

**Emerging Trends in Optometry on Vision Science and Eye
Health**

Edited by

Dipanwita Ghosh
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Swami Vivekananda University

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Emerging Trends in Optometry on Vision Science and Eye Health

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First and foremost, we extend our heartfelt gratitude to the contributing authors. Your commitment to advancing our understanding of eye and vision science, combined with your willingness to share your knowledge and research, has been instrumental in shaping this book. Your contributions are the foundation upon which this volume stands.

We are deeply appreciative of the peer reviewers who provided invaluable feedback and insights. Your thorough evaluations and constructive critiques have ensured the highest standards of academic rigor and clarity in this work.

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Finally, we extend our appreciation to the readers of this book. Your curiosity and passion for eye and vision science drive the continuous exploration and discovery that propel our field forward. It is our hope that this book will serve as a valuable resource and inspire further research and innovation.

Thank you all for your contributions and support.

Preface

The field of optometry is constantly evolving, driven by advancements in technology, research, and clinical practices. As our understanding of vision science and eye health deepens, new methodologies, treatments, and diagnostic tools continue to shape the way eye care professionals approach patient care. This book, *Emerging Trends in Optometry on Vision Science and Eye Health*, serves as a comprehensive collection of contemporary research, highlighting key developments that influence both clinical practice and academic discourse in optometry.

The purpose of this compilation is to provide an insightful and evidence-based perspective on the latest trends in optometry. From myopia management and dry eye syndrome to advancements in digital eye strain research and innovations in vision therapy, this book covers a diverse range of topics relevant to both practitioners and researchers. It aims to bridge the gap between theoretical knowledge and clinical applications, offering readers a well-rounded understanding of the current state of optometric science.

This book is intended for optometry students, educators, clinicians, and researchers who seek to stay informed about emerging developments in the field. By exploring various aspects of vision science, ocular disease management, and technological advancements, we hope to inspire further inquiry and discussion among professionals dedicated to enhancing eye care.

I extend my gratitude to all the contributors who have shared their expertise, as well as to the readers who continue to engage with and advance the field of optometry. It is my hope that this book serves as a valuable resource for anyone passionate about vision science and eye health.

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Evaluating Retinal and Choroidal Changes in Sturge-Weber Syndrome through Optical Coherence Tomography (OCT) Imaging: Insights and Analysis

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Abstract

Background: Sturge Weber Syndrome is a rare neurocutaneous condition which is characterized by ocular manifestations, neurological abnormalities and facial port wine stains. The aim of the study is to explore the changes in the eye by using Optical Coherence Tomography to examine the alterations in retina and choroid. This study was conducted during March 2023 to August 2024. Data was collected from multi-speciality clinics of Gujarat. All the subjects underwent high resolution spectral domain Optical Coherence Tomography imaging. Subjects were assessed for thickness of macula and choroid and structural abnormalities. Internal comparison was also done between affected and unaffected eyes. To evaluate statistically, tests like t tests, chi square test and correlation tests were incorporated with significance level set at $p < 0.05$. This study found that macular thickness is significantly increased in the affected eyes with value of $(290.3 \pm 15.2 \text{ microns})$ compared to the unaffected eyes $(273.7 \pm 12.5 \text{ microns}, p < 0.01)$. in areas where facial port wine stains are present, choroidal thickness was significantly reduced $(168.6 \pm 20.1 \text{ microns})$ as compared to unaffected areas $(198.4 \pm 18.7 \text{ microns}, p < 0.05)$. Additionally, structural abnormalities like retinal pigment

epithelial changes are seen in 65% and choroidal atrophy in 40% of the affected eyes. Significant positive correlation was found between the severity of choroidal changes and extent of facial port wine stains ($r = 0.62$, $p < 0.01$). This study reveals important differences in macular and choroidal thickness in Sturge Weber Syndrome, along with structural abnormalities. Significant correlation was also found between cutaneous and ocular manifestations. These findings underscore the connection between skin and ocular anomalies which signify the importance of comprehensive ocular examinations. These results also suggest avenues for further research to better understand the condition and to improve its clinical management.

Keywords: Sturge-Weber Syndrome, optical coherence tomography, retinal changes, choroidal changes, ocular manifestations, macular thickness, spectral-domain OCT, neurocutaneous disorder, cohort study, medical, community.

Introduction:

Sturge Weber Syndrome is a rare neuro cutaneous condition which is defined by an identifiable triad of facial port wine stain, neurological anomalies and ocular manifestations. The complex interaction between neurological, cutaneous and ocular elements poses appreciable challenges in knowing the complexity of this syndrome. Among its varied clinical manifestations, its ocular involvement in this syndrome has acquire the increasing attention due to its possible impact on ocular functions. This research focus on unravelling the ocular complexity of SWS by employing OCT for assessment of retinal and choroidal changes.

The ocular manifestations of SWS are known to embrace an array of anomalies, ranging from vascular deformity to structural modifications within the retina and choroid. There is much limited comprehensive research clarifying the limited research on specific retinal and choroidal changes associated with SWS, especially through advanced imaging technique such as OCT. This study addresses the gap by conducting evaluation of 23 subjects diagnosed with SWS, which employs high resolution OCT to examine macular and choroidal characteristics.

OCT with its non-invasive and high-resolution imaging capacity offers a specific possibility to dig into the micro structural modification of retina and choroid in subjects with SWS. The main objective of the study is to examine thickness of macula, choroidal thickness and the existence of structural anomalies in the affected eyes. It provides a significance of the ocular involvement in this syndrome. Comparative assessment between unaffected and affected eyes within the same subjects aim to depict specific changes related with the syndrome.

Basic literature suggest that choroid and retinal changes may serve as important indicator of the progression and severity of SWS related ocular complications. Alterations in the thickness of macula may reflect underlying vascular anomalies while changes in the choroidal thickness may be suggestive of vascular compromise in areas corresponding to facial port wine distribution of stain.

Furthermore, the determination of structural anomalies like RPE alterations and choroidal atrophy, may shed light on pathos physiological mechanisms which underly ocular manifestations in SWS.

The correlativity analysis between the severity of choroidal changes and extent of facial port wine stain introduces a fresh dimension to our understanding of the syndrome which suggest potential links between ocular involvement and cutaneous involvement. Identifying these associations is necessary for early detection, monitoring and strategies for management for ocular complications in subjects with SWS.

Methodology:

In this study, group of 23 subjects who were diagnosed with Sturge Weber Syndrome was precisely selected from specialized neuro cutaneous condition in clinics which ensures a democratic sample for the investigation. Detailed clinical assessments were conducted to conform the diagnosis, emphasizing the presence of facial port wine stains and neurological anomalies. Individuals with ocular comorbidities are excluded. Homogeneity is maintained within the study population. The research engages high

resolution spectral domain OCT, utilizing a standardized protocol. Macular thickness measurements cover central 6*6 mm area and choroidal thickness measurement focused on regions corresponding to facial port wine stain distribution were obtained. To recognize specific changes associated with SWS, internal comparative evaluation was conducted between affected and unaffected eyes within the same individuals. Quantitative analysis of choroidal and macular thickness measurement employed statistical tests with a p level of less than

0.05. Structural anomalies including RPE alterations and atrophy of choroid were identified through precise examination of OCT scans. Furthermore, correlational analysis explores the relationship between extent of severity of choroidal changes and facial port wine stain. Ethical consideration was predominant throughout the study, with approval obtained from ethical committee and commitment to patient privacy and confidentiality. These methodology aims to provide a detailed understanding of the ocular manifestations of SWS, which contributes important insights to the existing body of knowledge.

Results:

The results of our study expose significant insights into the choroidal and retinal changes associated with Sturge Weber Syndrome as assessed through precise OCT and detailed statistical analysis. Macular thickness in affected eyes shows statistically significant increase as compared to unaffected eyes, with a mean thickness of value 290.3 ± 15.2 microns in affected eyes and 273.7 ± 12.5 microns in unaffected eyes with value of ($p < 0.01$). Choroidal thickness shows variability, notably demonstrates a statistically significant reduction in areas corresponding to facial port-wine stain distribution, with a mean thickness value of 168.6 ± 20.1 microns in affected areas compared to 198.4 ± 18.7 microns in unaffected areas ($p < 0.05$). Structural anomalies were prevailing in affected eyes, with retinal pigment epithelial modification observed in 65% of cases and choroidal atrophy present in 40% of cases. Correlation analysis revealed a significant positive correlation between the extent of facial port-wine stain and the severity

of choroidal changes ($r = 0.62$, $p < 0.01$), suggests a possible link between cutaneous and ocular involvement. Relative assessments further highlighting distinct changes connected with SWS, systematically depicting enhanced macular thickness and decreased choroidal thickness in affected eyes compared to their unaffected counterparts.

Table 1: Comparison of Macular Thickness in Affected and Unaffected Eyes

Eye Condition	Mean Macular Thickness (microns)	Standard Deviation
Affected	290.3	15.2
Unaffected	273.7	12.5

Table 1 elaborate the mean macular dimension in affected and unaffected eyes, indicative a statistically significant increase in macular thickness in individuals with Sturge-Weber Syndrome with value of ($p < 0.01$).

Table 2: Comparison of Choroidal Thickness in Affected and Unaffected Areas

Area Condition	Mean Choroidal Thickness (microns)	Standard Deviation
Affected	168.6	20.1
Unaffected	198.4	18.7

Table 2 presents the average choroidal thickness in areas related to facial port-wine stain arrangement, indicating a statistically significant reduction in choroidal thickness in affected areas ($p < 0.05$).

Table 3: Shows Prevalence of Structural Abnormalities in Affected Eyes

Structural Abnormality	Percentage of Cases
Retinal Pigment Epithelial Alterations	65%
Choroidal Atrophy	40%

Table 3 shows the preponderance of structural abnormal

condition in affected eyes, with retinal pigment epithelial modification observed in 65% of cases and choroidal atrophy existing in 40% of cases.

Table 4: shows Correlation Between Facial Port-Wine Stain Extent and Choroidal Changes

Correlation Coefficient	p-value
0.62	<0.01

Table 4 exhibit the correlativity between the extent of facial port-wine stain and the severeness of choroidal changes, inform a significant positive correlation ($r = 0.62$, $p < 0.01$).

Discussion:

Macular Thickness:

The observed increase in thickness of macula in affected eyes as compared to unaffected eyes aligns with previous studies indicating vascular anomalies in SWS. These findings suggest possible alterations in retinal micro vasculature, possibly contributes to the observed increase. The main importance of the increased macular thickness in SWS may have ocular implications for visual function, which shows the need for ongoing observations and intervention scheme to address potential complications associated with macular thickness.

Choroidal Thickness:

The decrease in the thickness of the choroid corresponds to facial port wine stain distribution is a notable discovery. Thinning of choroid may be linked to compromise blood flow, possibly related to underlying vascular abnormalities. The localized nature of choroidal thinning aligns with vascular nature of the disorder which emphasize the need of investigations.

Structural Abnormalities:

The occurrence of structural anomalies like RPE alterations and atrophy of choroid improves our understanding of complex ocular manifestations in SWS. These findings underscore the need of detailed ocular examination in subjects with SWS for detection and management of structural changes at early age.

Correlation Analysis:

Positive correlation was found between the level of facial port wine stain and severity of choroidal changes is novel and interesting part of this study. This correlation suggests possible associations between cutaneous and ocular manifestations which indicates extent of facial involvement. It may serve as a clinical indicator of the severity of ocular changes.

Clinical Implications:

These findings have fundamental clinical implications for the management of Sturge Weber Syndrome. The observed changes in macular and choroidal thickness along with the presence of anomalies of structure highlights the need for specialized optometric care customized to the specific changes by this syndrome. Early detection and monitoring are crucial to monitor and to preserve ocular function and to improve quality of life.

Limitations and Future Directions:

The limitations of this study are relatively small sample size. Further research with larger groups and further longitudinal studies can provide more detailed understanding of the progression of ocular changes. Investigations on the more molecular and genetic factors underly the observed ocular alterations can improve our understanding of the pathophysiology of SWS.

Conclusion:

The multifarious nature of ocular changes in SWS requires ongoing investigations to modify our understanding and improve the management of this complex neuro cutaneous disorder.

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Systemic Comorbidities In Patients With Diabetic Macular Edema

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Abstract

Background:

The most prevalent and dangerous side effect of diabetes is diabetic macular oedema, which is also the main cause of vision impairment. Patients with DME often accompanied by various systemic comorbidities associated with DM that complicate treatment and its prognosis. This study aims to determine the most common systemic comorbidities associated with DME in patients with Diabetic Retinopathy. A retrospective study was conducted on 89 patients aged between 20 to 85 years, with confirmed history of diabetes. Data were collected from medical records based on demographics, types of diabetes and duration, diabetic retinopathy and presence of systemic comorbidities. Descriptive statistical analysis was performed. Result: The descriptive analysis showed that 53.7% of 54 patients were male and 46.3% are females. Among all the confirmed DME patients, it was found that 70.3% patients had HTN, 14.8% had dyslipidaemia, 14.8% had CVD, 7.4% had TSH, 5.5% had CKD and 1.8% had arthritis. The final outcomes revealed that all patients with DM had at least one associated comorbidity and the systemic comorbidities were associated more with T2DM. Patients with DME frequently suffer from multiple systemic comorbidities. The article reveals the high extensiveness of HTN in patients having diabetic macular edema and the low prevalence of arthritis.

Dyslipidaemia also a common systemic condition with another high prevalence in diabetic macular edema patients. This study showed that the prevalence of type II diabetes was more than type I diabetes.

Keywords: Diabetic macular edema, diabetic retinopathy, visual outcomes, systemic comorbidities, hypertension, dyslipidaemia

Introduction

The prevalence of diabetes among people in India is currently around 10%. Males are more likely than females to have this predominance, which develops with age. Studies have found that in India, 136 million individuals have pre-diabetes, 315 million have high blood pressure, and 101 million have diabetes. These show that 11.4% of the population of the country's population is living with diabetes.^[1]

DM is a metabolism-related disease that significantly increases the risk of various systemic comorbidities, including cardiovascular diseases, kidney disease, and neuropathy. It is a significant and widespread health problem in India. It can cause so many complications of the eye, such as diabetic retinopathy, diabetic macular edema, etc.

Diabetic retinopathy is an eye condition which causes loss of vision and impairments. It affects the retinal blood vessels and damage tiny vessels which may leak fluid and deposit under the macula. It causes swelling of the macula, known as diabetic macular edema (DME).^[2] Studies on the predominance of diabetic retinopathy in India shows the prevalence for diabetic retinopathy is 12.5%, people with known diabetes having the prevalence of 15.5%.^[3] Diabetes has vision-threatening forms of DR and DME. One of the main causes of vision impairment in diabetics is diabetic macular edema.^[4] The disease is marked by accumulation of fluid due to blood vessel leaking in the macula, the centre region of the retina that provides crisp, central vision. DME specifically impacts the eyes, leading to vision loss if not adequately managed. Given the systemic nature of diabetes, DME often presents with multiple concurrent comorbid conditions, which can complicate treatment and prognosis.^[5]

The other systemic comorbidities are associated with diabetes-related diseases. So that those comorbidities have impacts on DR and DME patients. Intravitreal treatment with steroids or VEGF inhibitors has also considerably improved the functional long-term result of DME patients. The intended therapeutic outcome is not always attained, even with extensive therapy. This could be because of additional systemic comorbidities including hypertension, dyslipidaemia, cardiovascular conditions, kidney illnesses, etc.^[6] After being diagnosed with diabetes, about 60–70% of people have at least one comorbidity, and 25–30% have more than two.^[7] So those systemic comorbidities have an impact on DR and DME.^[8]

Understanding the prevalence of systemic comorbidities in patients with DME is important because of-

- The effective management of DME requires a comprehensive approach that considers the patient's overall health and other diabetic-related diseases.
- The presence of systemic comorbidities influences the progression and treatment outcomes of DME.^[9]
- Identifying the common comorbidities can help in treatment plans.

Methodology

This is a retrospective study. The study was conducted according to the guidelines. A verbal approval was taken from the hospital authorities.

Study Participants:

Patients were included into the study from November 2023 to May 2024. The patients included must fall under the following criteria: (1) Age should be between 20 to 85 years; (2) Both male and female patients; (3) Confirmed diagnosis of diabetes mellitus type 1 or type 2 and DME patients and (4) DM and DME patients with other confirmed systemic comorbidities were included. The patients having other significant retinal diseases, such as ARMD, BRVO, and CRVO patients or who have undergone intraocular surgery within the last three

months or have severe systemic diseases such as advanced malignancies and severe heart failure were excluded from the study.

Methodology:

In this study, a total of 150 medical records from the last year were screened at ASG Eye Hospital, BT Road, Kolkata. Among 150 patients, 54 were diagnosed with DME. Among these 54 patients, the prevalence of systemic comorbidities such as HTN, CVD, CKD, dyslipidaemia, etc. was assessed.

For confirmation of DME, OCT was assessed. Among 54 patients, systemic comorbidities such as HTN, CVD, CKD, and dyslipidaemia were assessed. The systemic comorbidities were confirmed after seeing the supportive documents.

Data Collection:

Demographic data as well as general, medical and ophthalmological history were collected at study enrolment. In addition, a comprehensive clinical examination (OCT) was performed for confirm diagnosis of DME and DR.

Statistical Analysis:

The demographic and clinical data were collected, coded and entered in Microsoft Excel Sheet. Statistical analysis was performed using Primer of Biostatistics Version 7.0 and result was represented in tabular and graphical format using descriptive analysis.





Results

Data on 89 subjects were listed among the 150 searched subjects in the age range of 20 to 85 years old were collected from the medical records. The mean $\pm$ SD of age is 60.28 ± 9.319 years. Among the 89 participants, 35 were excluded as they had no DME. Among the 54 subjects, 29 were males (53.7%) and 25 were females (46.3%) [fig. 1]. 35.2% of patients were diagnosed with type I diabetes, whereas 64.8% had type II diabetes. Hence, the prevalence of type II diabetes was seen to be higher than that of type I. HbA1c values $>6.5\%$ were seen in 18 patients (33.33%), 5.7 to 6.5% were seen in 28 patients (51%), and $<5.7\%$ were seen in 8 patients (14.8%) [fig.2]. Among the subjects, all the patients had a diagnosis of DME. Descriptive analysis was performed [table 1], and

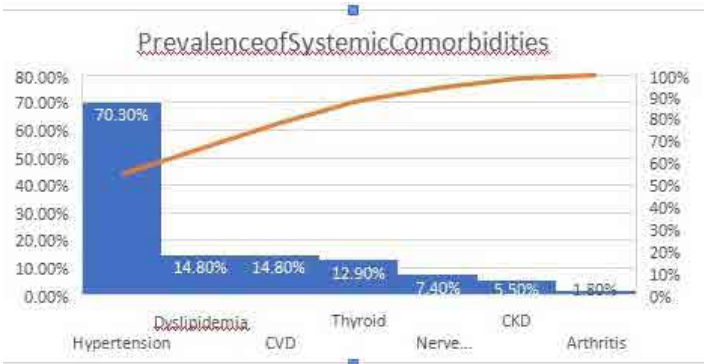


Fig. 2: HbA1c distribution 54 patients

it was found that 70.3% (38 patients) had HTN, 14.8% (8 patients) had dyslipidaemia, 14.8% (8

patients) had CVD, 12.9% (7 patients) had TSH, 5.5% (3 patients) had CKD, and 7.4% (4 patients) faced with nerve-related problems, and arthritis was 1.8%.

Systemic Comorbidities	No. Of Patients	Percentage Of Patients (%)
HTN	38	70.3
Dyslipidaemia	8	14.8
CVD	8	14.8
TSH	7	12.9
Neurological Problem	4	7.4
Arthritis	4	7.4
CKD	3	5.5

Table 1 : Descriptive analysis of systemic comorbidities patients associated with DM

All patients with DM had at least one associated comorbidity, and 35% had more than one associated comorbidity. It was seen that systemic comorbidities are associated more with type II diabetes.

Discussion

Patients with DME frequently suffer from multiple systemic comorbidities, which complicate their overall health and the management of their eye condition. A study based on 'Current epidemiology of diabetic retinopathy and diabetic macular edema' by Jie Ding found that diabetic retinopathy (DR) affects one-third of diabetic patients, with prevalence increasing with diabetes duration, hyperglycaemia, and hypertension, a common risk factors. Dyslipidaemia is a more significant risk factor for DME, impacting up to 7% of diabetics.^[5] And our study is revealed the high prevalence of HTN in patients with diabetic macular edema and the low prevalence of arthritis. And this study also shows that dyslipidaemia is also a common systemic condition with a high prevalence in diabetic macular edema patients. Our study revealed that all

patients with DM had at least one associated comorbidity, and 35% had more than one comorbidity. A study by Kristy Lglay et al. revealed that majority of patients with T2DM always associated with multiple comorbidities.^[8] Also, a lancet study showed that T2DM is most common factor that associated with other systemic comorbidities.^[1] Infect, our study is also showed that the prevalence of type II diabetes is higher than that of type I diabetes. It was seen that systemic comorbidities were associated more with T2DM.

Conclusion

Diabetes mellitus significantly impacts patients with diabetic macular edema (DME), leading to systemic comorbidities like cardiovascular disease, hypertension, chronic kidney disease, dyslipidaemia, and neuropathy. This necessitates a multidisciplinary approach to care, addressing both ocular and systemic health issues. Effective control of blood glucose, blood pressure, and lipid levels is crucial, along with regular screening for cardiovascular, renal, and neurological complications. Coordinated care involving ophthalmologists, endocrinologists, cardiologists, and nephrologists can optimize outcomes for DME patients.

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Factors Influencing Career Choices in Optometry Among Students in Northeast Tripura, India

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Abstract

Background: This study aimed to discover the elements that influenced Northeast Tripura optometrist students' decisions to pursue optometry as a profession. We conducted this research to determine what goes on within the minds of young teenagers that leads them to choose optometry as their career path. Using Google Forms and census sampling, we were able to collect responses from 108 Bachelor of Optometry students from 1st to 3rd years of the programme. Data were captured and analysed with the statistical programme of social sciences (SPSS) latest version 27. 100 students from the school of optometry took part. The mean age of the student was 20.39 years (SD= 1.014). Of 100 students, 64% were female and 36 % were male. Females were much more likely than males to be influenced by all of the factors. In general, over 82% of respondents cited a desire to serve others, a good wage and professional status, and employment availability as the most relevant considerations in choosing an optometry career. The major two determinants for getting a job after finishing a course were participation in induction and subject passes and points acquired in each year. Females were more likely to

pursue a profession in optometry than males. The main factors that prompted me to pursue optometry were job availability after graduation, a solid income and job prospects, and a flexible work schedule. Service to others in the community was a significant motivation for young Indians to pursue a career in optometry.

Introduction

Choosing a career is important for moulding one's life (Kulkarni & Abhilasha, 2020). Professional choices have a significant impact on an individual's chosen profession and overall success in life (Kobia-Acquah et al., 2020). Incorrect professional decisions can have serious consequences in an individual's life; hence, most people exercise caution while choosing a career path (Kobia-Acquah et al., 2020). It affects not only success and prosperity but also people's level of satisfaction (Kulkarni & Abhilasha, 2020). Yet, there is a complicated interaction of elements such as a person's psychological makeup, societal expectations, employment availability and personal ethos that can impact an individual's career selection (Kobia-Acquah et al., 2020). Professional decisions made by health professionals such as optometrists affect not only the individual but also society and the country as a whole (Kobia-Acquah et al., 2020). Together with traditional medical fields, paramedical studies are becoming more and more popular among prospective students (Kulkarni & Abhilasha, 2020). There are numerous different paramedical fields, including technology used in medical labs, dialysis, radiography, operating rooms, optometry, and audiometry, among many others. Skilled personnel, who work under the direction of the medical specialist, are in high demand in the healthcare system (Kulkarni & Abhilasha, 2020).

Since the opening of the first school of optometry in 1958, optometry in India has advanced significantly in terms of both education and service provision. Optometry is recognised as a main eye care profession in many parts of the world and is included in laws governing health care. Optometry is not yet recognised in India as a primary eye care profession on its own. The scope of optometry practise differs from nation to nation, and it is ill-defined in India (Arvind et al.,

2021). Optometry as a profession and optometric education in Africa have advanced rapidly in recent years, with a growing number of optometry schools being created across the continent (Kobia-Acquah et al., 2020). Optometry is a healthcare specialty that encompasses examining the eyes and relevant visual frameworks for anomalies, as well as correcting refraction errors with spectacles or contact lenses and treating eye infections (Osugwu et al., 2014). Traditionally, the field of optometry began with the primary focus of correcting refraction faults through spectacles (Osugwu et al., 2014). However, advanced optometry has evolved over time, and the educational curriculum now includes important preparation for the diagnosis and therapy of ocular disorders in the majority of the countries where this occupation is established and regulated (Osugwu et al., 2014). Optometry students in their clinical years frequently confront difficulty in deciding whether to pursue a profession in or outside of optometry (Kobia-Acquah et al., 2020). Optometry careers can be practice-oriented (with or without additional optometry interests) or non-practice-oriented (academic, research, and industrial optometry)

(Kobia-Acquah et al., 2020). Others, however, may pursue their hobbies and interests in subjects such as humanities, medicine, business administration, and law (Kobia-Acquah et al., 2020). Career options, residency length, and work-life balance have all been documented to have a substantial impact on medical students' career decisions (Kobia-Acquah et al., 2020). In the ordinary practice of ophthalmology, an optometrist is frequently the patient's first point of contact (Kulkarni & Abhilasha, 2020). The optometrist is trained to use ophthalmological tools like vision drums and more complex ocular scans, perform ocular exams, prescribe optical corrections like glasses or contact lenses, assist the ophthalmologist in the operating room, and conduct community-based eye check-up camps for visual rehabilitation (Kobia-Acquah et al., 2020). According to the World Council of Optometry, Indian optometrists possess a high level of training and competence. They operate in a range of settings, including academic institutions, optical retail stores, hospitals, and clinics, as well as in marketing,

administration, and independent private practises . In all, these statistics demonstrate that India accounts for around 19.6% of the world's optometrists (Venugopal et al., 2021).

According to the most recent data on the extent of vision impairment worldwide, there will be 38.5 million blind people and 237.1 million people with moderate to severe visual impairment by the year 2020 (Gyawali & Bhayal, 2019). According to estimates, 1.5% of Eritreans are blind, and another 10.5% have moderate to severe vision impairment (Gyawali & Bhayal, 2019). Similar to the general trend, uncorrected refractive error (18.1%) and cataract (56.3%) are the two main contributors to overall vision impairment in Eritrean adults (Gyawali & Bhayal, 2019). Two thirds of those who are visually impaired may regain good sight if these two major sources of vision impairment were prioritised and control techniques were used uniformly over the world. However, research have revealed that both the general adult population and visually impaired children in Eritrea have a high percentage of unmet refractive correction needs (Gyawali & Bhayal, 2019). Some of the reasons why Eritreans have a very low met need of spectacles for refractive errors have been cited include lack of awareness, lack of services, and expensive expenses of spectacles (Gyawali & Bhayal, 2019). India, which has 1.3 billion people, has 9000 optometrists who have completed a four-year optometry degree programme and 40 000 ophthalmic technicians and assistants who have completed a two-year diploma programme in ophthalmic training. Nearly all developed nations with optometry as a recognised profession (including the United States, United Kingdom, Australia, and Canada) place limitations on who is allowed to conduct eye exams and who is allowed to prescribe and dispense optical devices. There are no such limitations in India because there is no regulatory agency that oversees the provision of optical devices or optometric eye care. India offers two-year certificate and four-year degree programmes in optometry (Arvind et al., 2021). The India Vision Institute report estimates that there are about 49,000 optometrists who are now in practice and 164 institutes that offer optometry education in India (Venugopal et al., 2021). According to the WCO, there are around 358 training institutions and 250,000

optometrists worldwide (Venugopal et al., 2021). According to these statistics, India accounts for 19.6% of all optometrists worldwide (Venugopal et al., 2021). However, the percentage may be exaggerated given that only 70 out of the 358 known optometry organizations worldwide collaborate with WCO (Venugopal et al., 2021). Although being a long-standing profession, optometry is not well accepted in many nations (Venugopal et al., 2021).

With more optometry schools opening up across the continent in recent years, optometry as a profession and optometric education in Africa have advanced gradually (Kobia-Acquah et al., 2020). In Africa, optometry degrees are offered through either a six-year program that results in the award of a Doctor of Optometry (OD) degree or a four-year program that results in the award of a Bachelor of Optometry (B.Optom) degree (Kobia-Acquah et al., 2020). Just the Kwame Nkrumah University of Science and Technology (KNUST) and the University of Cape Coast (UCC) in Ghana currently offer the curriculum, which results in the award of an OD degree. (Kobia-Acquah et al., 2020). The curriculum must be created in a way that will inspire each student to learn the necessary skills and to perform them in a way that will support the continued growth of the optometry profession (Kulkarni & Abhilasha, 2020). Number of Optometry colleges in India are-

S. No	State	No. of Institutes
1	Andhra Pradesh	7
2	Assam	3
3	Bihar	4
4	Chhattisgarh	1
5	Gujarat	9
6	Haryana	2
7	Jammu and Kashmir	1
8	Jharkhand	1
9	Karnataka	7
10	Kerala	20

11	Madhya Pradesh	5
12	Maharashtra	23
13	Meghalaya	2
14	Nagaland	1
15	Punjab	2
16	Rajasthan	3
17	Tamil Nadu	18
18	Telangana	5
19	Tripura	1
20	Uttar Pradesh	18
21	Uttarakhand	1
22	West Bengal	14
	Total	149
S. No	Union Territories	
1	Chandigarh	3
2	Delhi	12
	Total	15
	Total no. of institutes in India	164

An increasing number of students are considering optometry as a career due to an increase in awareness regarding early treatment of refractive error, selecting trendy corrective alternatives, and the growth of optical stores, eye hospitals, and optometry schools. (Kulkarni & Abhilasha, 2020). The future of optometric education and practice in Ghana and the delivery of eye services in the nation are all impacted by the career objectives of Ghana's optometry students, even though they are purely personal. (Kobia-Acquah et al., 2020).

Number of optometry colleges in Northeast region are-

S. No	State	No. of Institutes
1	Arunachal Pradesh	3

2	Assam	3
3	Manipur	1
4	Meghalaya	2
5	Mizoram	1
6	Nagaland	1
7	Tripura	1
8	Sikkim	1

We were unable to locate research that examined variables influencing optometry as a profession choice or the type of educational institution in Northeast Tripura.

These studies are crucial because there are many variables that affect a student's decision to enroll in a course in a certain nation, and the institutions that offer the program would benefit from knowing these details (Mashige & Oduntan, 2011). An increasing number of students are considering optometry as a career due to an increase in awareness regarding early treatment of refractive error, the selection of trendy corrective alternatives, and the growth of optical stores, eye hospitals, and optometry schools. This study was carried out by the authors to investigate the factors that affected optometry students' decision to pursue it as a career in a Northeast Tripura.

Methodology

The questionnaire-based, cross-sectional study was conducted among the optometry students at Tripura Institute of Paramedical College, after carrying from the council authority. The study was followed by the Amity university Haryana and participants were enrolled after taking informed concurrence.

The questionnaire was distributed by first-year to third-year Tripura Institute of Paramedical College Optometry students and subsequently modified for easy understanding. Included in this study were all 108 students who were registered for the 2019-2022 academic year at the one , optometry college at Tripura Institute of Paramedical College. But successfully completed 100 students who click all questionnaire columns.

A questionnaire on the demographic such as Name, Age, Gender, Email, Year of students and factors (Impression about the course, Job opportunities after graduating, optometry for a social cause, personal gratification from choosing this career and others) that might have influenced their choice of career and institution of learning was used for data collection.

Participants

The study population included all registered first year to Third year optometry students in one institute at TIPS. For the quantitative component, the study sample (N=108) comprised First year to Third year optometry students registered at Tripura Institute of Paramedical Sciences. There were 100 registered optometry students in one institution at the time of this study and all were included in the study those who went for internship purposes that data has to exclude.

Data gathering

Following permission from the heads of the departments of optometry to conduct the survey, questionnaires were distributed in the institution to the graduating optometry students who agreed to participate in the study. The completed questionnaires from the institution were collected by the students.

Time Frame:

The current study was carried out from July 2022 to May 2023.

Sample Size: 100

Inclusion Criteria:

Participants in this study and birth place are only from Tripura and only optometry students are allowed to be a part of this study.

Exclusion Criteria:

Optometrists from other states and other institutes were not included in this study.

Results

Data Analysis:

Data were captured and analysed with the statistical programme of social sciences (SPSS) latest version

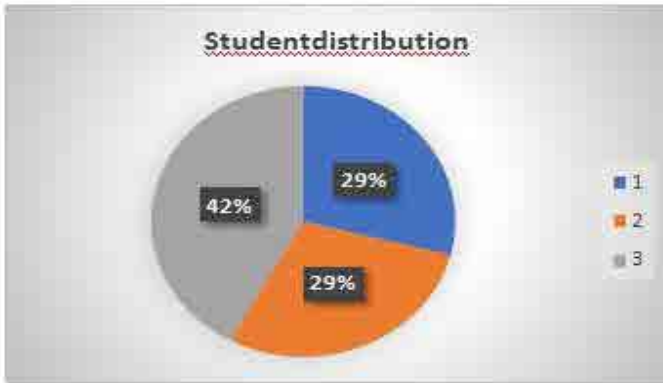
27. Descriptive statistics were used to analyse values such as Frequencies, mean, standard deviation and percentage of collected data. Person Chi-square and NPar test was used to analysis association between relevant variables.

Statistical Analysis:

All the data were analysed using SPSS software. Data were normally distributed. Kolmogorov test was employed to check the normality of the data. Descriptive statistics were used to analyse the data.

Demographic data:

100 students from the school of optometry took part. The mean age of the student was 20.39 years (SD= 1.014). Of 100 students, 64% were female and 36 % were male. Graph 1 shows the demographic breakdown of the student body.



1. 1st year

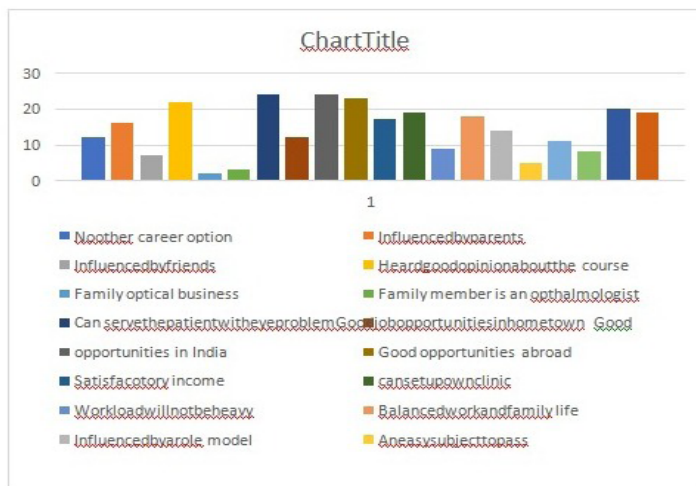
2. 2nd year

3. 3rd year

Factors influencing the choice of optometry: The graph-2 depicts the reported reasons given by 100 students for enrolling in the optometry programme.

Impression about the course:

72% of the class was exposed to the course's positive aspects. Over half of the students were agnostic as to whether or not the course was well-liked at their institution, while 32% wholeheartedly agreed. Around 32% of the student body felt they were stuck with their limited career possibilities. 9% of students said it was an easy course to succeed in. Here first year students 65% of the class was exposed to the course's positive aspects and second year students 68% of the class was exposed to the course's



positive aspects and third year students 81% of the class was exposed to the course's positive aspects Shown as figure 1,2,3.

Job opportunities after graduating:

Optometry was chosen as a profession by 38% of respondents because they believed there would be strong work prospects in their hometown, 74% because they believed there would be good job possibilities overseas, and 77% because they believed there would be good job opportunities in India. Among those surveyed, 47% thought an optometry degree may lead to a good wage or income, while 45% were unsure. Just 9% became optometrists because they felt obligated to join the family business. Here first year students 80% because they believed there would be good job possibilities overseas, and 75% because they believed there would be good job opportunities in India and secondary year students 75% because they believed there would be good job possibilities overseas, and 70% because they believed there would be good job opportunities in India and third year students 67% because they believed there would be good job possibilities overseas, and 86% because they believed there would be good job opportunities in India.

Optometry for a social cause:

The majority of participants (74%), therefore, believe they can help those with eye problems. 64% percent were confident that they could become doctors and help people. The majority (62%) of people who wanted to be eye surgeons didn't. However, 40% of respondents did not have a strong opinion either way. Here First year students 85% therefore, believe they can help those with eye problems, second year students 80% therefore, believe they can help those with eye problems and also third year students 57%, therefore, believe they can help those with eye problems.

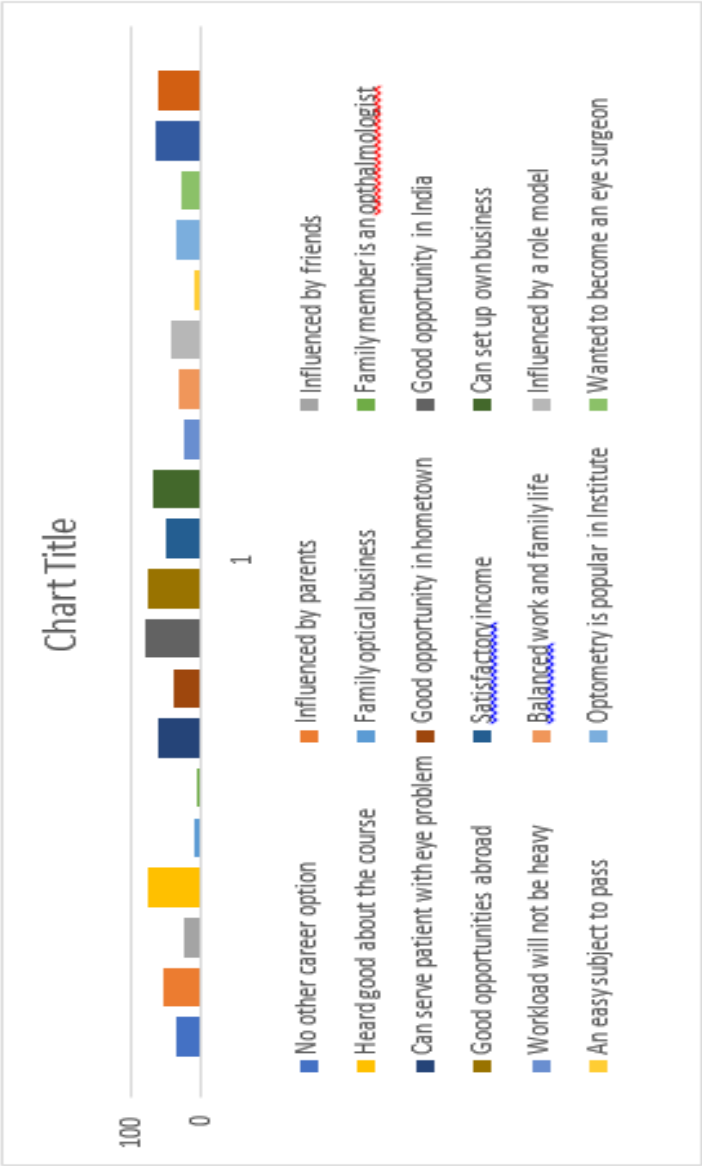
Personal gratification from choosing this career:

A plurality of students, 43%, think that an optometry job is a good way to maintain a healthy work-life balance. While 42% of respondents were agnostic about whether or not optometry practice involved a demanding burden, 34% strongly disagreed. Over 60% of respondents believed that optometry is an honourable profession. Here first year students 35%, think that an optometry job is a good way to maintain a healthy work-life balance, second year students 41%, think that an optometry job is a good way to maintain a healthy work-life balance and also third year students 53%, think that an optometry job is a good way to maintain a healthy work-life balance.

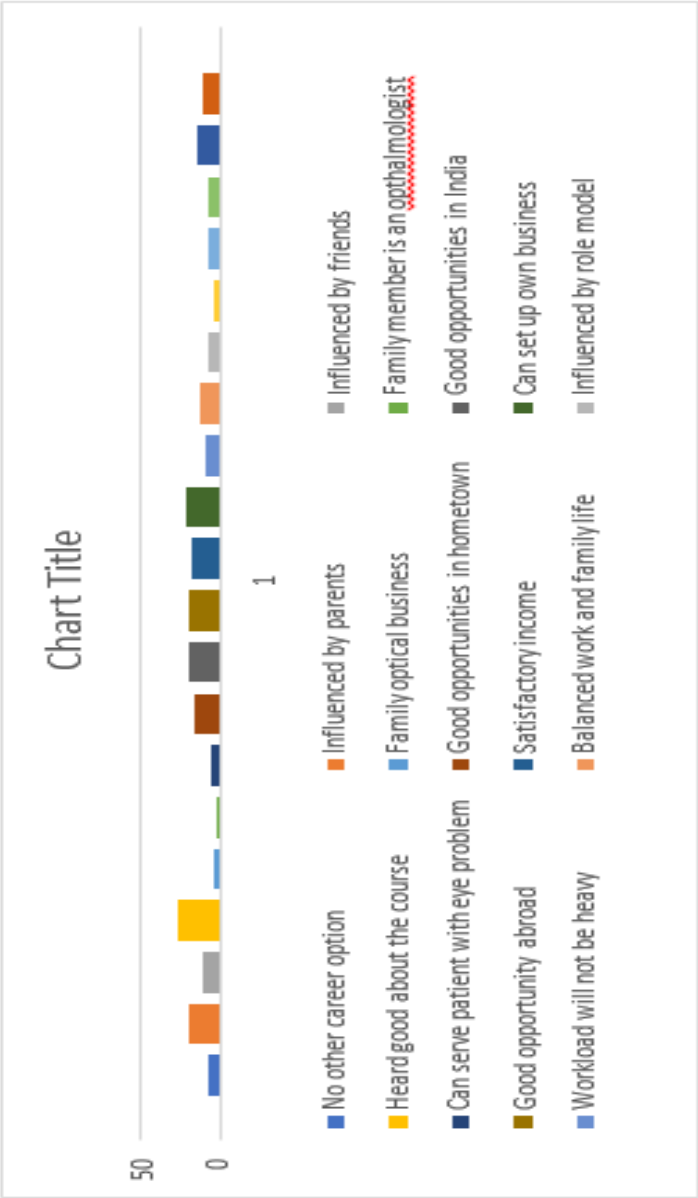
Other influences:

There were parental influences on 52% of students who enrolled in this course. In terms of professions, 39 percent have an optometrist role model. Family members who are ophthalmologists were affected only 4%, and friends only 6%. Here first year students There were parental influences on 70% of students who enrolled in this course here second year students There were parental influences on 61% of students who enrolled in this course and also third-year students There were parental influences on 25% of students who enrolled in this course.

First-year students:
Figure 1



Second-year students:
Figure 2



Third-year -year students:
Figure 3

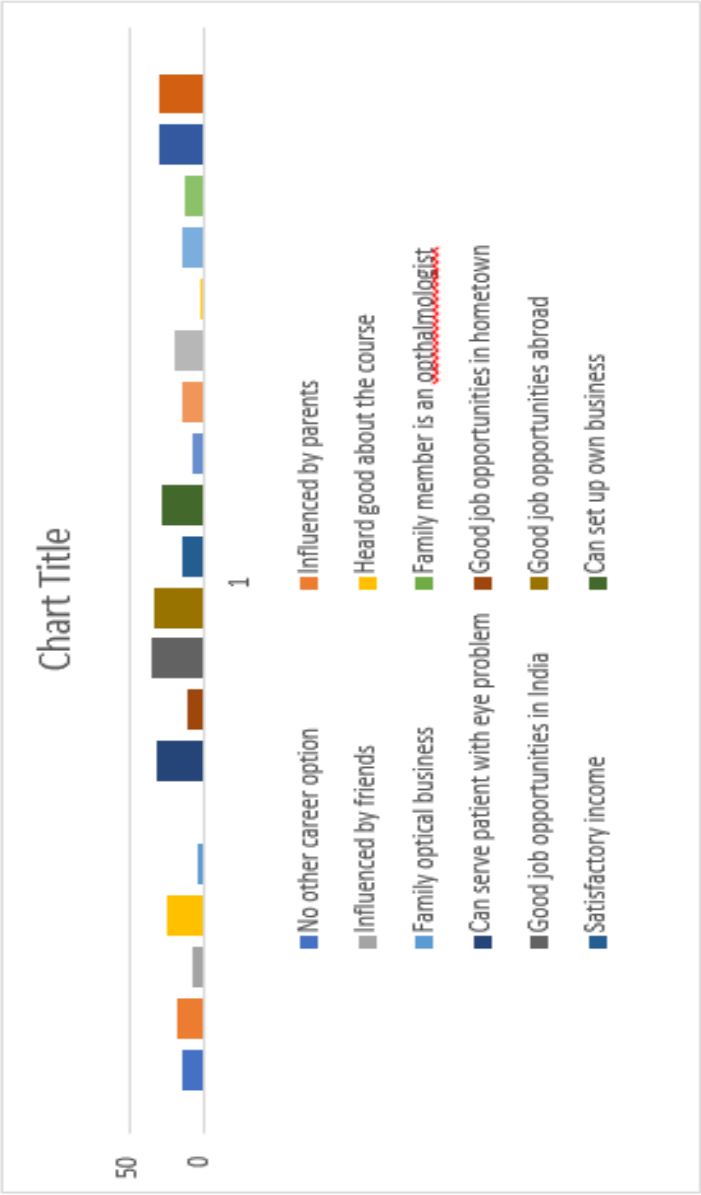


Table:1

Sl no	Questionnaire	1 st year Mean, SD and percentage			2 nd year Mean, SD and percentage			3 rd year Mean, SD and percentage		
		Mean	SD	Percent	Mean	SD	percent	Mean	SD	Percent
1	Because you had no other option left	3.62 0689 66	1.44 9477 57	72.4 1379 31	3.0714285 71	1.1524071 88	59.310 34483	3.119047 62	0.9927144 6	62.38095 24
2	Because you were told by your parents/elders/teachers to do so	2.37 9310 3	1.59 0458	47.5 8620 7	2.6206896 55	1.0827805 84	52.413 7931	2.928571 429	0.9726217 31	58.57142 857

3	Because your good friend chose to join this course	3.24 1379 31	1.43 0663 493	64.8 2758 621	3.6551724 14	1.2034433 36	73.103 44828	3.952380 952	1.0809296 12	79.04761 905
4	Because you heard good opinions about this course	3.24 1379	0.84 5154	40	2.2413793 1	0.8304547 99	44.827 58621	2.547619 048	0.8323455 24	50.95238 095
5	Because your family member has an optical shop/business	4.17 2413 79	1.03 7475 15	83.4 4827 59	4.1724137 93	0.7591802 68	83.448 27586	4.333333 33	0.9794639 3	86.66666 67
6	Because your family member is an ophthalmologist	4.68 an 9655 2	0.76 0800 7	93.7 9310 3	4.0344827 59	0.8653140 89	80.689 65517	4.476190 476	0.6339729 48	89.52380 952
7	So that you can serve patients with eye problems	2.20 6896 6	0.77 3642 1	44.1 3793 1	2.1379310 34	1.1869570 32	42.758 62069	2.285714 29	1.0189835 8	45.71428 57

8	Because there are good job opportunities in your hometown	2.51 7241	0.87 0988	50.3 4483	2.9310344 83	0.9610646 81	58.620 68966	3.095238 1	0.9320714 9	61.90476 19	
9	Because there are good job opportunities in many places in India	2.24 1379 31	0.63 5563 44	44.8 2758 62	2.1379310 34	0.9533451 61	42.758 62069	2.095238 1	0.7904776	41.90476 2	
10	Because there are good job opportunities abroad	2.17 2413 8	0.80 4849 8	43.4 4827 6	2.1379310 34	0.7894002 21	42.758 62069	2.071428 571	2.0969387 76	41.42857 143	
11	Because the salary/ income from this profession is satisfactory	2.41 3793 1	0.77 9983 6	48.2 7586 2	2.6206896 55	0.9788401 7	52.413 7931	2.714285 714	0.8050364 11	54.28571 429	

12	So that you can set up your own business	2.06 8965 52	0.79 8705 85	41.3 7931 03	2.3448275 86	0.9364012 44	46.896 55172	2.333333 333	0.9794639 32	46.66666 667
13	Because the workload will not be too heavy like other professions	2.79 3103 45	0.67 5029 65	55.8 6206 9	3.2068965 52	1.0134562 63	64.137 93103	3.333333 333	0.8164965 81	66.66666 667
14	Because work and family life can be balanced well	2.62 0689 66	0.56 1489 93	52.4 1379 31	2.5517241 38	0.9097176 52	51.034 48276	2.738095 238	0.6647766 47	54.76190 476
15	Because you have a role model who is an optometrist	3.55 1724	1.21 2618	71.0 3448	3	1.1019463 3	60	2.952380 952	1.0109734 73	59.04761 905
16	Because optometry is an easy subject to pass	3.48 2759	0.82 8971	69.6 5517	4	1.0886621 08	77.241 37931	3.976190 476	0.7152722 57	79.52380 952

17	Because optometry in this institution is popular	2.75 8621	0.57 6639	55.1 7241	2.9655172 41	1.0850529 49	59.310 34483	2.952380 952	0.9358022 76	59.04761 905
18	Because you wanted to become an eye surgeon and you couldn't	3.37 931	0.97 884	67.5 8621	3.1034482 76	0.9763206 29	62.068 96552	3.166666 667	0.9348709 75	63.33333 333
19	So you can handle eye patients just like a doctor	2.41 3793	0.68 2288	48.2 7586	2.4482758 62	0.9481638 98	48.965 51724	2.119047 619	0.6699974 86	42.38095 238
20	Because an optometrist gets lot of respect in the society	2.68 9655 17	0.54 1390 29	53.7 9310 34	2.4482758 62	1.0207212 75	48.965 51724	2.214285 714	0.7819835 41	44.28571 429

Discussion

In this institution, there were 64 percent of optometry students who were female, which is likely a result of the gender dynamics of the community. According to a study of young children's job expectations, paramedical fields were among the top 20 occupations, and middle-class girls were more likely to pick paramedical fields than boys. Due to the fact that technology seems to be a more male-dominated field of work, a survey conducted in the Netherlands found that only 17% of students are female who are enrolled in technology courses (Kulkarni & Abhilasha, 2020). The purpose of this research is to better understand the motivations of young adults who decide to pursue optometry as a profession. Optometrists are drawn to the pitch because they want to make a difference in people's lives, and the profession has a strong reputation because of this. The majority of male and female respondents also rated job security, salary growth possibilities, independence at work, and attendance at the induction day highly. The gender role in our society may be reflected in the fact that girls predominated in our study, encouraging women to pursue higher education. Additionally, according to the American Optometry, there will likely be a steady growth in the number of female optometrists (Kulkarni & Abhilasha, 2020).

There are several aspects to consider before choosing a career (Kobia-Acquah et al., 2020). Our study shown that a variety of factors, including the course content, employment prospects, societal causes, aspirations for oneself, and peer pressure, had an impact on pupils. The majority of students (72%) made their career decisions with the overall impression of the course, which was influenced by a number of factors. Even though very few people thought it was an easy subject and very few people were swayed by the organisation that oversees the course, this nonetheless happened (Kobia-Acquah et al., 2020). The hospital infrastructure and working atmosphere, however, had an impact on nearly 90% of students and graduates of medical technology courses in another study conducted in Pune. The explanation for this gap could be due to the diversity of the demographic and social groups (Kobia-Acquah et al., 2020).

In our study, it was shown that 29% of participants chose optometry as their career since they had no other options. This percentage was comparable to the South African study from 2011 where 29.5% of respondents selected optometry for a related reason (Kobia-Acquah et al., 2020). In order to ensure that even students who enrol in a course against their will do so with enthusiasm and motivation, it is crucial that educational institutions and teachers carefully plan and implement their curricula (Kobia-Acquah et al., 2020). This might lower student dissatisfaction and course drop-out rates (Kobia-Acquah et al., 2020).

According to our research, job opportunities outside of India (74%) have a significant impact on students' decisions to major in optometry. This was comparable to a study done in Ghana, where 90% of optometry students enrolled in the programme because there were jobs available (Kobia-Acquah et al., 2020). Students are more attracted to employment opportunities outside of India (74%) than inside of India (77%), which is similar to the trend of skilled workers, particularly women, migrating to Middle Eastern countries for employment and supporting the Kerala model of economy (Kobia-Acquah et al., 2020). In Karnataka, a similar pattern has begun to emerge (Kobia-Acquah et al., 2020).

In our study, 47 percent of participants said they could start their own firm, and 9% said they had an optical-related family business. According to an Indian research, even though many of them had numerous jobs, one-third of optometrists worked in optical stores (Kulkarni & Abhilasha, 2020). Optical stores are thriving throughout India. A career in optometry would give them the chance to help people with eye problems, according to 74% of the students (Kulkarni & Abhilasha, 2020). Other studies in Ghana and South Africa (92.5%) have found the desire to help others as a motivation in choosing optometry as a vocation (89.2%) (Kobia-Acquah et al., 2020). Serving a person who has vision issues is regarded as a noble, altruistic duty because vision is a particularly prized "special sense" and is much lacking in our society (Kulkarni & Abhilasha, 2020). In our study, 40% of participants had unfulfilled aspirations to become eye surgeons, whereas 62%

thought they could serve in a medical capacity. Their desire to contribute to society is evident from this. Many optometrists have this as their ultimate goal, and the Indian eye care sector also needs more optometrists to fill open positions (Kulkarni & Abhilasha, 2020).

Optometry is seen to give a healthy work- life balance and is applicable for women because they constantly wish to have a job while still playing an important part in their families (Mashige & Oduntan, 2011). Other variables that told the decision to pursue optometry included advice from elders, part models, and ophthalmologists in the family and among familiarity (Mashige & Oduntan, 2011). According to studies, kiddies' profession choices are heavily told by their families, part models have a good impact on professional development because they effectively increase thing and work engagement (Mashige & Oduntan, 2011).

According to our findings, the choice of optometry course is multifaceted and comprises personal objectives, course nature, job chances and income, and individual factors as indicated in other studies (Venugopal et al., 2021). After appropriate academic and clinical exposure to eye care, optometry students' perceptions of their profession changed (Venugopal et al., 2021). In addition, the students stated that their family members, relatives, and friends viewed the profession favourably once they enrolled in the course, as opposed to their previous perception (Venugopal et al., 2021). After beginning the course, students encountered numerous parts of optometry coursework, which led them to learn about future scopes and practise patterns in optometry. To the best of our knowledge, no research have shown changes in perception of optometry among students seeking the profession (Venugopal et al., 2021). According to a research by Thite et al.⁶, Indian optometrists were active in a variety of services at eye hospitals, optical stores, and community outreach programmes (Venugopal et al., 2021). These findings are similar to ours; nevertheless, the retrospective perspective of optometry revealed conflicting responses, indicating a lack of basic awareness of optometry practise (Venugopal et al., 2021). Furthermore, senior optometry students had a higher

grasp and knowledge of the employment options, spectrum of vision care services, and scope of practise than their junior counterparts (Venugopal et al., 2021). This implies that optometry students require adequate exposure and guidance to diverse eye care services throughout the curriculum in order to appreciate the larger viewpoint of optometry (Venugopal et al., 2021). Similarly, the literature reveals that senior students and optometrists with better academic degrees have more understanding about the diversity of practise patterns and the relevance of a multidisciplinary approach, indicating the importance of increased exposure (Venugopal et al., 2021). These findings emphasise the importance of education and optometry qualification in comprehending the profession's functions (Venugopal et al., 2021). According to our findings, the choice of optometry course is multifaceted, with personal objectives, the nature of the course, job chances and remuneration, and individual influences all playing a role, as indicated by other studies.

Conclusion

Females appear to prefer optometry as a career option more than boys (Kulkarni & Abhilasha, 2020). Personal objectives, the nature of the course, work chances and economic rewards, and individual influences are all factors affecting the choice of optometry as a career (Kulkarni & Abhilasha, 2020). Optometry students in Ghana desire primarily to work in clinical practice, with psychosocial motivation or personal factors (interest in a job field) having the largest influence on their career choices. Furthermore, practical motivations such as possible good salary, flexible working hours, and employment availability had a significant impact on profession choice (Kobia-Acquah et al., 2020). Factors such as a student's selection of optometry as an initial program of study during the university admission process have little bearing on optometry students' career goals in Ghana (Kobia-Acquah et al., 2020). It is proposed that institutions that offer optometry degrees improve their awareness campaigns in high schools in provinces where no universities offer the optometry degree (Osuagwu et al., 2014). This can be accomplished by establishing coordinated career awareness programs and recruiting

efforts between optometry departments and high schools in such jurisdictions (Osuagwu et al., 2014). It is proposed that institutions that provide optometry degrees expand their awareness initiatives in high schools in provinces where no universities offer the optometry degree (Osuagwu et al., 2014). This study demonstrates the significant importance of psycho-social motivation or personal considerations (such as a desire to serve others, acting on one's own initiative, and views of a career's status and prestige) in selecting optometry as a profession (Osuagwu et al., 2014). Furthermore, practical factors such as employment availability, topics passed and points acquired in matric, the possibility of earning a good pay, and a flexible work schedule were major influencers on career choice (Osuagwu et al., 2014). Traditional techniques of enticing potential students, such as career or open days, and media, on the other hand, were not evaluated highly in this study (Osuagwu et al., 2014). As a result, it is advised that institutional marketing techniques be expanded to incorporate additional new strategies such as seminars in which guidance counsellors and teachers interact more with students (Osuagwu et al., 2014). It is proposed that institutions that offer optometry degrees expand their awareness campaigns in high schools in provinces where no universities offer optometry degrees (Osuagwu et al., 2014). This can be accomplished by collaborating on career awareness programs and recruitment efforts between optometry departments and high schools in such provinces]

Limitation: The study is only performed in one city, only one institute students are included in this study.

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Ocular surface disease: allergy, biomarkers, diabetes, keratoconus, obesity and nutrition

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Abstract

Ocular surface disease (OSD) encompasses a range of disorders affecting the cornea, conjunctiva, and tear film. This complex condition is influenced by a multitude of factors, including allergy, biomarkers, diabetes, keratoconus, obesity, and nutrition. Recent studies have highlighted the significant impact of allergies on OSD, with allergic conjunctivitis and atopic keratoconjunctivitis contributing to chronic ocular inflammation and tear film instability. Biomarkers, such as inflammatory cytokines and tear film proteins, have emerged as valuable diagnostic tools for OSD. Diabetes has been linked to an increased risk of OSD, with diabetic patients exhibiting altered tear film composition and reduced corneal sensitivity. Keratoconus, a progressive corneal disorder, has also been associated with OSD, with patients experiencing chronic eye irritation and vision disturbances. Obesity and nutrition have been identified as modifiable risk factors for OSD. A diet rich in omega-3 fatty acids and antioxidants may help mitigate OSD symptoms, while obesity has been linked to chronic inflammation and tear film instability. This review aims to provide a comprehensive overview of the complex interplay between OSD and various factors, including allergy, biomarkers, diabetes, keratoconus, obesity, and nutrition. By elucidating these relationships, clinicians can develop more effective treatment strategies and improve patient outcomes for this debilitating condition.

Introduction:

Ocular surface disease refers to a group of conditions that affect the surface of the eye, including dry eye, blepharitis, and meibomian gland dysfunction. These conditions can cause symptoms such as redness, irritation, and blurred vision, leading to discomfort and decreased quality of life for those affected. Proper diagnosis and treatment are essential to managing ocular surface disease and preserving eye health in the long term(1,2).

One key aspect of managing ocular surface disease is identifying the underlying cause of the condition. Dry eye, for example, can be caused by a variety of factors, such as environmental conditions, hormonal changes, or certain medications. By pinpointing the specific cause of the disease, healthcare providers can tailor treatment plans to address the root issue and provide targeted relief for patients. Additionally, ongoing monitoring and follow-up care are crucial in managing ocular surface disease, as symptoms may fluctuate over time and require adjustments to treatment plans (3,4). Regular eye exams and communication with healthcare providers can help ensure that individuals with ocular surface disease receive the most effective care possible.

Factors such as environmental irritants, aging, hormonal changes, and underlying health conditions can all play a role in the development and progression of ocular surface disease. Lifestyle factors, such as prolonged use of digital devices or contact lens wear, can also exacerbate symptoms. By identifying and addressing these contributing factors, healthcare providers can help patients better manage their condition and improve their overall eye health. Additionally, education on proper eye care practices and the importance of regular follow-up appointments can empower patients to take control of their ocular surface disease and prevent future complications(5).

In some cases, treatment may involve prescription eye drops or ointments to reduce inflammation and promote healing of the ocular surface. In more severe cases, procedures such as punctal occlusion or amniotic membrane transplantation

may be necessary to improve symptoms and prevent further damage. It is important for patients to work closely with their healthcare provider to develop a personalised treatment plan that addresses their specific needs and concerns. By taking a proactive approach to managing ocular surface disease, patients can not only find relief from their symptoms but also protect their vision for the long term(6,7).

Importance of identifying biomarkers for early detection and treatment of ocular surface disease cannot be overstated. By identifying biomarkers that indicate the presence of the disease at an early stage, healthcare providers can intervene sooner and implement targeted treatments to prevent progression(7-9). This can lead to better outcomes for patients, reducing the need for more invasive procedures and preserving their vision. Research into biomarkers for ocular surface disease is ongoing, and continued efforts in this area promise to revolutionize the way this condition is managed in the future(10).

One promising avenue of research involves the study of inflammatory markers in tears, which have been shown to be elevated in patients with ocular surface disease. By measuring levels of these markers, healthcare providers may be able to identify at-risk individuals before symptoms manifest, allowing for early intervention. Additionally, advancements in imaging technology have enabled researchers to detect subtle changes in the structure of the eye that may be indicative of disease progression. By combining these approaches, healthcare providers can tailor treatment plans to each individual's specific needs, improving outcomes and quality of life for patients with ocular surface disease(11-13).

II. Allergy and Ocular Surface Disease:

Link between allergies and inflammation of the ocular surface has long been established, with allergic reactions often exacerbating symptoms of ocular surface disease. Understanding this link is crucial in developing effective treatment strategies that address both the underlying allergy and the resulting inflammation. By addressing both components simultaneously, healthcare providers can better

manage symptoms and improve overall quality of life for patients suffering from both allergies and ocular surface disease(14-16).

In addition to exacerbating symptoms, allergies can also increase the risk of developing ocular surface disease in individuals who are already predisposed to these conditions. Allergens such as pollen, dust mites, and pet dander can trigger an inflammatory response in the eyes, leading to redness, itching, and discomfort. This inflammation can then further compromise the health of the ocular surface, potentially leading to chronic conditions such as dry eye syndrome or conjunctivitis(17). Therefore, it is essential for healthcare providers to not only treat the symptoms of allergies and ocular surface disease but also to address the underlying causes in order to prevent further complications and improve long-term outcomes for patients(18-20).

Common symptoms of ocular allergies and their impact on overall eye health include watery eyes, swollen eyelids, and blurred vision. These symptoms can significantly affect a person's quality of life and ability to perform daily tasks. In addition, the constant irritation from allergies can weaken the eye's natural defense mechanisms, making it more susceptible to infections and other complications. By properly managing allergies and addressing the root causes, healthcare providers can help patients maintain healthy eyes and improve their overall well-being (21-23).

It is important for healthcare providers to educate patients on how to avoid allergens and to recommend appropriate treatments such as antihistamine eye drops or allergy medications. By taking proactive steps to manage ocular allergies, patients can experience relief from symptoms and reduce the risk of long-term damage to their eyes. Ultimately, addressing ocular allergies can lead to improved eye health and a better quality of life for patients (24-25).

Treatment options for managing ocular surface disease related to allergies may also include using artificial tears to help lubricate the eyes and reduce discomfort. In severe cases, patients may benefit from prescription medications such as

corticosteroids or immunomodulators to control inflammation and immune responses. Additionally, lifestyle modifications such as wearing sunglasses outdoors and keeping windows closed during high pollen seasons can help prevent allergens from exacerbating symptoms. By working closely with their healthcare providers and following personalized treatment plans, patients can effectively manage ocular allergies and maintain optimal eye health (26-28).

It is also important for patients to regularly clean their contact lenses and switch to daily disposables if they are prone to allergies. Avoiding rubbing the eyes and washing hands frequently can also help prevent irritation and infection. In some cases, allergen immunotherapy may be recommended to desensitise the immune system to specific triggers. Overall, staying proactive and informed about managing ocular allergies is key to maintaining clear vision and comfort (29-31).

III. Biomarkers for Ocular Surface Disease:

Biomarkers are measurable indicators that can help identify and monitor the presence of ocular surface disease. These can include specific proteins, enzymes, or genetic markers that are found in the tears or tissues of the eye. By analyzing these biomarkers, eye care professionals can better understand the underlying causes of the disease and tailor treatment plans accordingly. Using biomarkers can also help track disease progression and response to therapy, providing valuable information for both patients and doctors. In summary, biomarkers play a crucial role in diagnosing and managing ocular surface disease, leading to improved outcomes for those affected (32-34).

Furthermore, ongoing research in the field of biomarkers for ocular surface disease is continuously uncovering new markers that may further enhance diagnostic accuracy and treatment efficacy. By identifying and validating these biomarkers, clinicians can potentially revolutionise the way in which ocular surface diseases are diagnosed and managed. Additionally, the development of more targeted therapies based on specific biomarkers holds promise for personalised

medicine in the field of ophthalmology. As the field continues to advance, the integration of biomarker analysis into routine clinical practice may become standard, ultimately leading to better outcomes and quality of life for patients with ocular surface disease (35-37).

Current research on potential biomarkers for early detection and treatment of ocular surface disease is crucial for improving patient care and outcomes. By identifying specific biomarkers that are indicative of disease progression or response to treatment, clinicians can tailor interventions to individual patients, maximizing effectiveness and minimizing side effects. With ongoing research and advancements in technology, the future of ophthalmology looks promising in its ability to provide personalized and targeted care for those suffering from ocular surface diseases (38).

This personalised approach not only improves patient outcomes but also enhances the overall quality of care provided. Additionally, the use of biomarkers in the early detection of ocular surface diseases can lead to more timely interventions, potentially preventing further damage to the eye (39). As researchers continue to uncover new biomarkers and refine existing ones, the field of ophthalmology is poised to make significant strides in the diagnosis and treatment of these conditions. Collaborations between clinicians, researchers, and technology experts will be essential in driving these advancements forward and ultimately improving the lives of patients affected by ocular surface diseases (40,41).

By identifying biomarkers that can accurately predict the progression of ocular surface diseases, healthcare providers can tailor treatment plans to individual patients, leading to more effective management of their condition. This personalized approach can result in better outcomes and quality of life for those affected by these diseases. With ongoing research and collaboration, the future of ophthalmology looks promising in its ability to provide targeted and timely interventions for patients with ocular surface diseases (42,43).

In addition to personalised treatment plans, advancements in technology and surgical techniques are also contributing

to improved outcomes for patients. The development of new medications, such as anti-inflammatory drugs and immunomodulators, has shown promising results in managing symptoms and slowing the progression of ocular surface diseases. Furthermore, the use of minimally invasive surgical procedures, such as corneal transplants and amniotic membrane grafts, has revolutionised the field of ophthalmology and provided new options for patients with severe cases of these diseases. As research continues to expand our understanding of ocular surface diseases, the potential for even more innovative and effective treatments continues to grow (44,45).

Diabetes and Ocular Surface Disease:

Impact of diabetes on the ocular surface and risk of developing ocular surface disease is a topic of ongoing research and clinical interest. Patients with diabetes are at a higher risk for developing ocular surface diseases such as dry eye syndrome, diabetic retinopathy, and corneal neuropathy. The impact of diabetes on the ocular surface can lead to chronic inflammation, decreased tear production, and increased risk of infection. Early detection and management of ocular surface diseases in diabetic patients are essential to prevent vision loss and improve overall eye health (46).

Management strategies for individuals with diabetes to prevent ocular surface disease include regular eye exams, maintaining optimal blood sugar levels, using artificial tears or prescription eye drops as needed, and practicing good eyelid hygiene. It is also important for diabetic patients to follow a healthy diet, exercise regularly, and quit smoking to reduce their risk of developing ocular surface diseases (43-46). By taking proactive measures and working closely with their healthcare team, individuals with diabetes can protect their vision and maintain good eye health for years to come (47).

Regular eye exams are crucial for individuals with diabetes to monitor their eye health and catch any potential issues early on. These exams can help detect conditions such as diabetic retinopathy, glaucoma, and cataracts before they progress

and cause irreversible damage to the eyes. By staying on top of their eye health, diabetic patients can ensure that any problems are addressed promptly and effectively, ultimately preserving their vision and overall quality of life. So, it is vital for individuals with diabetes to prioritize regular eye exams as part of their overall healthcare routine(46,47).

Keratoconus and Ocular Surface Disease:

Keratoconus is a progressive eye condition that causes the cornea to thin and bulge outward, resulting in distorted vision. This can lead to discomfort, sensitivity to light, and difficulty with daily tasks such as driving or reading. Additionally, keratoconus can also increase the risk of developing ocular surface diseases, such as dry eye syndrome. Proper management and treatment of these conditions are essential to maintaining good eye health and preventing further complications. Patients with diabetes should be especially vigilant in monitoring their eye health and seeking timely care from an eye care professional if any symptoms or changes in vision occur. By staying proactive and informed, individuals can take control of their eye health and preserve their vision for years to come(48,49).

Common symptoms of keratoconus-related ocular surface disease include blurry or distorted vision, increased sensitivity to light, and difficulty seeing at night. It is important for individuals experiencing these symptoms to seek prompt evaluation and treatment from an eye care specialist to prevent any further progression of the disease (50). Regular eye exams and proper management of underlying conditions, such as diabetes, are key components in preserving eye health and overall vision. By staying proactive and informed about their eye health, individuals can take the necessary steps to protect their vision and maintain a high quality of life (51,52).

Treatment options for managing ocular surface disease related to keratoconus may include the use of special contact lenses, such as scleral lenses, to improve vision and reduce discomfort. In more severe cases, surgical interventions like corneal cross-linking or corneal transplants may be necessary to stabilize the cornea and improve vision. It is important for individuals

with keratoconus to work closely with their eye care specialist to determine the best treatment plan for their specific condition. By following their doctor's recommendations and staying diligent with their eye care regimen, individuals can better manage the effects of keratoconus and preserve their vision for years to come (53,54).

Obesity and Nutrition in Ocular Surface Disease:

Link between obesity, poor nutrition, and ocular surface disease has been increasingly recognized in recent years. Research has shown that obesity and a diet high in unhealthy fats and sugars can contribute to inflammation and oxidative stress in the body, including on the ocular surface. This can lead to conditions such as dry eye syndrome, blepharitis, and even corneal damage (55). Therefore, maintaining a healthy weight and eating a balanced diet rich in vitamins and antioxidants is crucial for preventing and managing ocular surface disease. Patients should also work with their eye care provider to develop a comprehensive treatment plan that addresses both the underlying causes and symptoms of their condition (56,57).

-By reducing inflammation and oxidative stress through proper nutrition, individuals can help protect their eyes from potential damage and discomfort. Additionally, staying at a healthy weight can also reduce the risk of developing systemic conditions that may impact eye health. Overall, taking proactive steps to care for one's overall health can have a significant impact on the prevention and management of ocular surface disease (58,59).

Nutritional recommendations for individuals with ocular surface disease to improve eye health include incorporating foods rich in antioxidants, omega-3 fatty acids, and vitamins A, C, and E into their diet. Consuming foods such as leafy greens, nuts, seeds, and fatty fish can help support eye health and reduce inflammation. It is also important to stay hydrated and limit the intake of processed foods and sugars, as these can exacerbate symptoms of ocular surface disease. Working with a healthcare provider or nutritionist to develop a personalized dietary plan can be beneficial in managing the condition and promoting overall well-being (60-62).

Conclusion:

In conclusion, incorporating a variety of nutrient-dense foods into one's diet can play a significant role in maintaining eye health and managing ocular surface disease. By focusing on foods high in antioxidants, omega-3 fatty acids, and vitamins A, C, and E, individuals can support their eye health and reduce inflammation. Additionally, staying hydrated and avoiding processed foods and sugars can help alleviate symptoms of the condition. Consulting with a healthcare provider or nutritionist to create a personalized dietary plan is recommended for optimal management of ocular surface disease and overall well-being(63-65).

Implications of identifying biomarkers for early detection and treatment of ocular surface disease include the potential for more targeted and effective interventions. By identifying specific biomarkers associated with the disease, healthcare providers can detect it at earlier stages and tailor treatment plans accordingly (66-68). This personalized approach may lead to improved outcomes and quality of life for individuals living with ocular surface disease. Research in this area is ongoing, with the hope of developing more precise diagnostic tools and therapies in the future. Ultimately, the goal is to enhance the overall management of ocular surface disease and provide patients with better outcomes. By pinpointing biomarkers early on, healthcare professionals can intervene sooner and potentially prevent the progression of the disease. This proactive approach not only benefits individuals by improving their quality of life but also reduces healthcare costs associated with more advanced stages of the condition. As research continues to advance, the futu(69-72).

Future research directions for improving management of ocular surface disease include exploring new technologies like artificial intelligence and machine learning to analyze biomarkers more efficiently and accurately. Additionally, investigating the role of genetics in the development of ocular surface disease may lead to personalized treatment plans based on individual genetic predispositions. Collaborations between researchers, healthcare professionals, and pharmaceutical companies will also be crucial in developing

innovative therapies and medications to target specific underlying causes of the disease. Overall, the ongoing efforts in research and collaboration hold great potential for revolutionizing the way ocular surface disease is managed and treated in the future.

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Innovative Strategies in Myopia Control and Management: Bridging Science, Technology, and Public Health

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Abstract

Myopia, a leading cause of visual impairment worldwide, is expected to affect approximately 50% of the global population by 2050, posing substantial risks to public health systems globally. This paper provides an overview of the latest advances in myopia control strategies, focusing on pharmacological, optical, and digital health interventions. A systematic review of the literature highlights key developments in low-dose atropine, orthokeratology, multifocal lenses, and AI-powered predictive models. Additionally, emerging therapies such as 7-methylxanthine, light-guided spectacles, and gene therapy are evaluated for their potential to curb the progression of myopia. The review emphasizes the importance of personalized treatment strategies, the integration of technological innovations, and public health interventions in tackling the rising prevalence of myopia globally. The paper highlights recent studies and emerging trends that suggest a promising future for myopia management, but also points out ongoing challenges that need to be addressed to ensure wider accessibility and long-term effectiveness of treatments.

Keywords: Myopia Control Low-Dose Atropine, Orthokeratology (Ortho-K), Multifocal Lenses, Defocus-Incorporated Spectacles (DIMS), AI Predictive Models, 7-Methylxanthine, Gene Therapy, CRISPR-Cas9, Digital Health, Telemedicine.

Introduction

Myopia, or nearsightedness, has become a global public health concern, with the number of affected individuals steadily rising. Characterized by an excessive elongation of the eye's axial length, myopia leads to a blurred vision at distance. Traditionally, myopia was seen as a minor inconvenience, but its increasing prevalence and the associated risks—such as myopic maculopathy, retinal detachment, and glaucoma—have prompted significant interest in its management and prevention.

Global projections indicate that nearly 50% of the world's population will be myopic by 2050 (Morgan et al., 2023), with East Asia facing the highest prevalence rates. In response to this growing burden, recent research has focused on both slowing the progression of myopia in children and improving the quality of life for those already affected. This paper explores the most promising myopia control strategies, from pharmacological interventions like atropine to cutting-edge digital health technologies.

1. Literature Review

The management of myopia has evolved from simply correcting refractive error with glasses to a more proactive approach aimed at slowing the progression of the condition, particularly in children. This section summarizes recent advances in pharmacological treatments, optical therapies, environmental influences, and digital health tools for myopia control.

1.1 Pharmacological Innovations

Pharmacological treatments aim to target the underlying biological processes involved in myopia development. These treatments range from traditional options, such as atropine, to newer compounds showing promise in clinical trials.

1.1.1 Low-Dose Atropine

Atropine, a muscarinic receptor antagonist, has been one of the most widely studied pharmacological agents for myopia control. Initially, high-dose atropine (1%) was used, but

it led to significant side effects, such as photophobia and accommodation loss. Recent studies have focused on low-dose atropine (0.01–0.05%), which has shown a significant reduction in axial elongation with far fewer side effects. The LAMP 2 trial (Yam et al., 2021) found that 0.05% atropine slowed myopia progression by 67% over two years, with minimal adverse effects such as photophobia. Despite the promising results, concerns over rebound myopia – the rapid progression of myopia once treatment is stopped – have led to research into pulsed dosing regimens, where atropine is administered intermittently to reduce this risk (Yam et al., 2023).

1.1.2 Novel Therapeutics:

In addition to atropine, several new pharmacological agents have been explored for their myopia control potential. 7-Methylxanthine (7-MX): This compound, an adenosine receptor antagonist, has been shown to slow the progression of myopia in animal models by strengthening the sclera and reducing axial elongation by 40% (Trier et al., 2023). Early-phase human trials show promising results, with a 30% efficacy in controlling myopia progression (Chen et al., 2023). Dopamine Agonists: Studies have shown that dopamine plays a role in regulating eye growth, and topical dopamine agonists, such as apomorphine, have been tested in animal models with success. These treatments aim to target retinal dopamine pathways, which are known to be involved in controlling axial length elongation (Zhou et al., 2022).

1.2 Optical Interventions

Optical interventions are widely used to manage myopia progression, particularly in children. These strategies include orthokeratology, multifocal lenses, and defocus-incorporated spectacles, each with varying degrees of effectiveness.

1.2.1 Orthokeratology (Ortho-K)

Orthokeratology (Ortho-K) involves the use of specially designed contact lenses that reshape the cornea overnight, inducing peripheral myopic defocus. A meta-analysis by Bao et al. (2023) found that Ortho-K lenses reduced axial

elongation by 49% when compared to standard single-vision lenses. However, the use of Ortho-K is associated with an increased risk of microbial keratitis (annual incidence of 0.15%), requiring careful hygiene and patient compliance (Bullimore et al., 2023).

1.2.2 Multifocal and Defocus-Embedded Lense

Multifocal lenses and Defocus Incorporated Multiple Segments (DIMS) spectacles are designed to slow the progression of myopia by providing a different focal point in the periphery of the eye, inducing peripheral defocus. The BLINK study (Walline et al., 2020) demonstrated that high-add multifocal contact lenses reduced myopia progression by 43%. Additionally, DIMS spectacles have been shown to reduce axial elongation by 52%, making them an effective non-invasive option for myopia control (Lam et al., 2022).

1.3 Environmental and Behavioral Strategies:

Environmental and behavioral modifications are becoming increasingly recognized as essential components in managing myopia. Encouraging children to spend more time outdoors and reducing digital eye strain are simple but effective strategies.

Outdoor Time: A randomized controlled trial (RCT) by He et al. (2023) found that 2 hours of outdoor activity per day significantly reduced the incidence of myopia by 34% in Chinese schoolchildren. It is believed that exposure to natural light promotes the release of dopamine in the retina, which inhibits excessive eye growth.

Digital Eye Strain Mitigation: With the rise in screen time, particularly among children and adolescents, managing digital eye strain has become a priority. Interventions such as blue-light-blocking lenses and adherence to the 20-20-20 rule (taking a 20-second break every 20 minutes of screen use) have shown effectiveness in reducing the risk of myopia progression due to excessive close-up work (Li et al., 2023).

1.4 Digital Health and AI

Recent advances in digital health technologies have provided new avenues for myopia management, enabling remote monitoring and predictive modeling to improve treatment adherence and precision.

Predictive Algorithms: AI-driven models can predict the progression of myopia with remarkable accuracy, combining genetic data (such as PAX6 gene variants) with environmental factors like time spent outdoors and screen time. One such algorithm was able to predict myopia progression with 89% accuracy (Lin et al., 2023). This allows clinicians to tailor treatment plans more effectively and intervene earlier.

Telemedicine and Remote Monitoring: Platforms like MyopiaMaster allow for remote monitoring of axial length and other key metrics, improving patient adherence, especially in rural areas where access to specialized eye care may be limited (Wang et al., 2023).

2. Emerging Innovations

Several emerging treatments show promise for future myopia control strategies, including gene therapy, smart spectacles, and nutritional interventions.

2.1 Gene Therapy

Gene therapy has the potential to address the genetic underpinnings of myopia. Using CRISPR-Cas9 technology, researchers have successfully edited genes like BMP2 and TGF- β in animal models to halt scleral remodeling, preventing axial elongation (Zhang et al., 2023). While this approach is still in its early stages, it represents a novel and exciting direction for myopia management.

2.2 Smart Spectacles

SightGlass Vision's DOT lenses, which use contrast-reducing optics to reduce peripheral defocus, have shown a 38% reduction in myopia progression in clinical trials (Cooper et al., 2022). These smart spectacles offer a non-invasive, comfortable solution for controlling myopia, particularly for children.

2.3 Nutritional Interventions

Emerging evidence suggests that nutrition may play a role in myopia prevention. Omega-3 fatty acids and lutein, found in foods like fish and leafy greens, have been shown to reduce the risk of myopia in some studies (Ma et al., 2023). While further research is needed, dietary interventions may complement other myopia control strategies.

3. Challenges and Future Directions

Despite the advances in myopia control, several challenges remain:

Personalized Medicine: The development of biomarker-driven treatment plans could optimize the efficacy of existing therapies, such as atropine and Ortho-K, by tailoring them to individual patients based on their genetic makeup and risk factors (Wei et al., 2023).

Global Access: Access to effective treatments remains a significant challenge in many low- and middle-income countries, where the cost of Ortho-K lenses and atropine can be prohibitive. More affordable solutions and subsidized programs are needed to ensure equitable access to myopia control therapies.

Long-Term Safety: Long-term studies are needed to evaluate the safety and efficacy of newer treatments like low-dose atropine and DIMS lenses, especially as they are increasingly used in children and young adults.

Conclusion

Myopia management has evolved from passive correction of refractive error to a more proactive, multi-disciplinary approach aimed at slowing progression and improving quality of life. Advances in pharmacological treatments, optical therapies, and digital health innovations offer promising solutions, but significant challenges remain, particularly in ensuring global equity and long-term safety. Collaborative efforts among clinicians, researchers, and policymakers will be essential to combat the growing myopia epidemic and reduce its global burden.

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A Review of Digital Eye Strain Studies

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Introduction:

The increasing reliance on digital devices for education, work, and leisure has led to a surge in digital eye strain (DES), also known as computer vision syndrome (Gammoh, 2021). This condition encompasses a range of ocular symptoms, including eye fatigue, dryness, blurred vision, headaches, and neck pain (AlQarni, A. M. et al 2023). The COVID-19 pandemic, with its shift to online learning and remote work, further exacerbated this issue (Munsamy, A. J. et al 2022). This review critically analyzes several studies investigating DES prevalence, risk factors and impact, highlighting their strengths and weaknesses.

Research Gap:

While numerous studies have explored DES, variations exist in the populations studied (students, general population, specific professions), the assessment tools used (questionnaires, clinical measurements), and the specific digital activities investigated. This creates a research gap in terms of generalizability and comparability of findings. Furthermore, a deeper understanding of the long-term effects of prolonged digital device use on ocular health, particularly in vulnerable populations like children and adolescents, is still needed. The interplay between DES and other factors like sleep quality, mental health, and ergonomic setup also requires further investigation.

The reviewed studies collectively identify several key research gaps in the understanding and management of digital eye strain (DES):

Longitudinal Impact: The predominantly cross-sectional nature of the research limits insights into the long-term effects of prolonged digital device use on ocular health.

Longitudinal studies are needed to track changes in ocular function and DES symptoms over time, particularly in vulnerable populations like children and adolescents (e.g., Mohan et al., 2021; Aldukhayel et al., 2022). This would help determine if DES is a transient issue or if it leads to more permanent ocular damage.

Objective Measures: The heavy reliance on self-reported questionnaires introduces subjectivity and potential bias. A major research gap is the integration of objective measures of ocular health, such as tear film break-up time, Schirmer's test, corneal topography, and accommodation amplitude (Jakhar et al., 2023). Correlating subjective symptoms with objective findings would provide a more comprehensive and accurate assessment of DES.

Intervention Effectiveness: While many studies identify risk factors, there is a lack of rigorous research evaluating the effectiveness of interventions designed to prevent and manage DES. Studies are needed to assess the impact of ergonomic modifications, eye exercises, blue light filters, and educational programs on DES symptoms and ocular function.

Specific Population Focus: While several studies focus on university students (e.g., Gammoh, 2021; AlQarni et al., 2023; Munsamy et al., 2022; Huyhua-Gutierrez et al., 2023; Sawaya et al., 2020; Almudhaiyan et al., 2023), more research is needed on other populations, including children (Mohan et al., 2021; Aldukhayel et al., 2022), older adults, and individuals with pre-existing ocular conditions. Furthermore, research focusing on specific professions with high digital device use (e.g., office workers, gamers) is also warranted.

Multifactorial Approach: DES is likely influenced by a combination of factors, including digital device use,

environmental factors, individual characteristics and lifestyle habits. Future research should adopt a more holistic approach, examining the complex interplay between these factors. For example, studies should consider the combined effects of screen time, lighting, ergonomics, sleep quality (Rana et al., 2023), and mental health (Rana et al., 2023; Alzahrani, 2024) on DES.

Mechanism of Action: The underlying mechanisms by which digital device use leads to DES are not fully understood. More research is needed to investigate the physiological changes that occur in the eye and visual system during prolonged digital screen time.

This could lead to the development of more targeted and effective interventions.

Dependent and Independent Variables In the context of these DES studies, the following general framework for dependent and independent variables can be identified:

Dependent Variables: These are the outcomes being measured or studied. In DES research, the primary dependent variable is typically digital eye strain, which can be operationalized in various ways:

- **Subjective Symptoms:** These are measured using questionnaires and include symptoms like eye fatigue, dryness, blurred vision, headache, neck pain, and difficulty focusing.
- **Objective Measures of Ocular Function:** These include measures like tear film break-up time, Schirmer's test results, corneal topography, accommodation amplitude, and blink rate. (Note: Many of the studies reviewed primarily focus on subjective symptoms.)

Independent Variables: These are the factors that are thought to influence or be associated with the dependent variable (DES). These can be categorized as:

o **Digital Device Use: This includes factors like:**

- **Screen Time:** Duration and frequency of digital device use.

- Type of Device: Smartphone, computer (desktop; laptop), tablet, etc.
- Viewing Distance: Distance between the eyes and the screen.
- Breaks Taken: Frequency and duration of breaks during digital device use.

o **Environmental Factors:**

- Lighting: Ambient lighting conditions.
- Ergonomics: Workstation setup, chair height, screen position.
- Humidity: Environmental humidity levels.

o **Individual Factors:**

- Pre-existing Eye Conditions: Dry eye syndrome, refractive errors, etc.
- Age
- Gender
- Sleep Quality
- Mental Health: Stress, anxiety, depression.
- Smartphone Addiction

o **Other Factors:**

- COVID-19 Pandemic/Online Learning: This acts as a contextual independent variable in several studies, representing a period of increased digital device use for educational purposes.

Methodology:

The reviewed studies predominantly employed cross-sectional survey designs, relying on self-reported questionnaires to assess DES symptoms. Several studies, like Gammoh (2021),

AlQarni et al. (2023), Munsamy et al. (2022), Huyhua-Gutierrez et al. (2023), Lotfy et al. (2022), Sawaya et al. (2020), Mohammed et al. (2021), Alzahrani (2024), Almudhaiyan et

al. (2023), Aldukhayel et al. (2022), Jakhar et al. (2023), and Rana et al. (2023), followed this approach.

While this method allows for efficient data collection from large samples, it is susceptible to recall bias and may not accurately reflect the severity of DES. Objective measures of ocular function, such as tear film break-up time, Schirmer's test, and accommodation amplitude, were largely absent, limiting the ability to correlate subjective symptoms with objective findings. Only Kaur et al. (2022) provided a comprehensive review of DES, summarizing existing literature.

Mohan et al. (2021) focused specifically on children and their online learning.

Discussion:

This collection of studies provides valuable insights into the prevalence and risk factors of digital eye strain (DES) across diverse populations, primarily university students, during a period marked by increased digital device use, particularly due to the COVID-19 pandemic. While variations in prevalence exist, a consistent theme emerges: DES is a significant health concern, especially among young people engaged in extended digital learning.

Prevalence and Demographics: The reported prevalence of DES varies considerably across studies. This heterogeneity likely stems from several factors, including differences in study populations (e.g., Gammoh, 2021, focusing on Jordanian university students; Aldukhayel et al., 2022, examining children in Saudi Arabia), the specific assessment tools employed, and the intensity of digital device use within the studied cohorts. Studies conducted during the pandemic, such as AlQarni et al. (2023), Munsamy et al. (2022), and Mohammed et al. (2021), often capture a period of heightened online learning, potentially contributing to higher reported prevalence rates compared to studies conducted before the pandemic. Furthermore, variations in how "screen time" and "DES" are defined and measured across studies (e.g., self-reported estimates versus device usage data) complicate direct comparisons. Concerning demographics, some studies suggest female students may report higher DES prevalence

(e.g., Rana et al., 2023), possibly due to hormonal influences, differences in device usage patterns, or reporting biases, though more research is needed to confirm these observations.

Risk Factors and Their Significance: Prolonged screen time consistently emerges as a significant risk factor for DES across the reviewed literature. However, the precise relationship between screen time and DES severity remains complex. While increased screen time generally correlates with increased DES symptoms, the specific type of digital activity, breaks taken, and individual susceptibility also play crucial roles. Near work, not exclusively digital, also contributes to eye strain. Studies focusing solely on digital screen time might underestimate the cumulative effect of all near visual tasks. Environmental factors, including lighting, ergonomics, and humidity, while acknowledged as potential contributors, are not always thoroughly investigated in these studies. Individual factors like pre-existing eye conditions, refractive errors, and dry eye syndrome are important confounders. Jakhar et al. (2023) specifically explored the overlap between dry eye symptoms and DES, highlighting the potential for these conditions to exacerbate each other. The COVID-19 pandemic and the rapid shift to online education clearly impacted DES. Studies conducted during this period (e.g., AlQarni et al., 2023; Mohammed et al., 2021; Munsamy et al., 2022) suggest a potential increase in both prevalence and symptom severity.

Methodology and its Impact: The reliance on cross-sectional survey designs and self-reported data represents a significant methodological limitation across the majority of studies.

While these methods allow for efficient data collection from larger samples, they are inherently susceptible to recall bias and limit the ability to establish causal relationships. The lack of objective measures of ocular function (e.g., tear film break-up time, accommodation amplitude) further weakens the conclusions about the severity and nature of DES. Sample sizes and demographic characteristics vary, impacting the generalizability of findings. Furthermore, the specific questionnaires used to assess DES symptoms differ across studies, which can make comparing results difficult. Kaur

et al. (2022) provide a valuable comprehensive review, but it highlights the need for more standardized DES assessment tools.

Comparing Specific Studies: While all studies contribute to our understanding of DES, some offer unique perspectives. Alzahrani (2024) specifically investigated the association between smartphone addiction and DES, a relevant area of inquiry given the increasing use of smartphones. Rana et al. (2023) explored the relationship between DES, sleep quality, and loneliness, suggesting a potential interplay between physical and mental health factors. Mohan et al. (2021) focused specifically on children and the impact of online learning, a population particularly vulnerable to the effects of digital device use.

Future Directions: These studies underscore the need for more rigorous research on DES. Longitudinal studies employing both subjective and objective measures of ocular health are essential to understand the long-term effects of digital device use and establish causal relationships between risk factors and DES. Standardized DES assessment tools and consistent definitions of key variables (e.g., screen time, DES symptoms) are crucial for improving the comparability of findings across studies. Furthermore, intervention studies evaluating the effectiveness of various strategies for preventing and managing DES (e.g., ergonomic interventions, eye exercises, blue light filters) are needed to inform best practices and protect the ocular health of digital device users.

The studies consistently reported a high prevalence of DES among their respective populations, particularly students. Factors associated with DES included prolonged screen time, inadequate breaks, poor lighting, and uncorrected refractive errors (Huyhua-Gutierrez et al 2023). The COVID-19 pandemic and the subsequent increase in online activities were identified as a significant contributing factor in many studies (Lotfy et al 2022). Some studies, like AlQarni et al. (2023), specifically linked DES to virtual learning (Sawaya et al 2020). The association between DES and other factors, such as sleep quality (Rana et al., 2023), smartphone addiction (Alzahrani, 2024), and dry eye symptoms (Jakhar et al., 2023),

was also explored. However, the cross-sectional nature of the studies limits the ability to establish causal relationships.

Limitations:

The primary limitation of the majority of the reviewed studies is their reliance on self-reported questionnaires, which are prone to subjective bias. The lack of objective clinical assessments of ocular function is a significant weakness. The cross-sectional design also limits the ability to draw causal inferences (Mohammed et al 2021). Furthermore, the sample sizes and demographics of the study populations varied, affecting the generalizability of the findings.

Some studies focused on specific student populations (e.g., medical students, nursing students), making it difficult to extrapolate the results to other groups. Recall bias might have influenced the accuracy of reported screen time and symptom duration.

Conclusion:

DES is a prevalent and growing concern, particularly with the increasing reliance on digital devices (Alzahrani, 2024). The reviewed studies highlight the need for increased

awareness of DES risk factors and the implementation of preventive measures, such as regular breaks, ergonomic workstation setup, and proper lighting (Mohammed et al 2021). Future research should focus on employing more objective measures of ocular function, utilizing longitudinal study designs to investigate the long-term effects of digital device use, and exploring the interplay between DES and other health factors. Interventions aimed at reducing DES, such as educational programs and ergonomic modifications, should be evaluated for their effectiveness. A more comprehensive and multi-faceted approach is needed to address the complex issue of DES and mitigate its impact on individuals' health and well-being.

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Ocular Diagnostic Tests Effect on Ocular Health

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Abstract

The review is centred on the importance of ocular diagnostics in improving the status of ocular health. Its purpose is to assess how effectively different diagnostic devices and technologies perform for early detection, correct diagnosis, and monitoring of eye diseases. The book emphasizes the growing significance of advanced diagnostic equipment to reveal complex information regarding the anatomical and functional anatomy of the eye, including corneal topography, fundus photography, and OCT.

Their effect on patient outcomes and whether they have a role in routine clinical practice are overall questions addressed. How machine learning and artificial intelligence can assist in personalized treatment strategies and enhance the reproducibility of diagnoses is also taken into account by the analysis. It also takes into account the issues related to accessibility and the necessity for ongoing education.

In general, the research shows that modern ocular diagnostics enhance early detection and treatment of most eye diseases, including age-related macular degeneration, diabetic retinopathy, and glaucoma. Better patient outcomes are the result of such innovation, for example, prevention of vision loss and enhancement of the general state of eye health. The review ends by showing that additional research and development in ocular diagnostics are required so as to

make them more accessible and beneficial in a wide range of therapeutic interventions.

Keywords

Ocular diagnostics, ocular health, imaging, optometry, eye diseases, visual assessment.

Introduction

Despite being a vital part of general health, ocular health is nevertheless frequently disregarded in medical care. Ocular disorders account for a considerable portion of the global disease burden, affecting millions of people with conditions that can cause severe visual impairment or blindness. Over

2.2 billion people worldwide suffer from a visual impairment; at least 1 billion of these instances could have been avoided or are yet unresolved, according to the World Health Organization (1). Age-related macular degeneration (AMD), diabetic retinopathy, cataracts, glaucoma, and uncorrected refractive errors are the most frequent causes of vision impairment. These illnesses not only lower quality of life but also place a heavy financial strain on people and healthcare systems, especially in low- and middle- income nations where access to care is limited.

Reducing the effects of eye disorders requires early detection and prompt action. As many eye diseases, including diabetic retinopathy and glaucoma, remain asymptomatic in their early stages, routine screenings and sophisticated diagnostics are crucial to averting permanent damage (2). Given the aging of the world population and the rising incidence of chronic disorders like diabetes that exacerbate ocular diseases, there is an increased need than ever for comprehensive eye care programs that prioritize early identification and therapy (3).

1.1 Advancements in Ocular Diagnostics

Technological developments have completely changed the field of ocular diagnostics, changing the way medical practitioners who treat eye disorders identify, treat, and track their conditions. Modern eye care now includes advanced technologies including fundus photography, corneal

topography, optical coherence tomography (OCT), and, more recently, diagnostic tools powered by artificial intelligence (AI) (4). The ability to view ocular structures at a microscopic level, made possible by these technologies' unparalleled precision and resolution, is essential for the early detection of conditions like AMD and glaucoma (4).

For example, OCT offers cross-sectional retinal pictures that allow physicians to identify minute variations in retinal thickness that could signal the beginning of macular disorders or glaucoma (5). Similar to this, fundus photography helps identify and track diabetic retinopathy by taking precise pictures of the retina (Journal of Diabetes Research). The use of AI in ocular diagnostics has improved these instruments' precision and effectiveness even more. Large datasets can be swiftly analyzed by AI algorithms, which can then spot patterns and anomalies that could be signs of disease before the human eye can (6).

In addition to increasing diagnosis accuracy, these technological developments have enabled more effective disease progression monitoring, enabling individualized therapy regimens catered to each patient's specific requirements (6).

1.2 Purpose of the Review

The purpose of this review is to summarize the effect of ocular diagnostics on ocular health, with emphasis on new technology and its use in clinical practice. With the function of these devices in the early diagnosis of disease, treatment, and follow-up, the review tries to acknowledge the enormous difference in patient outcome caused by these technologies. The review also addresses the limitations and disadvantages of these technologies, including accessibility and their adoption in the general clinical practice (Ophthalmology Review). The ultimate goal is to give a general idea of how diagnostics are transforming the practice of eye care in the future and enhancing the lives of those afflicted with ocular disease (Ophthalmology Review).

1. Historical Perspective and Evolution of Ocular Diagnostics

Ocular diagnostics has a long history; it started with simple instruments and developed into complex technology that transformed eye care. The voyage began in 1851 when Hermann von Helmholtz invented the ophthalmoscope, a ground-breaking invention that allowed one to view the inside workings of the eye (7). Modern ophthalmology began with the invention of the ophthalmoscope, which allowed medical physicians to see the retina, optic nerve, and other structures up close. Prior to this innovation, little was known about ocular disease and most eye diseases could be diagnosed only on a theoretical basis.

Other diagnostic instruments, such as the slit-lamp biomicroscope, became available in the early 20th century and made it possible to examine the anterior portion of the eye in great detail. A variety of lenses with a slit lamp allowed for enlarged views of the cornea, lens, and anterior chamber, which aided in the diagnosis of anterior uveitis, cataracts, and corneal disorders (8). Although the depth and quality of the images these early instruments produced were limited, they set the groundwork for the systematic investigation and management of ocular disorders.

2.1 Transition to Modern Techniques

The use of advanced imaging and functional testing technologies has significantly increased over the second half of the 20th century and the first part of the 21st. A significant advancement in ocular diagnostics was made in the 1990s with the introduction of Optical Coherence Tomography (OCT). OCT provides detailed, high-resolution images that enable the early diagnosis of disorders like glaucoma, diabetic retinopathy, and macular degeneration (9). OCT uses light waves to create cross-sectional images of the retina. The accuracy of diagnoses was greatly increased by this technique, which allowed medical professionals to identify previously invisible minute changes in retinal thickness and structure.

Simultaneously, technology for visual field testing, such as automated perimetry, emerged as indispensable instruments for evaluating the functional consequences of illnesses such

as glaucoma. These tests measure the patient's visual field, identifying areas of vision loss that are indicative of optic nerve damage (10). The combination of structural imaging provided by OCT and functional assessment through visual field testing has become the cornerstone of modern glaucoma management, allowing for early intervention and better disease control.

2.2 Milestones in Ocular Diagnostics

The field of ocular diagnostics has seen several turning points that have influenced eye care today. The mid-20th century saw the advent of fundus photography, which made it possible to record the retina in great detail. This allowed medical professionals to monitor changes in the retina over time, which improved the treatment of diabetic retinopathy (Wolff, 1958). The ability to see retinal blood flow and identify vascular abnormalities—both crucial for the diagnosis and treatment of retinal illnesses like macular degeneration—was significantly improved with the development of fluorescein angiography in the 1960s (11).

Another important trend in recent years has been the incorporation of artificial intelligence (AI) into eye diagnosis. Today, AI programs can analyze image data and identify patterns and abnormalities with incredible accuracy; in fact, they can often identify early disease detection more effectively than human operators (12). This trend could revolutionize ocular diagnostics in the future by enabling even more accurate and individualized eye care.

The advancement of ocular diagnostics from primitive tools to cutting-edge technology indicates a persistent desire to enhance the early detection, management, and treatment of ocular diseases, ultimately improving patient outcomes and preserving vision.

1. Contemporary Ocular Diagnostic Techniques

1.1 Imaging Techniques:

1.1.1 Optical Coherence Tomography (OCT)

Principles and Applications

One imaging test that does not require surgery, optical coherence tomography (OCT), is performed using light waves to take detailed cross-sectional images of the retina, optic nerve, and other tissues of the eye.

OCT began functioning in the early 1990s and utilizes low-coherence interferometric methods where the light waves are back-scattered from the various tissue layers. The method produces high-resolution images since the reflective qualities of the various layers of tissues vary (9). With the application of this technology, doctors are able to view the microscopic make-up of the retina and obtain important information about the state of the retina and optic nerve. OCT has become imperative in the detection and management of most diseases of the retina and optic nerve.

For instance, OCT can identify drusen and track the development of choroidal neovascularization or geographic atrophy progression, two of the most important signs of age-related macular degeneration (AMD) (13). OCT quantifies retinal nerve fiber layer (RNFL) thickness in glaucoma, which can identify optic nerve damage due to glaucomatous disease long before visual field loss becomes symptomatic (14). OCT allows for diagnosis and monitoring of disease progress by giving precise images of these structures to allow early intervention.

Impact on Early Detection

It is well understood that OCT has applications in early diagnosis of eye diseases. Prevention of irreversible visual loss is crucial since various studies have indicated that it is able to detect changes in retinal and optic nerve structures in the initial stages of disease. For instance, OCT has been proven to detect RNFL thinning in glaucoma patients even before the onset of abnormalities in the visual field

(14). According to Schmidt-Erfurth et al. (2014), OCT can also detect subclinical fluid accumulation in the retina in AMD, enabling an earlier diagnosis and course of therapy that can halt or reduce the progression of visual loss (15).

Leung et al. (2010) conducted a seminal study that demonstrated the utility of OCT in the diagnosis of pre-perimetric glaucoma, a condition in which structural optic nerve damage exists prior to the detection of functional vision loss by conventional visual field testing (16). This is why OCT is a vital part in the initial management of glaucoma because it can significantly minimize the risk of visual loss through early treatment and detection. Additionally, OCT has been effective in detecting diabetic macular edema in diabetic retinopathy, usually before clinical presentation, for timely therapeutic intervention (17).

Recent Advances

The clinical and potential applications of OCT technology have been largely extended by recent advances. One of the greatest developments is OCT angiography (OCTA), dispenses with the need for dye injection—necessary for routine fluorescein angiography—and permits imaging of retinal and choroidal vasculature (18). OCTA creates very high-resolution images of blood flow through the retinal and choroidal layers by identifying movement of the red blood cells in the arteries. Since it can identify earlier neovascularization and other vascular derangements, this has been especially valuable in the diagnosis and treatment of retinal vascular disease, such as diabetic retinopathy and AMD.

Furthermore, greater penetration and higher resolution images of the sclera and choroid are obtained by SS-OCT with longer wavelengths and higher scanning speeds allowing for improved visualization of these tissues (19). This has greatly aided in the diagnosis of conditions like polypoidal choroidal vasculopathy and central serous chorioretinopathy.

These developments cement OCT's position as a cornerstone of contemporary ocular diagnostics by once again expanding its diagnostic utility and application. As technology evolves, the diagnosis of eye disease and patient management on a case-by-case basis can be increasingly optimized, with improved patient outcomes.

Fundus Photography and Angiography Clinical Uses

In the care of the majority of retinal and general medical disorders, fundus photography and angiography are mandatory diagnostic strategies. By providing true images of the retina, optic disc, macula, and retinal vasculature, these imaging modalities enable the detection, surveillance, and treatment of conditions such as age-related macular degeneration (AMD), diabetic retinopathy, and retinal vein occlusions.

Fundus photography is instrumental in detecting early signs of retinal damage in diabetic retinopathy, including microaneurysms, haemorrhages, and exudates, which are indicative of the course of the disease (20). Repeated fundus imaging enables it to track such changes over time and treat these with intravitreal injections or laser photocoagulation before irreversible loss of vision.

The second setting where fundus imaging and fluorescein angiography perform magic is retinal vein occlusions (RVO). Fluorescein angiography enables the clinician to detect regions of ischemia, edema, and neovascularization by visualizing the blood flow within the retinal vessels (Brown et al., 1996). This is important for the choice of proper intervention to manage issues, e.g., anti-VEGF therapy or laser treatment.

In addition to these disorders, fundus photography is applied in diagnosing and tracking many retinal dystrophies, hypertensive retinopathy, AMD, and glaucoma. Having the capacity to document and image changes in the retina over time is invaluable in clinical practice and research.

Recent Advances

Clinical utility and access to fundus photography have been greatly boosted by the transition from digital to analog technology. Better definition of images, on-the-spot inspection of images, and ease of storage, transmission, and comparison with previous studies over time are just some of the benefits that digital fundus photography over film-based systems has to offer. All these enhancements have added to the effectiveness and dependability of fundus photography

as a procedure in retinal disease management (Wong & Lamoureux, 2006).

The use of digital fundus photography in telemedicine—particularly in screening disadvantaged groups for diabetic retinopathy—has one of the greatest impacts. Remote screening programs are made possible by telemedicine platforms, which allow images taken in a primary care or community clinic to be sent to a specialist for analysis. It has been demonstrated that this strategy is quite successful.

Corneal Topography:

A vital diagnostic tool for mapping the surface curvature of the cornea and obtaining precise details about its shape and contour is corneal topography. This data is of great use to a variety of clinical applications, i.e., early keratoconus detection and refractive surgery.

Corneal topography is of prime importance in pre-operative assessment of refractive surgery, e.g., LASIK (Laser-Assisted In Situ Keratomileusis) and PRK (Photorefractive Keratectomy). Accurate creation of the cornea's surface to a point of refractive flaws like astigmatism, hyperopia, or myopia is essential to the success of this procedure. Through the use of corneal topography, the surgeons can

evaluate the regularity, symmetry, and the presence of any underlying defects that may influence surgical outcomes by having a precise map of the corneal surface (21). For example, corneal steepening or flattening can be detected to help modify the pattern of laser ablation to improve vision and decrease the incidence of postoperative complications like irregular astigmatism or ectasia.

In addition, corneal topography is required to screen refractive surgery candidates. It is able to detect subtle corneal defects, such as forme fruste keratoconus, a subclinical keratoconus, that do not require surgery. The reason it is found at such an early phase is that it is dangerous to treat a weakened cornea with refractive surgery because it can worsen the condition called ectasia characterized by progressive thinning and bulging of the cornea and severe loss of vision (22).

The progressive degenerative disorder known as keratoconus is characterized by the cornea's thinning and conical deformation, which results in visual distortion. Corneal topography is the gold standard for keratoconus diagnosis, and early detection is essential for preventing serious vision loss. The topographic map displays distinctive features that are indicative of keratoconus, including inferior steepening, uneven astigmatism, and a conical protrusion (23). Clinicians can start appropriate care techniques, such as corneal cross-linking, to stop the disease's progression and maintain vision by identifying these alterations early.

More in-depth details regarding the anatomy of the cornea can be obtained by using advanced topography techniques, including corneal tomography, which give three-dimensional imaging of both the anterior and posterior corneal surfaces. Since alterations to the posterior corneal surface frequently occur before anomalies to the anterior surface, this is especially crucial for the early diagnosis of keratoconus (24).

To sum up, corneal topography is an essential tool for managing keratoconus and refractive surgery. Whether a patient is having vision correction surgery or is being tracked for progressive corneal illnesses, its capacity to produce accurate and detailed maps of the corneal surface guarantees that they receive tailored and appropriate treatment.

Ultrasound Bio-microscopy and Confocal Microscopy

The eye's visual health is primarily the job of its anterior segment, i.e., the lens, ciliary body, iris, and cornea. The appropriate imaging in diagnosis of various diseases is the foremost requirement of this segment. Novel imaging technologies like Ultrasound Bio-microscopy (UBM) and Confocal Microscopy (CM) have restructured the anterior segment disease diagnosis as well as management.

UBM employs 50-100 MHz high-frequency ultrasound waves to produce high-resolution cross-sectional images of the anterior segment. Because of the penetration capability through opaque structures, anatomical structures such as the anterior chamber angle, iris, and ciliary body can be evaluated that are inaccessible to other imaging techniques. UBM has

been extremely helpful in clinical practice for the evaluation of angle-closure glaucoma because it gives accurate images of the ciliary body and anterior chamber angle. This allows identification of the pathophysiology of angle closure, such as pupillary block, plateau iris, or abnormalities of the ciliary body (25). Besides that, UBM can also distinguish between benign and malignant anterior segment disease, e.g., ciliary body tumors and iris cancers. Its capability to precisely measure tumor size and extension.

It is possible to achieve high-resolution imaging of the cornea and conjunctiva at the cellular level by using confocal microscopy, especially in vivo confocal microscopy (IVCM). With the aid of a laser scanning the tissue, high-resolution images are produced by probing the reflected light. By detection of alterations in the corneal sub-basal nerve plexus and stromal keratocytes not detectable with standard imaging methods, CM is highly valuable in early keratoconus diagnosis. Early detection is important to avoid progression of the disease (Mazzotta et al., 2021). Moreover, infection directly within ocular tissue, i.e., fungal filaments and cysts of *Acanthamoeba*, can be detected using CM. This allows for rapid and accurate diagnosis, particularly useful where conventional culture methods fail (26). CM also provides detailed images of corneal dystrophies, such as

3.2.Functional tests

3.2.1.Visual field testing

Visual field testing is a key diagnostic tool when a patient is diagnosed with glaucoma and other ocular neuropathies. With the aid of equipment such as the Humphrey Visual Field Analyzer, practitioners are able to map a patient's field of vision and where there is deterioration in vision, an indicator that optic nerve damage is present (27). Visual field testing should be used to follow the advancement of glaucoma and test how well treatment is going along.

3.2.2.Electro-Diagnostics(ERG & VEP)

Electrophysiological tests known as ERG and VEP evaluate the functional integrity of the retina and the visual pathway,

respectively. Retinal illnesses like retinitis pigmentosa and congenital stationary night blindness are diagnosed using the help of electroretinograms (ERGs), which evaluate the electrical response of the retina to light stimulation (28). VEP, on the other hand, tests the electrical activity of the visual cortex when stimulated visually and helps in the identification of optic nerve and visual pathway disorders, such as multiple sclerosis (29).

3.2.3. Tonometry

Intraocular pressure is measured by tonometry, which is a quick test for the diagnosis and treatment of glaucoma. Although non-contact tonometry and other techniques are employed in routine clinical practice, the Goldmann applanation tonometer is still considered the gold standard to measure intraocular pressure (IOP) (30). To diagnose glaucoma and assess the efficacy of treatment, accurate measurement of IOP is necessary.

3.3. Biochemical and Molecular Diagnostics

3.3.1. Tear Film Analysis

Dry eye disease is diagnosed by assessing the production, constitution, and stability of tears in the process of tear film analysis. For detecting the tear film and assessing the dry eye-related conditions, testing methods like Schirmer testing, tear break-up time (TBUT), and osmotic testing are well used

(31). Diagnostic outcomes of dry eye disease have highly improved due to the development of new biomarkers and advanced diagnostics through the technological advancements in the field of tear film analysis.

1. Impact of Ocular Diagnostics on Patient Outcomes

1.1 Early Detection and Prevention

In order to avoid permanent vision loss, early disease detection is required. Due to the progress of modern ocular diagnostics, pathologies are now detectable at an early stage, which is crucial for age-related macular degeneration (AMD), diabetic retinopathy, and glaucoma.

Research has demonstrated, for example, that OCT can identify retinal nerve fiber layer (RNFL) thinning in glaucoma patients before any observable visual field defects are evident, and thereby facilitate early treatment (32). Likewise, fluorescein angiography and fundus photography have played important roles in diagnosing and monitoring diabetic retinopathy, the world's leading cause of blindness. As pointed out by the Early Treatment Diabetic Retinopathy Study (ETDRS), early laser

photocoagulation has proved to decrease the risk of severe visual impairment by 50% as long as it is used in combination with precise diagnostic imaging (33).

1.2 Individualized Treatment Regimens

The advances in ocular diagnostics have also provided for the creation of individualized treatment regimens that are created based on the status and progression of each patient's disease. For instance, OCT monitoring is employed when quantifying the effect of anti-VEGF therapy for AMD to enable modification of treatment protocols based on disease activity (34). Such an individualized strategy minimizes the burden and risks associated with unnecessary therapy to the least possible extent and maximizes the therapeutic benefit.

Furthermore, the management of inherited eye disease has also come to rely heavily on genetic diagnosis. Physicians can foresee disease progression and alter treatment plans by determining individual genetic defects. Personalized medicines rely on precise molecular diagnostics, as witnessed in the introduction of gene therapy, for instance, Luxturna for RPE65 mutation-induced retinal degeneration (35).

1.3 Enhancement of Quality of Life

The patients' quality of life rises in proportion to precise diagnosis and successful treatment of eye disease. Advanced diagnostics made it possible to better control the disease and, as a result, preserve visual function for long-term conditions such as diabetic retinopathy and glaucoma, where it is crucial to preserve monitoring in the long term (36).

Evidence has proved that early glaucoma treatment, based on sound diagnostic testing, significantly minimizes the risk of vision loss, preserving the patient's functional ability to undertake regular activities and remain independently living (27). In a similar vein, superior visual results from routine OCT monitoring of AMD patients have allowed them to maintain a greater quality of life (37).

2. Emerging Technologies and Future Directions

2.1 Artificial Intelligence and Machine Learning

Ophthalmology has advanced significantly with the introduction of artificial intelligence (AI) and machine learning (ML) into ocular diagnostics. For the diagnosis of retinal disease using fundus photographs and OCT scans, AI algorithms—deep learning-based algorithms in particular—have been extremely accurate, sometimes even matching or even exceeding the diagnostic ability of human specialists (38). Google's diabetic retinopathy detection AI system is perhaps the most notable development in this regard; it has demonstrated high sensitivity and specificity in its diagnosis across different populations. AI diagnosis has the potential to transform the practice of eye care, particularly in low-resource environments and areas with limited access to trained personnel (39).

2.2 Teleophthalmology

Telecommunication technology utilization in delivery of remote eye care, also known as teleophthalmology, is now a prevalent occurrence nowadays, especially during the COVID-19 pandemic. The process is a valuable method of reaching underserved populations in rural or remote communities because it permits the remote diagnosis and treatment of eye disease (40). Teleophthalmology is the mass technology utilized with the assistance of portable fundus cameras and OCT machines. High-quality images that can be captured are forwarded for specialist review. It inhibits repeated face-to-face visits and facilitates repeated monitoring of chronic diseases while ensuring access to eye care (Rathi et al., 2017).

2.3 Wearable Devices

Another cutting-edge technology that has the potential to revolutionize ocular diagnostics is wearable technology. The development of wearable IOP sensors and smart contact lenses will allow for continuous monitoring of ocular parameters, which will be especially helpful for disorders like glaucoma. (Kang & Park, 2020)

For example, glucose levels in tears are being measured using smart contact lenses, a non-invasive way to monitor diabetes, which is extremely closely linked with a number of ocular conditions. Similarly, wearable sensors for IOP can provide real-time feedback on variations in intraocular pressure, enabling more accurate glaucoma management (41).

3. Challenges and Limitations in Ocular Diagnostics

3.1 Accessibility and Affordability

Despite all these advancements in eye diagnostics, there is still a lot of barrier yet to be overcome for such technologies to ensure equal access to the world populations. Their accessibility may be restricted because of the prohibitive cost factor, particularly among most individuals from low- and middle- income countries (42).

Global differences in healthcare infrastructure also translate to the fact that, while some areas are equipped with the latest diagnostics, others are still using old-fashioned methods, which results in late diagnosis and poor outcomes. It will require combined effort to reduce the cost of diagnostic technology and push the world healthcare system to try and meet these differences.

3.2 Technological and Ethical Concerns

Ocular diagnostics is rapidly developing and poses a number of ethical as well as technological issues. Promising though the use of AI in diagnostics may be, it provokes issues with data privacy, algorithmic bias, and the necessity for proper validation prior to clinical use(43).

Furthermore, there are also ethical concerns with respect to patient consent, genetic bias, and treatment of genetic

information that are evoked by the extensive use of genetic testing in ophthalmology. For these reasons, strict ethical principles and regulations have to be established so that advantages of new technology are gained without sacrificing the rights of patients (44).

Conclusion:

Ocular diagnostic has immensely transformed the practice of ophthalmology and optometry by substantially facilitating the early identification, follow-up, and treatment of ocular ailments. Invention of the diagnostic technologies of Optical Coherence Tomography (OCT), fundus photographs, and gene testing has empowered clinicians to diagnose diseases such as glaucoma, diabetic retinopathy, and age-related macular degeneration (AMD) at a preclinical level, thereby permitting early interventions and more personalized therapy regimens. This has not only enhanced patient outcomes but also prevented permanent vision loss, improving the quality of life in patients.

A major impact of these technologies is the movement toward personalized medicine. The inclusion of ocular diagnostics in retinal disease treatment, particularly the treatment of AMD using anti-VEGF therapy, underscores the importance of monitoring on an ongoing basis. OCT has made it possible to have individualized treatment plans based on disease progression, leading to better care and reducing risks from unnecessary procedures. Similarly, the increasing use of genetic testing to identify inherited retinal diseases is a reflection of the role of precision diagnostics in delivering targeted therapy, such as gene therapy.

The future of ocular diagnostics is vast with the advent of future technologies. Machine learning (ML) and artificial intelligence (AI) hold the promise to revolutionize eye care, particularly in environments with limited resources where access is limited to trained experts. AI models have performed impressively to diagnose retinal conditions from OCT scans and fundus images and often match, if not better, the results of human professionals. This holds out the prospect of bridging the eye care accessibility gap across the globe.

Teleophthalmology, another emerging specialty, holds the potential to enhance access to rural areas and disadvantaged groups. Telemedicine-based remote diagnosis and monitoring of eye conditions using portable imaging devices can reduce healthcare disparities. The expansion of teleophthalmology, especially during the era of the COVID-19 pandemic, has validated the feasibility of remote care, reducing the requirement for in-person visits and facilitating continued surveillance of chronic conditions such as glaucoma and AMD.

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A Narrative review on Dynamic Retinoscopy: A method for Assessment of Accommodation

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Abstract

Dynamic retinoscopy is a critical tool in the clinical assessment of the accommodative function and binocular vision anomalies. Unlike static retinoscopy, which measures refractive errors under relaxed accommodation, dynamic retinoscopy evaluates the eye's response to accommodative stimuli in real-time. This narrative review provides an in-depth examination of dynamic retinoscopy, discussing its principles, techniques, clinical applications, and future directions. Emphasis is placed on understanding its role in diagnosing accommodative dysfunctions and enhancing patient care in various clinical settings.

Introduction

Retinoscopy, an essential procedure in optometric and ophthalmologic practice, allows practitioners to determine the refractive status of the eye. Traditional static retinoscopy evaluates refractive errors with accommodation at rest, typically under cycloplegia.^[1] Dynamic retinoscopy, however, assesses the accommodative response to near stimuli, offering a more comprehensive view of the visual system's functional state. This review aims to elucidate the principles, techniques, and clinical applications of dynamic retinoscopy, highlighting its significance in contemporary vision care.

Principles of Dynamic Retinoscopy

Understanding Accommodation

Accommodation is the process by which the eye alters its optical power to maintain a clear image on the retina as the distance to the object of regard changes. This mechanism involves the ciliary muscle, lens, and zonular fibres working in concert to adjust the lens curvature. Dynamic retinoscopy evaluates the effectiveness of this process, providing insights into the accommodative function that static retinoscopy cannot offer.^[2]

Dynamic vs. Static Retinoscopy

Static retinoscopy measures refractive errors when the eye's accommodation is relaxed, typically under the influence of cycloplegic agents.^[1-6] In contrast, dynamic retinoscopy assesses the accommodative response to near targets in a non-cycloplegic state, reflecting the eye's natural functioning. This distinction makes dynamic retinoscopy invaluable for evaluating accommodative and binocular vision functions in real-world scenarios.

Techniques of Dynamic Retinoscopy

There are three basic methods of dynamic retinoscopy: the monocular estimate method (MEM), the Nott method and the bell method. In all these techniques, the retinal conjugate's location is ascertained by monitoring the retinoscopic fundus reflex while the patient is focusing on a close object.

Monocular Estimation Method (MEM) Retinoscopy

MEM retinoscopy is a widely used dynamic retinoscopy technique. It involves the patient fixating on a near target while the practitioner observes the reflex of the retinoscope beam. Lenses of varying powers are introduced to neutralize the reflex, thus determining the accommodative response. MEM retinoscopy is particularly useful for assessing the lag of accommodation, which is the difference between the accommodative response and the demand. The normal lag of accommodation is +0.75D.

[3] If MEM reveals more lag of accommodation $>+0.75D$ that means there is possibility of near esophoria, accommodative insufficiency, or uncorrected hyperopia. If the system shows a lead of accommodation or overaccommodation then there is a possibility of near exophoria or spasm of accommodation.

Nott Retinoscopy

Nott retinoscopy, another common dynamic technique, involves the practitioner moving the retinoscope back and forth along the visual axis as the patient focuses on a near target.^[5] The point where the reflex is neutralized indicates the accommodative response. Nott retinoscopy is effective in identifying the accommodative lag or lead and is relatively straightforward to perform. For the purpose of calculating the accommodation lag, the accommodation response, expressed in dioptres, is deducted from the accommodation demand (2.50D at 40 cm).

Book Retinoscopy

Book retinoscopy is a more naturalistic approach where the patient reads a book or a detailed target at a comfortable distance. The practitioner observes the retinoscopy reflex and introduces lenses to neutralize the reflex, assessing the dynamic accommodative response during a real-world task.^[4] This technique is beneficial for evaluating visual performance in everyday activities.

Clinical Applications

Diagnosing Accommodative Dysfunctions

Dynamic retinoscopy is instrumental in diagnosing various accommodative dysfunctions, including accommodative insufficiency, excess, and infacility. By assessing how the eye responds to accommodative demands, practitioners can identify abnormalities that may not be apparent with static retinoscopy alone. For instance, accommodative insufficiency, characterized by an inability to sustain near focus, can be detected through dynamic retinoscopy's assessment of the accommodative lag.

Evaluating Binocular Vision Anomalies

Dynamic retinoscopy also plays a significant role in diagnosing and managing binocular vision anomalies such as convergence insufficiency and divergence excess. By evaluating the accommodative-convergence relationship, clinicians can develop targeted treatment plans. For example, in convergence insufficiency, dynamic retinoscopy can reveal a lag in accommodation that contributes to the condition, guiding appropriate therapeutic interventions.^[3]

Assessing Visual Performance in Specific Populations

Dynamic retinoscopy is valuable for assessing visual performance in populations with special needs, such as children with learning disabilities or individuals with traumatic brain injuries. These populations often exhibit unique visual challenges that static retinoscopy may not fully capture.

Dynamic retinoscopy provides a more detailed understanding of their accommodative function, allowing for tailored interventions to improve visual comfort and performance.

Discussion

Advantages and Limitations

Dynamic retinoscopy offers several advantages, including real-time assessment of accommodative function and the ability to diagnose conditions that static retinoscopy might miss. However, it also has limitations, such as inter-practitioner variability and the need for considerable expertise. The technique's accuracy depends on the practitioner's skill and experience, highlighting the importance of thorough training.

Future Directions: Future research should focus on standardizing dynamic retinoscopy techniques to reduce variability and improve reliability. The development of automated systems and digital tools could enhance the accuracy and efficiency of dynamic retinoscopy, making it more accessible and user-friendly. Additionally, exploring the application of dynamic retinoscopy in tele-optometry could expand its reach, providing comprehensive eye care to underserved populations.

Integration with Modern Technology

The integration of modern technology with dynamic retinoscopy holds significant promise. Digital retinoscopes with enhanced imaging capabilities can provide more precise measurements and real-time analysis. Furthermore, advancements in artificial intelligence could lead to automated interpretation of dynamic retinoscopy findings, reducing practitioner variability and improving diagnostic accuracy.

Conclusion

Dynamic retinoscopy is a crucial tool for assessing the accommodative and binocular functions of the eye. Its ability to provide real-time information about the accommodative response makes it invaluable in diagnosing and managing various visual anomalies. Despite its limitations, the continued evolution of dynamic retinoscopy techniques and the integration of modern technology are likely to enhance its clinical utility and application. By providing a comprehensive view of the eye's functional state, dynamic retinoscopy significantly contributes to improving patient care in optometric and ophthalmologic practice.

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