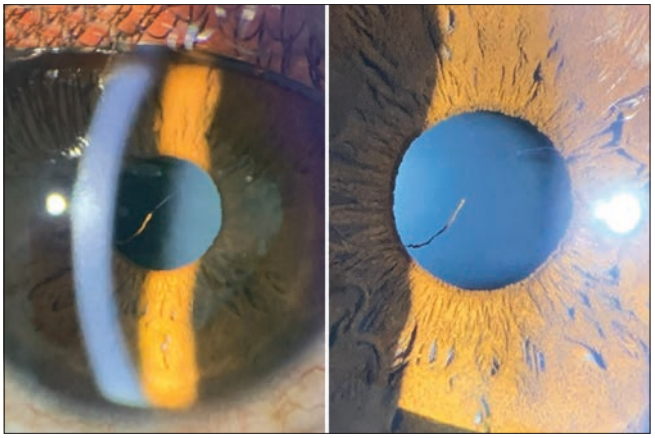


Figure 1: Slit-lamp image with direct focal illumination at magnification 10× (left) and 25× (right) showing partly pigmented PPM strand attached to the collarette on either side

Prateek Jain, Pooja Sah[1], Anshuman Pattnaik[2]

Consultant at Paliwal Eye Hospital, Jodhpur, [1]Registrar at Global Hospital Institute of Ophthalmology, Talhati, Abu Road, Sirohi, Rajasthan, [2]Department of Ophthalmology, Manipal Tata Medical College, Manipal Academy of Higher Education, Manipal, Karnataka, India

Address for correspondence: Dr. Prateek Jain, Paliwal Eye Hospital, Jodhpur, Rajasthan, India.
E-mail: docprateekjain@gmail.com

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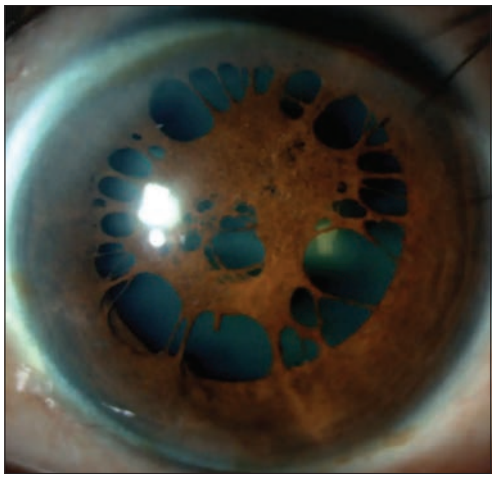


Figure 2: Image depicting accessory iris membrane. Source: https://www.djo.harvard.edu/site. php?url=/physicians/im/4206

AIM is always bilateral and usually avascular in contrast to PPM which can be unilateral or bilateral and is vascular.[3]

Though PPM is visually insignificant, cases with a pupillary opening of <1.5 mm with decreased retinal illumination and diffraction can result in impaired vision.[4] A dense PPM in a newborn can lead to amblyopia. Vascularized persistent pupillary strands can cause spontaneous hyphema.[4] Its association with congenital cataract, high refractive errors, glaucoma, microphthalmos, and iris coloboma have been reported.[5]

A thick, dense, and centrally located PPM should be managed by mydriatics and Nd-Yag Laser to prevent stimulation-deprivation amblyopia. Surgical excision is reserved for very dense PPM.

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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How to Select an Indexed Journal for Publication?

ABSTRACT

Choosing an indexed journal for publishing scientific research is the crucial decision that profoundly influences a work's visibility, credibility, and academic progression. Selecting a journal involves more than just its Impact Factor; it also necessitates a comprehensive alignment of your research, the journal's focus, and your career objectives.

Keywords: Indexed journal, publication, selection

INTRODUCTION

An indexed journal is one that has been chosen for inclusion in a major database (or "index") such as Scopus, Web of Science, or MEDLINE, indicating a high level of quality and rigor. However, navigating the selecting process might be challenging. This article describes a systematic method to picking the most relevant indexed journal for your manuscript.

Salient points

- **Thematic fit and Target Audience:** Prioritize reviewing the journal's official "Aims and Scope" on its website. The most common and readily avoidable desk rejection is when a paper is denied because it is out of journals scope and interest.[1] Assess whether the journal serves a wide range of interdisciplinary readers.
- **Journal Reputation and Metrics**: Check the Indexing Status of selected journal. Do not rely on logos seen on the home page of a journal. Verify that it is currently listed in recognized databases like PubMed/MEDLINE (NIH/NLM) or Scopus Source List (Elsevier) or WoS Master Journal List. Consider journal's metrics like Impact Factor (IF) for web of science journals only, CiteScore for Scopus journals and Quartile Ranking (Q1, Q2, Q3, Q4) based on the subject category.
- **Smooth Publication Process:** Decide on publication model—Subscription Access (Often free for author, Paywall for readers) or Open access. Look for clear details on peer review transparency and speed of decision. Faster publication is not always preferable; a sufficient peer review duration indicates adequate quality control.

Common mistakes/pitfalls

- **Beware of Predatory Journals:** Check the indexing in the official WoS/Scopus database. Verify whether the journal has a valid editorial board with substantiated academic affiliations and is included in the Directory of Open Access publications (DOAJ) for Open Access publications.
- **Fast Track Publications**: Do not fall in fast-track publications, which often leads to predatory journal without proper peer review process.
- **Single-Journal Submission:** Do not focus solely on one extremely prestigious journal without knowing your manuscript's novelty and significance. Always shortlist 3–5 journals to streamline resubmission if rejected.

Take home messages and reference tool

Choosing an indexed journal is a smart scientific effort. It necessitates extensive research about the journal's scope and audience, a thorough evaluation of its reputation and

Sruthi M. V

Department of Community Medicine Amala Institute of Medical Sciences, Thrissur, Kerala, India

Address for correspondence: Dr. Sruthi M. V,
Amala Institute of Medical Sciences, Thrissur, Kerala, India.
E-mail: drsruthimv@amalaims.org

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metrics, and avoidance of Predatory journals. Available online resources help in finding an appropriate journal for publication and Journal indexing and metrics are given below:

- **For Journal Finder:** Based on your title and abstract, the online tools like JANE (Journal/Author Name Estimator),[2] Elsevier Journal Finder,[3] Taylor and Francis Journal Suggester[4] can be used.
- **For Indexing Database and Journal Metrics**: Official database like Web of Science Master Journal List, Scopus Source List, NLM Catalog/PubMed can be used.

Financial support and sponsorship

Nil.

Conflict of interest

There is no conflict of interest.

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4. Taylor and Francis Journal Suggester-Author service. Available from: https://authorservices.taylorandfrancis.com/publishing-your-research/choosing-a-journal/journal-suggester/.

Curated article summaries

1. OUTCOMES OF ANTERIOR CHAMBER WASH WITH ADJUVANT INTRACAMERAL AND INTRASTROMAL VORICONAZOLE IN DEEP STROMAL FUNGAL KERATITIS WITH ENDOEXUDATES—A RETROSPECTIVE STUDY

Muraleedharan P, Christy JS, Radhakrishnan N. Outcomes of anterior chamber wash with adjuvant intracameral and intrastromal voriconazole in deep stromal fungal keratitis with endoexudates—A retrospective study. Indian J Ophthalmol 2025;731482-5.

Filamentous fungal keratitis often shows poor response to topical antifungals because natamycin has limited stromal penetration and topical voriconazole, though achieving adequate AC levels, is ineffective as monotherapy. Deep stromal infections with anterior chamber exudates frequently progress to therapeutic keratoplasty, which usually results in suboptimal visual recovery. Intrastromal and intracameral voriconazole have been used as adjuncts with variable outcomes. However, a systematic evaluation of their combined role in managing deep stromal keratitis with endoexudates has not been conducted before.

In this retrospective observational study done in a tertiary care center in South India from January 2022 to December 2022, records of patients with microbiologically proven deep stromal fungal keratitis were analyzed. Patients unresponsive to or worsening on topical natamycin and voriconazole dual therapy, were subjected to AC wash with intracameral and intrastromal voriconazole (50 mcg/0.1 mL), repeated up to a maximum number of three times within a 24–48-hour interval. In patients with rapid progression of ulcer or impending perforation or perforation during or even after three AC washes with intracameral and intrastromal voriconazole, therapeutic keratoplasty was done.

Out of the 40 patients who underwent AC wash with intrastromal and intracameral voriconazole, Only 7 (17.5%) achieved complete resolution with scarring; the remaining 33 eyes (82.5%) required therapeutic penetrating keratoplasty (TPK), of which 10 (≈30.3%) experienced reinfection despite the intervention.

WHY THIS ARTICLE?

This article directly addresses a practical, high-stakes clinical question. Deep fungal keratitis with intraocular involvement is sight-threatening and there's little high-quality evidence guiding escalation beyond topical/systemic therapy. Many have tried intrastromal/intracameral voriconazole, but the results were inconsistent. Although the outcome is negative, this study offers crucial information that should temper enthusiasm for routine use of these adjuvants and may push toward earlier surgical intervention or alternative strategies.

2. EFFICACY AND SAFETY OF PILOCARPINE HYDROCHLORIDE OPHTHALMIC SOLUTION USP 1.25% W/V VERSUS PLACEBO OPHTHALMIC SOLUTION FOR THE TREATMENT OF PRESBYOPIA—A MULTICENTRIC CLINICAL TRIAL

Singh P, Garasiya T, Ajila V, Sengupta S, Datta A, Nivean M. Efficacy, and safety of pilocarpine hydrochloride ophthalmic solution USP 1.25% w/v versus placebo ophthalmic solution for the treatment of presbyopia—A multicentric clinical trial. Indian J Ophthalmol 2025;73:1251-7.

Pilocarpine is a cholinergic muscarinic receptor agonist that enhances accommodation by inducing miosis and stimulating the ciliary muscle. The GEMINI 1 and 2 trials (2021, Allergan)) have led to FDA approval of pilocarpine 1.25% (Vuity) in the US for pharmacological treatment of presbyopia. Indian eyes have smaller pupils and increased iris pigmentation, which may alter pilocarpine's efficacy and pharmacodynamics. Despite global evidence supporting pilocarpine, there is a lack of studies and local availability in India, limiting applicability to the Indian population.

This multicenter, randomized, double-masked, parallel-assignment clinical trial evaluated the efficacy and safety of 1.25% pilocarpine for the treatment of presbyopia, comparing it to a placebo, with 1:1 randomization of Indian men and women aged 45–55 years with a clinical diagnosis of presbyopia. Participants instilled one drop of the study drug or placebo in each eye once daily in the morning and were evaluated on day 0,3, 7, 14, and 30

50% of participants gained at least two lines of near visual acuity, while 31% gained three lines by day 30, which was almost identical to the GEMINI1 clinical trial, despite several racial anatomical differences in eyes. No adverse drug reactions or ophthalmic side effects were reported during the study.

WHY THIS ARTICLE?

Although pilocarpine 1.25% was found to be effective in treatment of presbyopia, almost all the studies were conducted in Western populations, under industry sponsorship and used stringent inclusion criteria (healthy emmetropic presbyopes, no refractive error, no lens changes). So, while we know the drug can work in ideal eyes, real-world data in diverse populations were lacking. This study was

- Conducted in Indian eyes, which often have smaller pupils, darker irides, and higher baseline accommodative tone than Western counterparts—all of which affect miotic-based near vision improvement.
- Done in different light environments and in non-ideal eyes (mild cataract, ametropia), which is closer to real life situation
- Multicentric, which increases its external validity
- Non-industry, investigator-initiated work which provides a neutral safety and tolerability profile

The results of the trial support the findings from previous trials, and validates the use of pilocarpine 1.25% as a viable pharmacotherapy in Indian presbyopes, although further studies are required before we include it in the armamentarium

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

Aswathy P
Department of Ophthalmology, Government Medical College, Kozhikode, Kerala, India

Address for correspondence: Dr. Aswathy P, Department of Ophthalmology, Government Medical College, Kozhikode, Kerala, India.
E-mail: aswathyponnarath@gmail.com

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Fellowship exams: A catalyst for excellence

ABSTRACT

Fellowship exams in ophthalmology, Fellow of All India Collegium of Ophthalmology(FAICO) Fellow of the National Board (FNB) and global credentials such as the Fellow of Royal College of Physicians & Surgeons of Glasgow (FRCS Glasgow) and Fellowship of the Royal College of Ophthalmologists(FRCOphth), offer a unique opportunity to consolidate clinical knowledge and to align your expertise with international standards. We provide the essential guidelines on the most pursued national and international fellowship exams. Tips are provided by experts who have been successful in the exams.

Keywords: Fellowship exams in ophthalmology, Fellow of All India Collegium of Ophthalmology(FAICO) Fellow of Royal College of Surgeons of Glasgow (FRCS Glasgow), Fellowship of the Royal College of Ophthalmologists (FRCOphth)

In the rapidly evolving world of ophthalmology, pursuing certifications, like a Fellowship, validates your expertise and refines your clinical approach in addition to expanding your global opportunities.

Fellowship exams in ophthalmology, including nationally acclaimed certifications like Fellow of All India Collegium of Ophthalmology (FAICO) Fellow of the National Board (FNB) and global credentials such as the Fellow of Royal College of Physicians and Surgeons of Glasgow (FRCS Glasgow) and Fellowship of the Royal College of Ophthalmologists (FRCOphth), offer a unique opportunity to consolidate clinical knowledge and to align your expertise with international standards. We provide the essential guidelines on the most pursued national and international fellowship exams. Tips are provided by experts who have been successful in the exams.

FAICO (FELLOW OF ALL INDIA COLLEGIUM OF OPHTHALMOLOGY)

It is conducted by the AIOS (All India Ophthalmic Society) in various subspecialties, namely, comprehensive ophthalmology, vitreoretina,glaucoma, pediatric ophthalmology oculoplasty, neuro-ophthalmology, cornea, and phacorefractive [Figures 1 and 2].[1]

Mode of exam: 2-stage exam

1st Stage: Written exam, which is online—60 MCQs to be answered in 1 hour

Monisha Mohan, Remya Edachery[1], Bushra Thajudeen[2], Rakhi D. Cruz[3], Supreme Goel[4], Mini Ajith Mathew[5]

Ahalia Foundation Eye Hospital, Palakkad, Kerala, [1]Payyanur Cooperative Hospital, Payyanur, Kerala, [2]Royal Gwent Hospital, Newport, Wales, United Kingdom, [3]Chaitanya Eye Hospital, Kollam, Kerala, [4]Department of Ophthalmology, Chaithanya Eye Hospital and Research Institute, Trivandrum, Kerala, [5]Department of Ophthalmology, Regional Institute of Ophthalmology, Trivandrum, Kerala, India

Address for correspondence: Dr. Mini Ajith Mathew, Department of Ophthalmology, Regional Institute of Ophthalmology, Trivandrum, Kerala, India.
E-mail: miniacherian@gmail.com

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	Expert Tips: Review all sections of the FAICO curriculum	Reference Books
Comprehensive Ophthalmology	#All subspecialty questions, # emphasis on surgical aspects in all subspecialities, for viva and OSCE. # revise your notes for postgraduation exams	Kanski AAO series Oxford handbook
Glaucoma	#thorough knowledge of glaucoma medications and LASER procedures #recent advances including MIGS and imaging in glaucoma	AAO Glaucoma landmark clinical trials (Indian and global) recent advances (MIGS and imaging in glaucoma)
Paediatric Ophthalmology	#Review your fellowship logbook #I focus YouTube videos on OSCEs to familiarize yourself with common cases. #Questions are crafted to ensure that only those with hands-on experience can provide accurate answers. #postoperative complications, their management, and systemic associations of various pediatric diseases.	AAO Pediatric Ophthalmology and Strabismus Kanski Eyedocs question bank
Oculoplasty	# Review your fellowship textbooks #Utilising the videos from Ifocus can be particularly beneficial, as they highlight some lesser-known topics that may be important for your revision. #Pay attention to questions related to genetics and ocular oncology, while also preparing for a few questions from community ophthalmology and pathology.	Kanski Oculoplastic Surgery by Leatherbarrow for illustrated surgical descriptions, AAO Ocular Oncology and Oculoplastic Surgery
Neuro Ophthalmology	# important topics are optic neuritis and its atypical forms, brainstem and cortical syndromes,imaging protocols including stroke protocols and clinical trials. #The practical examination focuses on common clinical cases	Kanski Chua website MCQs I focus videos

Figure 1: Subspeciality exams of FAICO

A detailed curriculum for each speciality is available on the AIOS website. In addition to the core textbooks, such as AAO, online resources, like iFocus lectures and MCQ banks, are also very useful.

2nd Stage: (Practicals) OSCE and Viva voce. Eighteen months of experience in the concerned sub-speciality will make one well-prepared for the OSCE and viva. It is best to appear for the exam after the completion of one's fellowship or a couple of years into practice. The clinical part of the exam requires candidates to think critically and respond based on their practical experience. Throughout the viva, honesty is crucial. It is best to be straightforward, especially if you are uncertain about an answer.

FNB (FELLOW NATIONAL BOARD) VITREORETINAL SURGERY

After the FET exam, admission to the courses will be through centralized merit-based counselling. There are regular classes held by NBEMS. There is a FAT (formative assessment test) and an internal examination during the course and an Exit exam at the end [Figure 3].[2]

	VitreoRetina	#Additional attention should be given to retinal dystrophies and degenerations, particularly their incidence and genetic basis, as they remain important for examinations. #Focus on posterior uveitis, including VKH, sympathetic ophthalmia, and viral retinitis. # practical questions on vitrectomy, scleral buckling, macular hole management, and related indices are frequently asked. retinal imaging, diagnostic modalities, electrophysiology, and retinopathy of prematurity	AAO, Kanski, Ryan Retina MCQs – Review Of ophthalmology by Kenneth G, Review Questions by Massachusetts Eye and Ear Review Manual
	Phacorefractive	#Knowledge on Pentacam and Corneal Biomechanics is emphasized for practical understanding. #Staying updated with the latest refractive surgery platforms is crucial for the exam #Surgical planning and data entry in LASIK machine #Presbyopia management # Practical Surgical Skills in LASIK, PRK, SMILE, ICL, IPCL, ICRS, Intracorneal Ring Segments, Microkeratome, Femtosecond LASIK, and Contoura Vision # The exam covers complications of refractive surgery and comparison of different surgical platforms	AAO Refractive Surgery Handbook BCSC, Section 13 Current Concepts in Refractive Surgery: A Comprehensive Guide for Decision Making and Surgical Techniques by Dr. J.S. Titiyal: The Art of Refractive Surgery by Dr. Sudarshan Khokhar Refractive Surgery: An Interactive Case-Based Approach by J. Bradley Randleman. Image-based questions involving Pentacam and planning of LASIK and IPCL are commonly featured.
	CORNEA	Surgical skills in various types of keratoplasty Therapeutic keratoplasty Optical keratoplasty DSEK,DMEK,DSAEK,DALK,PDEK Femtosecond LASER assisted keraoplasty	AAO External Disease and Cornea Kanski Cornea Fundamentals ,diagnosis and management (Mannis and Holland) Colour atlas and synopsis of Clinical Ophthalmology ,Cornea (Will'sEyeHospital)

Figure 2: Subspeciality exams of FAICO (Contd)

FRCS FELLOWSHIP OF THE ROYAL COLLEGE OF SURGEONS (GLASGOW)

It is conducted by the Royal College of Physicians and Surgeons of Glasgow, UK.[3]

This award demonstrates an individual's knowledge of the scientific basis of ophthalmology, with the experience and competence to apply that knowledge to patients [Figure 4].

- **Exempting Qualifications for Part 1**
  1. FICO-basic science and optics
  2. FRCSEd part A
  3. MRCSEd part 1
  4. FRCOphth part 1
- **Exempting Qualifications for Part 2:** Passed FICO-clinical sciences
  1. **Expert's Tip for Orals:** Answer comprehensively from history, examination, to surgical management—surgical steps can be asked in detail.
  2. **Expert's Tip for Clinical Stations:** Each station is 12 minutes, during which you will be allotted two to three patients for which you have to examine, narrate your findings and diagnosis, which is followed by one or two viva questions.

There will be two examiners per station. The key to success is your confidence in examining the patient, quickly and crisply answering, and a faster examination of patients so that you can get a minimum of two patients/station.

BOARD	Mode of exam	Eligibility	Reference literature	Expert Tip
National Board of Examinations in Medical Sciences(NBEMS)	MCQ based Fellowship Entrance Test (FET	DNB/MS Ophthalmology	Kanski AAO Ryan's retina	#knowledge in comprehensive ophthalmology i#ndepth knowledge of vitreoretina as it carries 60% weightage.

Figure 3: FNB vitreoretinal surgery

FICO-FELLOW OF THE INTERNATIONAL COUNCIL OF OPHTHALMOLOGY

The exam is conducted by the International Council of Ophthalmology, whose headquarters are located in Geneva, Switzerland [Figure 5].[4]

FELLOW OF THE ROYAL COLLEGE OF OPHTHALMOLOGISTS (FRCOPHTH)

For details on the number of attempts allowed, exam structure, please visit the examination section of the RCOphth website.[5]

1. **Expert Tips Part 1**
   This is a long, challenging exam that requires a lot of revision [Figure 6].
   Use a question bank to regularly practice questions.
   Practice as much as you can, on patients/staff. Try to borrow glasses and practice focimetry and lens

Frcs Glasgow	Part 1	Proctored Online	160 questions,2 Hours	MBBS+1 Yr Internship+1 Year Clinical Experience	Syllabus Anatomy,Physiology,Pathology,Biochemistry ,Optics Books:Aao,Optics (Elkington),Renal Physiology,John D Ferris,The Eye Basic Science In Practise By Forrester
	Part 2	Proctored Online	180 Questions 2.5 -hours'	MBBS+ 1 Year Internship+ 5 Years Of Clinical Experience	Clinical Ophthalmology-A Systematic Approach By Kanski. Oxford Emergency Medicine •Kumar And Clark's Clinical Medicine – Systemic Manifestations, Cardiac Murmurs
Eligibility Passed Frcs Part 2/ Fico Clinicals	Part 3	2 Parts Offline	Viva/Osce Oculoplasty 1.Anterior Segment 2.Posterior Segment 3.Neurology , Motility And General Medicine	Stations 4 Stations 1.Anterior Segment Disorders 2.Posterior Segment Disorders 3.Neuro-Ophthalmology 4.Oculoplasty And Lid Disorders	1.Frcs Ophthalmology Cakewalk By Mamta Mittal 2.Practical Guide To Viva And Osce In Ophthalmology By Wei Yan, Li Lian Foo, Tien Yin Wong 3.Oxford Handbook Of Ophthalmology 4.A Manual Of Systematic Eyelid Surgery By Collins 5.Review Questions In Ophthalmology By Kenneth C Chern 6.Von Noorden -Ocular Motility 7.Oxford Handbook Of Emergency Medicine

Figure 4: FRCS Glasgow.Disclaimer - FRCS policies may change; readers should verify the latest guidelines online

FICO	Topic	Pattern	Syllabus	Books
Part A	Visual sciences	120 MCQs in 3 hours, single best answer, no negative marking	Anatomy, physiology, biochemistry, epidemiology and statistics, pathology and microbiolog	1.John D Ferris basic science book 2.The eye -basic science in practice by Forrester
PART B	Optics, Refraction and instruments	60 MCQs in 1.5 hours, single best answer, no negative marking	Part A+B can be combined and written on a single day one after the other	1.Elkington clinical optics. 2.Khurana optics and refraction, 3.Chua optics MCQ book
PART C after clearing part A& B-	Clinical ophthalmology	200MCQ's in 4 hours, single best answer, no negatives	Clinical ophthalmology covering all subspecialties Community ophthalmology and public health General medicine related to ophthalmology	1.Clinical ophthalmology-a systematic approach by Kanski 2.Review questions in ophthalmology by Kenneth C Chern 3.Wills eye manual
PART D-Advanced after clearing part A, B & C	Clinical Acumen, Application Of Knowledge And Decision Making Time	3 hours exam 10 extended matchquestions 75 multiple choice questions		Clinical ophthalmology-a systematic approach by Kanski •Review questions in ophthalmology by Kenneth C Chern •Massachusetts eye and ear infirmary review manual of ophthalmology •PROVISION -5th edition •Decision making in ophthalmology by Johan Zwaan

Figure 5: FICO

FRCOphth	FRCOphth Part 1	Refraction certificate	FRCOphth Part 2 written	FRCOphth Part 2 oral
	Written	Practical exam assessing candidate's ability to do clinical refraction	For those who passed part 1	for those who passed part1,Refraction Certificate and written part 2
Format	2 X 2 hours of 90 MCQs	5 OSCE sations with two elements in each,with retinoscopy simulators and real patients	2X90 question papers – MCQ single best answer	Structured viva and OSCE with real patients and videos
		3 stations:retinoscopy. Subjective refraction and lens neutralization,refraction and sphere refinement		5 stations for VIVA:1.patient investigation/management/ethics/audit and research OSCE:6 stations anterior segment/glaucoma/lid/posterior/orbit and strabismus/neurophthalmology/communication
FRCOph Books	https://www.efrcophth.com Clinical optics by Elkington for time bound practice tests. https://ripleyhosting.co.uk/fmi/webd/RCOphth_Web?homeurl=https://ripleyhosting.co.uk/fmi/webd/RCOphth_Web/ How to Pass the Refraction Certificate/Park Jones			Kanski Oxford

Figure 6: FRCOphth

neutralization as much as possible. Practice is the key to passing this examination.

2. **Expert Tips Part 2**
   Practice is the key for the OSCE part. Find a colleague who is sitting the same exam and practice each station many times. With practice, you should be able to come up with ways to elicit clinical findings without missing any in the given timeframe and be prepared for the questions. The more confident and accurate you are with your findings and the way you answer questions, the more likely you are to be scored higher than the candidate before you.

Preparing for one of these esteemed exams—whether FAICO or the full FRCS/FRCOphth pathway—is a game-changer. It challenges you to reassess your knowledge, refine your skills, and reaffirm your commitment to excellence in eye care. It is not just about passing—it is about transformation. Take that next step. Your future self will thank you. The descriptions of the exams are provided as guidelines for the fellowship exam preparation and are not exhaustive. Readers are requested to visit the websites of the exams for updates.

Answer to previous issue MCQ

Ans: C Tolosa–Hunt syndrome; Perform contrast-enhanced MRI brain and orbit.

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Conflicts of interest

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A closer look at the inferior oblique recession surgery

ABSTRACT

The inferior oblique muscle plays a crucial role in ocular motility, primarily responsible for extorsion, elevation, and abduction of the globe. The muscle has a unique anatomical course that makes surgical manipulation both technically nuanced and critical in the management of certain strabismus conditions like primary or secondary inferior oblique overaction, dissociated vertical deviation, or V-pattern strabismus. This video article demonstrates a standardized technique for inferior oblique muscle recession, a commonly performed weakening procedure in strabismus surgery. The step-by-step surgical approach are clearly outlined, beginning from conjunctival incision to disinsertion and reattachment of the muscle at a recessed site. Intraoperative challenges include the risk of leaving residual muscle fibers attached, which may result in under correction or recurrence; inadvertent scleral perforation, with a risk of retinal or macular injury and significant bleeding resulting from damage to the vortex veins or adjacent vascular structures. Due to the proximity of the inferior oblique muscle insertion to the posterior pole, particular caution is required to prevent inadvertent injury to the macular region during surgery.

Keywords: Inferior oblique, strabismus, recession

FOCUS POINTS

- Anatomical orientation of the Inferior Oblique muscle and its relationship to nearby structures like macula and vortex vein.[1]
- Careful isolation and disinsertion of the muscle to prevent injury to the vortex veins and macula.[2]
- Fornix incision helps to perform surgeries on multiple muscle through a single incision (lateral rectus, inferior oblique and inferior rectus can be approached through a single incision)
- To prevent under correction, meticulous dissection ensuring inclusion of all the muscle fibers is crucial.
- Inferior rectus insertion as the reference point for recession according to the degree of inferior oblique overaction.[3]

CONCLUSION

Inferior oblique recession surgery, when performed with careful attention to the anatomical details and potential complications, offers an effective solution for managing complex strabismus ensuring improved functional and cosmetic outcomes for patients.

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Conflicts of interest

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Remya Edachery

Pediatric Ophthalmology, Strabismus and Neuro Ophthalmology, Payyanur Co-operative Hospital, Payyanur, Kerala, India

Address for correspondence: Dr. Remya Edachery, Consultant in Cataract, Pediatric ophthalmology, Strabismus and Neuro Ophthalmology, Payyanur Co-operative Hospital, Payyanur - 670 307, Kerala, India.
E-mail: remyae2003@gmail.com

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Management of Argentina flag sign in intumescent soft cataract

ABSTRACT

The Argentina flag sign is a well-recognized intraoperative complication in intumescent cataracts, resulting from elevated intralenticular pressure. When this occurs, the central white cataractous lens with a stained blue capsule on either side resembles the Argentina flag. This event carries a significant risk of posterior capsular extension and potential nucleus drop. Timely and appropriate intraoperative measures are therefore crucial to prevent further complications. In this report, we present the management of an Argentina flag sign in an intumescent soft cataract in a 25-year-old young patient with coexisting Fuchs' heterochromic iridocyclitis in the same eye.

Keywords: Argentina flag sign, capsulorhexis, complications, Fuchs' heterochromic iridocyclitis, intumescent soft cataract, management, phacoemulsification, phacoaspiration

FOCUS POINTS

Important Key Steps [Video 1] for the Management of the Argentina Flag Sign[1-5]:

1. In all cases of intumescent cataract planned for phacoemulsification, always keep intraocular scissors and a small incision cataract surgery (SICS) or extracapsular cataract extraction (ECCE) set ready to manage possible intraoperative complications and allow conversion if necessary.
2. In the event of a capsular rupture during capsulorhexis, promptly aspirate the liquefied lens material using a cannula attached to a manual syringe during the "golden period" (the phase of continuous extension of the tear), and then check for any posterior capsular involvement.
3. In soft cataracts without posterior capsular extension, the lens can be safely aspirated using an irrigation–aspiration cannula. In cases, if the extension involves the posterior capsule, the lens may be carefully aspirated or gently prolapsed into the anterior chamber.
4. In cases where the cataract is not soft, the nucleus can be prolapsed into the anterior chamber and removed either through phacoemulsification or by converting to SICS or ECCE.
5. The torn edges of the anterior capsule can be converted into a near-circular capsulorhexis by creating semicircular rhexis on either side of the tear using intraocular scissors.
6. Soft lens material could be aspirated using the irrigation–aspiration cannula under low phacoemulsification parameters—irrigation bottle height 40–60 cm, vacuum

Balamurugan R, Gayathri R[1], Shubhangi S. N. Prasad, A. M. Raja[1]

Department of Ophthalmology, All India Institute of Medical Sciences, Mangalagiri, Andhra Pradesh, [1]Department of Ophthalmology, All India Institute of Medical Sciences, Madurai, Tamil Nadu, India

Address for correspondence: Dr. Balamurugan R, Department of Ophthalmology, All India Institute of Medical Sciences, Madurai - 625 008, Tamil Nadu, India.
E-mail: bala16690@yahoo.co.in

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150–200 mmHg, and flow rate 15–20 mL/min. In case, if phacoemulsifcation is needed for moderate-hard cataract, low phacoemulsification ultrasound 20–40% could be used.

7. The anterior chamber should always be filled with ocular viscoelastic devices (OVDs) such as hydroxypropyl methylcellulose (HPMC 2%) before removing any irrigation source. Cohesive viscoelastic like sodium hyaluronate (1.4%) could be preferred in case of bag and anterior chamber formation for intraocular lens (IOL) implantation.
8. The IOL can be implanted in the capsular bag with the haptics positioned beneath the capsular remnants. IOL dialing should be avoided or performed minimally and gently to ensure the haptics remain under adequate anterior capsular support.
9. At the end of surgery, the anterior chamber should be reformed with an air bubble.
10. Intraoperative miotics should be administered to stabilize the IOL.

CONCLUSION

The Argentina flag sign is likely to occur in intumescent cataracts despite all precautions, due to high intralenticular pressure. Proper intraoperative management can prevent posterior capsular extension and ensure a favorable visual outcome.

Video1: https://drive.google.com/file/d/1jRrpnNRHhZeny8q6dJWJlM-TaSCrLu8g/view?usp=sharing

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SD-OCT in Sickle cell haemoglobinopathies

Dear editor,

We studied the article titled "Comparison of central macular thickness using spectral domain optical coherence tomography in sickle cell hemoglobinopathy patients and age-matched controls—A comparative cross-sectional observational study" by Dhanbad *et al.*[1] We have a few observations. The study group has included sickle cell hemoglobinopathy (SCH) without any clinical evidence of retinopathy. In such a scenario, we feel that only eyes with best-corrected visual acuity of 6/6 should have been included. Few patients with vision less than 6/60 have also been included. The authors have mentioned that the vision in such cases was less because of cataract. With vision less than 6/60, the thickness of the cataract will be significant and this can compromise the quality of the optical coherence tomography (OCT) scans. These eyes should not be included. It will also be informative to know if patients on medications that can be retinotoxic were excluded from the study. Similarly, if patients with positive smoking history were also excluded.

We would also like to know how the results of the study are clinically significant. Even though the central macular thickness (CMT) in eyes with SCH was found to be statistically thinner as compared to normal control eyes, it was still within the normal range for age and gender. It would have been much more informative if the patients were sub-divided according to the duration of disease and a correlation found between CMT and disease duration. Similarly, a correlation could also have been found between CMT and patients with a history of sickling crisis. Ideally, a correlation should also have been studied between blood parameters and retinal indices. Finally, addition of OCT angiography related retinal indices, could have increased the significance of the study.

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Pradeep Kumar Panigrahi, Rahul Bector

Department of Ophthalmology, Institute of Medical Sciences and SUM Hospital, Siksha O Anusandhan (deemed to be) University, 8-Kalinga Nagar, Bhubaneswar, Odisha, India

Address for correspondence: Dr. Pradeep Kumar Panigrahi, Department of Ophthalmology, Institute of Medical Sciences and SUM Hospital, Siksha O Anusandhan (deemed to be) University, 8-Kalinga Nagar, Bhubaneswar - 751 003, Odisha, India
E-mail: doc.pkp25@gmail.com

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