A TEXT BOOK ON

OPTICS AND REFRACTION

OATS

Ophthalmic Assistant Training Series

ARAVIND EYE CARE SYSTEM

The Training in Ophthalmic Assisting Series and Training in Eye Care Support Services Series were born from the vision and inspiration of one very special man, Dr. G. Venkataswamy, founder of Aravind Eye Hospitals and guiding light in the world of eye care and community ophthalmology.

We dedicate this effort to him.

Intelligence and capability are not enough. There must also be the joy of doing something beautiful. Being of service to God and humanity means going well beyond the sophistication of the best technology, to the humble demonstration of courtesy and compassion to each patient.

- Dr. G. Venkataswamy

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Ophthalmic Assistant Training Series (OATS)

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This series of modules can be improved with your help. If you have ideas or suggestions for ways the OATS could better meet your needs, please write to Aravind Communications, C/O Aravind Eye Hospitals or email to communications@aravind.org. We welcome your comments and experiences.

Foreword

The discipline of eye care requires a number of appropriately trained personnel working as a team to deliver comprehensive eye care. The services that are delivered must include the promotion of eye health, the preservation of sight and the prevention of vision loss, restoration of sight when it is lost, the enhancement of vision and functional vision, where feasible and facilitation of rehabilitation through vision substitution. Various cadres of trained personnel, with complementary skills contribute to the work of the team.

In an ideal world, with infinite resources there would be a temptation to use the most highly trained personnel to carry out these tasks. This is neither appropriate nor cost effective, given that human resources for health care comprise the most expensive component of the recurring health budget.

It has been possible to select, train and deploy different cadres of human resources, to carry out tasks in a safe and effective manner to help achieve the goal of eliminating avoidable blindness. One of such cadres is variously referred to as Ophthalmic Assistants, mid level personnel or by their primary functions, such as Nurses, Refractionists etc. Where they exist and function in a stipulated manner, it is acknowledged that they constitute an effective backbone for eye care services. However a critical element to their success lies in the adequacy and appropriateness of the training imparted to them.

There have been several training programmes put in place around the world to train such mid-level personnel depending on the one hand, on the human resource needs for eye care in the country, and the local human resource policies, rules and regulations, on the other.

The Aravind Eye Care System, over the years has developed a cadre of Ophthalmic Assistants who have specific job descriptions. To enable them to perform effectively as part of the eye care team, their training has been task oriented with defined requisite knowledge, skills, competencies and attitudes, to carry out the tasks.

This manual sets out in several sections a step by step method for imparting such task oriented training through didactic, hands on and practical training in real life situations. The sections relate to tasks required of such personnel in different settings in the eye care delivery system such as the out-patient department (general and specialist clinics), wards, operating rooms, optical departments etc. Considerable emphasis has been paid to diagnostic technology, which is increasingly a part of the armamentarium in eye care practice.

Finally the manuals include sections for self assessment as well as for continuing monitoring of the achievements of task oriented objectives. The manual lends itself to translation into local languages where required proficiency in English may not exist. The Human resource Development team at Aravind Eye Care System need to be complimented on their efforts to share there wide and successful experience in this field with others who are already involved in or are planning to venture into such training programmes, particularly in the context of VISION 2020: the Right to Sight.

Dr. Ramachandra Pararajasegaram MB., FRCS., FRCP., FRCOphth. DSc. (Hon)
Past President, IAPB, Co Chair,
Human Resource Programme Committee, IAPB.

Preface

In recent years there have been significant advances in eye care, both in technology and in the increasing resolution to address the scourge of needless blindness. Achievements in medical technology have vastly improved diagnosis, treatment and surgery in all aspects of eye care, and efforts like the global initiative "VISION 2020: The Right to Sight" -- which calls for the elimination of avoidable blindness by the year 2020 -- have galvanized support for those working to improve the quality of eye care at the grassroots level around the world.

It has become increasingly evident that trained personnel is one of the most important elements in achieving this goal, and that the effective practice of eye care is a team effort that must combine the talents of ophthalmologists, ophthalmic assistants, ophthalmic technicians, orthoptists, counsellors, medical record technicians, maintenance technicians, and others.

Currently the focus in human resource development continues to be on the training of ophthalmologists. But in many successful eye hospitals it has been shown that four or five trained ophthalmic assistants are engaged to supplement and support the work of an ophthalmologist. When such assistants are used effectively by eye care centres, doctors can treat more patients in less time while still ensuring a high standard of care. It is therefore vital that more attention be paid to the structured training of other ophthalmic personnel.

Over the past three decades, Aravind Eye Hospital has developed and refined a system of structured training programmes for ophthalmic assistants and support services personnel. These series were created to bring together the lessons we have learned over the years, and to share our insights with other eye care programmes and the community at large.

Dr. G. Natchiar
Vice-Chairman, Aravind Eye Care System

Blindness Prevalence

World wide it is estimated that at least 38 million people are blind and that an additional 110 million have severely impaired vision. In all, about 150 million people are visually disabled in the world today, and the number is steadily increasing because of population growth and aging. Overall, the data shows that more than 90% of all blind people live in developing countries and that more than two-thirds of all blindness is avoidable (either preventable or curable). Unfortunately, little information is available on the incidence of blindness around the world; it seems probable, however, that there are some 7 million new cases of blindness each year and that despite every intervention, blindness in the world is still increasing by 1 to 2 million cases a year. Thus, trend assessment points to a doubling of world blindness by the year 2020 unless more aggressive intervention is undertaken.

A major cause of preventable blindness is cataract. Presently, an estimated 7 million cataracts are operated on each year. There is a backlog of 16 million cases that have not yet been operated on. If this backlog is to be eliminated in the next two decades…a staggering 32 million cataract operations must be performed annually by the year 2020.

In addition, there must be an improvement in technology because more than 50% of cataract surgeries in the least developed countries today are still performed without intraocular lens implantation. Thus, most of the developing countries need more surgery facilities, supplies and equipment, and an increased number of trained surgeons. Furthermore, particularly in sub-Saharan Africa, India, China and other parts of Asia, the volume of cataract surgeries must increase greatly. Although considerable progress is being made in some of these countries, the provision of good quality, affordable cataract surgery to all those in need will nevertheless remain the main challenge for ophthalmology world wide for many years to come.

An important aspect of combating cataract blindness is human resource development. To increase the efficiency of ophthalmologists in clinical work, further training of support staff such as paramedical ophthalmic assistants, ophthalmic nurses and refractionists is essential.

Introduction

In the past three decades, a number of auxiliary professionals such as ophthalmic assistants, opticians, certified orthoptists, research assistants and ultrasonographers have come to be identified as allied health personnel in ophthalmology. Although each of these groups provides a specific meaningful role in the ophthalmic field, it is the ophthalmic assistant (OA) who carries out or helps with certain tasks that were traditionally and uniformly performed by the ophthalmologist.

These tasks involve collecting data and recording measurements on patients, preparing patients for surgery, assisting with surgery, offering postoperative care, and counseling patients. However, these tasks do not involve any judgments or conclusions such as diagnosis, disposition of treatment, or prescription. Ophthalmic assistants do not (and can not) supplant the physician but rather supplement the ophthalmologist by rendering support services. Their broad areas of work include outpatient and refraction departments, operation theatre, wards, and patient counseling.

The ophthalmic assistants in all these areas make vital contributions to the achievement of high quality, high volume, and financially sustaining eye care in large volume settings.

Ophthalmic Assistant Training

Objective

To provide eye care programmes/hospitals/practitioners in developing areas with lessons learned regarding the work of trained ophthalmic assistants and their critical contributions to high quality, large volume, sustainable eye care.

To describe the valuable role of trained OAs and patient counselors in outpatient and refraction departments, operating theatres, wards and patient counseling. To illustrate ways for existing programmes to increase their volume, quality and sustainability through the development and utilization of paramedical personnel.

To provide curriculum and materials for training the OAs in all areas. To elicit feedback from users regarding the strengths and weaknesses of this first edition.

Definitions

The ophthalmic assistant (OA) is a skilled person whose academic and clinical training qualifies to carry out ophthalmic procedures. These are done under the direction or supervision of an ophthalmologist or a physician licensed to practice medicine and surgery and qualified in ophthalmology.

At Aravind, based on their skills and performance, an ophthalmic assistant with at least five years of experience is upgraded to an ophthalmic technician. At Aravind the term nurse usually refers to registered nurse (RN) fully trained elsewhere in all aspects of nursing care. However, the term is some times used at Aravind in traditional operating theatre terminology, as in scrub nurse, running nurse, etc.

Ophthalmic assistant training

Recognizing the importance of ophthalmic assistants in eye care service delivery, Aravind established its in-house training program to meet its own need for trained Ophthalmic Assistant staff. Yearly two batches of 17 to 19 year old candidates (35-40 students in each batch) who have cleared their high school examinations (plus two) are selected based on the eligibility criteria deemed appropriate by the institution.

Structure of the OA training programme at Aravind

Basic training: Four months observation and classroom learning

Specialisation: Eight months demonstration training and practice

Probationary Period: One year on the job training under constant supervision

The basic training portion includes studies and practice in

- Basic general anatomy and physiology
- Ocular anatomy, eye diseases and emergency management
- Skills such as
  - Visual acuity testing
  - Tonometry
  - Lacrimal duct patency
  - Blood pressure management
  - Bed making
  - Human relations, communication skills and compassion

On completing the four-month basic training, students take one of the specialization courses:

- Out-patient care (OPD)
- Operation theatre assistance
- In-patient care (Wards)
- Refraction

The next eight months are spent training in the specialty with lectures in the morning and supervised practical work in the afternoon. For the final 12 months, candidates work under close supervision.

The Aravind model of Ophthalmic Assistant staffing

The role of trained Ophthalmic Assistant staff in facilitating high quality, large volume sustainable eye care is central to Aravind's successful large volume eye services. The principle of division of labor helps to maximize the skills of the ophthalmologist by developing a team approach with auxiliary personnel. Efficient eye care service delivery depends on optimum utilization of all categories of resources – human resources, equipment, instruments, beds and financial.

At Aravind, the concept of human resource development evolved in response to increasing need for OAs and to provide adequate clinical experience to develop their professional competence.

Human resource development is one of the important components of large volume eye care. The history of Aravind's Ophthalmic Assistant training can be traced back to 1970-1972 when its founder, Dr. G. Venkataswamy , was Professor and Head, Department of Ophthalmology, Madurai Medical College.

Trained and skilled human resources are critical and therefore must be utilized optimally. Typically, an ophthalmologist's repertoire of work involves administrative tasks, skilled but repetitive tasks, and judgement-based tasks. An ophthalmologist's unique competence lies in judgement-based tasks such as interpreting investigative findings and decision-making tasks such as delineating the line of treatment or surgery.

Administrative and repetitive tasks can often be done (and better also) by a non-ophthalmologist who has been adequately trained.

In large volume eye care programs, efficient and knowledgeable Ophthalmic Assistants play a vital supportive role in many areas of ophthalmic care.

About the Ophthalmic Assistant Training Series (OATS)

The Ophthalmic Assistant Training Series responds to the desire of many organisations and institutions around the world to provide high quality and high volume eye care.

The contribution of the ophthalmic assistants to this work is fundamental.

The Ophthalmic Assistant Training Series is a set of manuals explaining the principles and techniques for increasing high quality and high volume eye care through the use of paramedical staff.

Each module is based on the practices of Aravind Eye Hospitals in South India.

The intent of this series is to provide a format for Ophthalmic Assistant Training based on Aravind Eye Hospitals' "best practices", based on over 30 years of growing, changing, and learning from mistakes.

The five modules of OATS

1. **Introduction to Basics of Ophthalmic Assisting** : This is the foundation of the entire Ophthalmic Assistant Training. All the trainees are given general knowledge and training for the fundamentals necessary for their duties, as well as specific information about all activities required in their work.

2. **Handbook for Clinical Ophthalmic Assistants, Principles & Techniques of Clinical Ophthalmic Procedures:** Out-patient Department (OPD): This includes theory and practice of initial patient evaluations. An introduction to refraction is presented as well as steps for assisting the doctor.

   Ward: This contains all the information necessary for the smooth running of a Ward. Pre and post operative procedures and patient instructions, as well as management of emergency and post operative complications are discussed. Ward set-up and management and laboratory functions are covered.

3. **Handbook for Surgical Ophthalmic Assistants (Operation Room Services)**: Contains background and practical steps to the smooth running of a sterile theatre. Personnel requirements, roles and duties of theatre personnel including management of emergencies and medications, and assisting in specific procedures are detailed.

4. **A text book on Optics and Refraction:** All aspects of refractions are covered, including step- by step instruction for subjective and objective refraction, room set up, and equipment required. All types of refractive errors are described as well as the methods of assessing them. The theories and practice of visual fields, ultrasonography, contact lens fitting, low vision aids and optical dispensing are included.

5. **Role of Counselling in Eye Care Services - A practical guide :** Helping patients help themselves. The importance and types of patient interaction are discussed in detail. Basics of communication and specific examples are presented.

About Training in Eye Care Support Services Series (TECSSS)

The Training in Eye Care Support Services Series (TECSSS) responds to the desire of many organisations and institutions around the world to train support services personnel to provide high quality and high volume eye care.

The Training in Eye Care Support Series is a set of manuals explaining the principles and techniques for the effective procedures to be followed by the support services personnel.

Each module is based on the practices of Aravind Eye Hospitals in South India.

The intent of this series is to provide a format for Training in Eye Care Support Services based on Aravind Eye Hospital's "best practices", based on over 30 years of growing, changing, and learning from mistakes.

The three modules of TECSSS

1. **Housekeeping in Eye Care Services - A practical guide :** The invisible "bottomline" for patient safety and satisfaction. Cleanliness, appearance, maintenance, attitude are all essential for the entire hospital and OPD. Duties, responsiblities and specific tasks are covered.

2. **Medical Records Management in Eye Care Services - A practical guide** : A complete guide to establishing and running an efficient medical records department: information retrieval, generating statistics, personnel requirements, importance of accuracy.

3. **Optical Sales and Dispensing - A practical guide :** This gives clear guidance about the various spectacle lenses and frames, how to fit the lens into frame, the technical measurement and sales procedure.

REFRACTION IN EYE CARE SERVICES

- A PRACTICAL GUIDE

Ophthalmic Assistant Training Series

Acknowledgements

We take great pleasure in presenting the Handbook for Clinical Ophthalmic Assistants (Priniciples & Techniques of Clinical Ophthalmic Procedures) which is the consummation of many years of experience and tireless efforts by Aravind's ophthalmic assistant training department.

We acknowledge Seva Foundation's help through a series of volunteers who coached our team, helped in designing the structure, edited the contents, ensured academic rigor and making it relevant for transfer to a larger global audience, under the initiative of Dr.Suzanne Gilbert. In addition Seva Foundation is covering a part of the production costs. Sight Savers provided the initial stimulus and support for understanding the role of ophthalmic assistants in a broader context and in the development of a draft curriculum. We express our gratitude to Mr. David Hirschman for editing the manual.

We express our sincere thanks to Dr.Pararajasegaram for contributing foreword to the series.

We take this opportunity to thank Aravind Publications Department particularly Mr.K.V.S.Lakshmanan, Consulting Editor, for his contribution to the final edition and to Ms. Dhanalakshmi, Ms. N. Deepa, Mr. Ramraj & Mr. Veeranayagam whose team effort has resulted in the fruition of this manual. We are grateful to Ms. Pattammal for co-ordinating the contributions from various sources and also for her contribution in editing the manual.

Finally we sincerely thank the senior leadership team of Aravind Eye Care System particularly our Vice - Chairman Dr. Natchiar for the constant support and encouragement.

The Ophthalmic Assistants team

Aravind Eye Care System

REFRACTION IN EYE CARE SERVICES
- A PRACTICAL GUIDE

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CHAPTER 1 AN ORIENTATION TO REFRACTION CHAMBER

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Introduction
Equipments needed in refraction chamber
Cubicle dimension and space management in refraction unit
Arrangements

GOAL

To impart the Ophthalmic assistant (OA) knowledge about how to set up the refraction room, with necessary equipment and instruments needed to do refractive evaluation for prescribing power of glasses and for correcting the patients' visual problem

OBJECTIVES

The OAs will understand

- How to arrange the refraction testing room
- The instruments and equipment needed for prescribing the power of glasses for patients
- The principles and uses of the instruments used in refraction

CHAPTER 1

An Orientation to Refraction Chamber

Introduction

Refraction chamber is very essential in eye care practice for doing preliminary vision assessment of all patients and also to know the impact of their diseases/disorders.

A refraction chamber is a technical unit, a semi-dark room 3 or 6 metres in length and 1½ metres in width. Refraction evaluation is done to prescribe suitable glasses for correcting the patient's vision problems, and for carrying out individualised visual needs in terms of subjective and objective refraction.

Equipments needed in refraction chamber

General equipment

- Plane mirror to reflect the Snellen's chart letters
- Adjustable illumination set for variable light conditions mainly for near vision assessment
- Torch for doing the preliminary examination

Clinical equipment

1. Trial frame and standard trial lens set / phoropter
2. Streak retinoscope
3. Snellen's vision drum / chart projector
4. Near vision chart
5. Auto refractometer
6. Accessory lenses: Occluder, Pinhole disc, JCC, Maddox rod, Stenopic slit and Red and Green and prism lenses
7. Prism bar
8. PD ruler
9. RAF Ruler
10. Color vision chart
11. Topical drugs - mydriatic and cycloplegic agents
12. Lensometer

Trial lens box: Trial lens set is the primary and most essential device in a refraction chamber (Fig. 1.1). A standard trial lens set contains a pair of plus and minus lenses on each power in sphere and cylinder form. The spherical lenses are available in the ranges from 0.12 D to 20.0 D and the cylindrical lenses from 0.12 D to 6.0 D. The accessory lenses are occluder, pinhole disc, stenopic slit, Maddox rod, Red and Green goggles and prisms from 0.5 to 12.0 D are

Fig. 1.1 - Trial lens box

also available in the trial set. All trial lenses are mounted either by a metal or plastic rim with hand grip for easy handling. In cylindrical lens, axis meridian is indicated by special marks and comes without handle for easy rotation. Prism has its apex and base marked on the lens.

Fig. 1.2 - Occluder

Occluder: Occluder is an opaque disc used to close or cover one eye during refraction examination (Fig. 1.2). It blocks one eye vision while performing the test on the fellow eye, so that we can check each eye separately. In occluder, the opaque disc is mounted either in metal or plastic rim with hand grip for easy handling.

Pinhole: Pinhole is an opaque disc used for determining whether the decreased vision is due to refractive error or due to pathological diseases of the eye (Fig. 1.3). It actually reduces the retinal blur and allows the central light rays to reach the macula (retina) which enhances vision. Pin holes are available in the ranges of 1mm, 2mm in diameters. The optimum size of 1.32 mm is recommended as a standard one. Multiple pinholes are a better option if patient is not able to view through the visual axis and for patients with low vision.

Fig. 1.3 - Pinhole

Maddox rod: Maddox rod is constructed of a series of red cylindrical rods (Fig. 1.4). Each rod acts as a strong '+' cylindrical lens that forms a red streak band before the eye. It is used to detect the presence of heterophoria and to measure the amount of heterotropia.

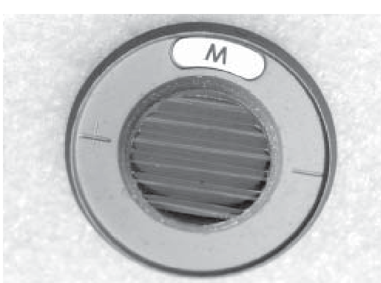

Fig. 1.4 - Maddox rod

Stenopic slit : It consists of a rectangular aperture with a linear slit 1mm in width and up to 15 mm in length (Fig. 1.5). It is useful for refining the axis of high irregular astigmatism.

Fig. 1.5 - Stenopic slit

Red and Green filters: Red and green goggles are mainly used in checking the binocular single vision by worth's four dot test and stereopsis test using TNO charts.

Jackson Cross Cylinder (JCC): JCC is a combination of minus and plus cylinder power, the same power located perpendicular to each other and supported with hand grip (Fig. 1.6). The axis of two cylinders is marked in white and red colors. The white mark indicates the axis of '+' cyl and the red indicates the axis '-' cyl. It is used for determining the power and for refining the correct axis. Cross cylinders are available in 0.12D, 0.25D, 0.50D and 1.0D powers.

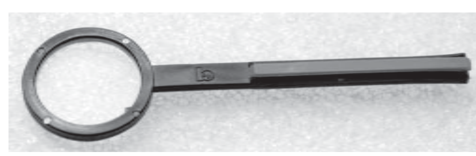

Fig. 1.6 - Jackson cross cylinder

Trial frame: The trial frame is a metallic / plastic frame for holding the trial lenses before the eye during refraction (Fig. 1.7). Each eye frame is constructed of three cells on front side and one on back side. The front three surfaces of the trial frame are used for keeping the spherical, cylinder and other accessories i.e. occluder, pinhole etc. The second front cell is arranged for placing the cylindrical lens and the axis is marked counterclockwise. The extreme forward cell is molded with three knobs with support to place the lens accessories.

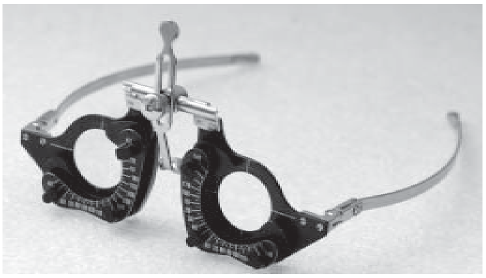

Fig. 1.7 - Trial frame

Like spectacles, two eye frames are being mounted by an adjustable bridge and sides. It is necessary to adjust the trial frame depending on the patient's pupillary distance before starting the refraction test. Special trial frames are available for children and for doing low vision refraction.

Retinoscope: Retinoscope is one of the most essential tool for determining the patient's refractive status objectively (Fig. 1.8). Retinoscope is the only device to estimate the refractive errors of those who are unable to co-operate, particularly children and mentally retarded persons.

Fig. 1.8 - Retinoscope

Retinoscope is basically available in two types. They are spot retinoscope and streak retinoscope. In the early days, the spot retinoscope was used widely and now the streak retinoscope is popular among the practitioners because of its simple and easy principles.

Phoropter: Phoropter or refractor is exclusively designed for refraction (Fig. 1.9). It is comprised of spherical lens, cylindrical lens, prisms and all types of auxiliary lenses. It is also equipped with Jackson cross cylinder. Although the trial lens/frame is used widely, a phoropter is capable of doing all the tests such as JCC test, duochrome test, measurement of phoria and tropia and the binocular vision test.

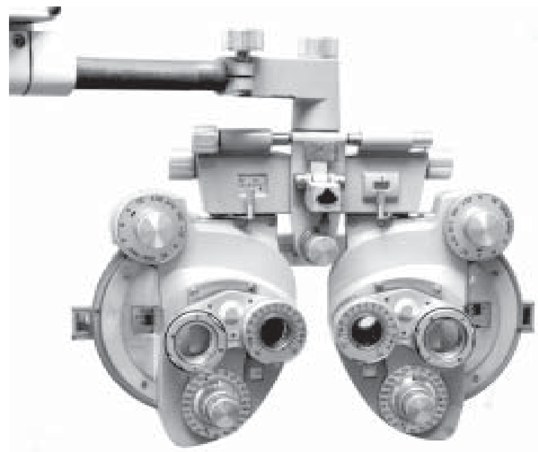

Fig. 1.9 - Phoropter

Auto refractometer: Auto refractometer represent the most advance technology of measuring the refractive powers of the eye. It is easily operated even by non technical persons (Fig. 1.10). It provides a quick reliable guideline for the objective refraction.

Fig. 1.10 - Auto refractometer

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Colour vision: Ishihara color vision plates are used for screening for color blindness. This chart helps to detect red and green color deficiencies. It contains 38 plates includes 25 numerals plates and 13 pathway plates.

Lensmeter: The procedure used to measure the corrective lens powers i.e. sphere, cylinder and axis and prism or the power of rigid contact lenses is called lensometry. It is performed with a specialized instrument known as lensmeter or focimeter.

PD ruler scale: The interpupillary distance is measured using a PD ruler. Interpupillary distance is the distance between the center of pupils in millimeters. This measurement should be obtained for both near and distance for each patient.

RAF ruler: RAF ruler is the instrument used for measuring the ability of accommodation and convergence (Fig. 1.11). It also provides the dioptric value of accommodation and convergence of the patient.

Fig. 1.11 - Royal air force ruler

Prism bar: There are two prism bars in a box. One is for measuring horizontal deviation, the other for vertical deviation (Fig. 1.12). These bars are used for finding the fusional range.

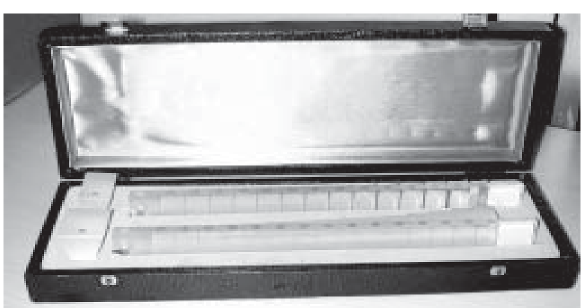

Fig. 1.12 - Prism bar

Topical drugs

Mydriatics

Mydriatics causes the pupils to dilate, usually by stimulating the iris dilator muscle. It is used to facilitate the retinoscopy to the patients having opacity of visual axis and for funduscopy.

Cycloplegics

These drugs essentially paralyze the iris sphincter muscle causing dilation of the pupil. These agents also limit or prevent accommodation by paralysing the ciliary muscle, which controls the ability of the lens to expand and contract. Cycloplegic refraction is especially important in children, who have a strong accommodative mechanism that frequently interferes with accurate refraction.

Furniture

Standard furniture aids in refraction testing for obtaining the result very quickly. The movable revolving chairs may be a better option to the practitioners so that they can easily approach the patient. For the patient, a sophisticated chair for comfortable seating may be provided.

Cubicle dimension and space management in refraction unit

Normally the refraction room is arranged in a adequately long compartment with a dark environment because vision assessment is being done at a distance of 6 metres. Alternatively it can be planned in 3 metres distance by using a reversible letters on a chart that is reflected through a mirror towards the patient’s view.

Generally the refraction room may be arranged in a more spacious place to examine the patient as well as provide accommodation to the patient’s attendants. According to the space availability, plan the refraction cabin. Now many institutes prefer to have a 3 metre testing distance unit because of limited space. The following diagram illustrates the measurements and how to set a refraction testing room in three metres testing method.

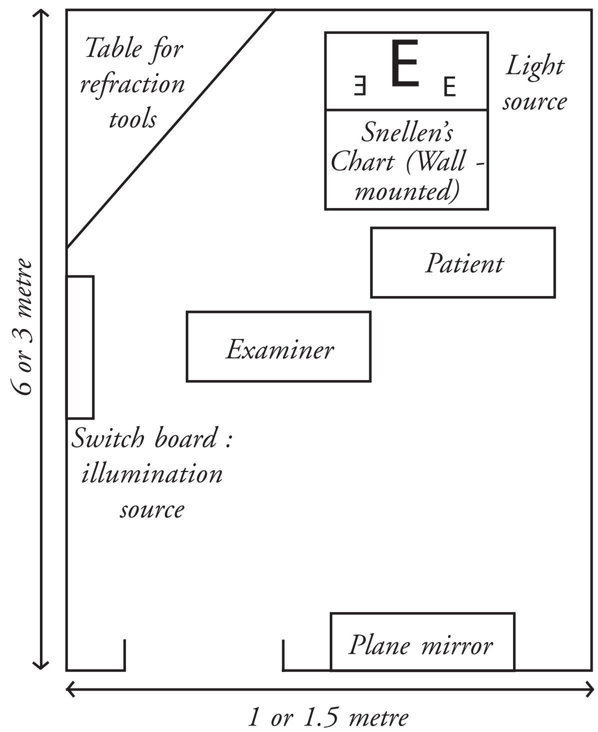

Fig. 1.13 - Floor plan of refraction chamber (3m chart)

Arrangements

The refraction room arrangements and location of the furniture should facilitate the examination as well as make the patient comfortable .Patient is seated to the right side of the examiner for easy approach.

Snellen's drum is positioned straight over the patient's head and the mirror placed straight in front of the drum at 3 metres so that all letters can be seen clearly in the patient's normal viewing.

The adjustable illumination set is fixed by the side of the patient for near vision assessment. This can be adjusted while doing retinoscopy. The illumination level required is 19 foot candles (60W filament bulb which are equal to normal sunlight condition). For the proper illumination of the refraction room and air circulation standard electrical fittings are essential. The controlling switches should be located near the examiner for easy operation. Similarly assessment record forms / glass prescriptions forms are to be kept near the examiner.

Summary

In this unit we have covered the refraction room set up with all the necessary equipment. The length and breadth of the room, the lighting arrangement and the furniture details are also given. Details about the equipment with their uses will help the student identify the equipment and use it appropriately.

Key points to remember

- *Vision assessment is a major tool in knowing the impact of diseases / disorders.*
- *Refraction is an essential assessment in restoring the potential vision by optical correction.*
- *Well - furnished refraction rooms facilitate comfortable refraction to both the patient and the practitioner*

Student exercise

Answer the following

1. *Where will the trial set be kept?*
2. *What is the distance between the drum (chart) and mirror?*
3. *What is the diameter of the hole in the streak retinoscope?*
4. *What is the diameter of the pinhole?*
5. *What is the use of the pinhole?*
6. *What are the uses of red and green glass?*
7. *Describe about the arrangements in the trial frame.*
8. *What is a retinoscope?*
9. *Mention the tests that could be done with phoropter.*
10. *Give a short note on refraction cubicle.*

CHAPTER 2 OPTICS

CONTENTS

Properties of light
Refractive index
Prisms
Lens
Vergence

GOAL

To enable the ophthalmic assistant (OA) will learn about the properties of light and the different laws of reflection and refraction

OBJECTIVES

The OAs will be able to

- Apply the laws of reflection and refraction
- Use prisms and lenses as refraction devices
- Differentiate between positive and negative lens
- Measure lens power and focal length

CHAPTER 2
Optics

Optics is the study of light. Light helps one to see.

Properties of light

1. Light travels in a straight line

Light travelling in a straight line represents a ray of light. A set of straight lines represent a beam of light. The beam may be parallel, converging or diverging.

The branch of optics based on this property of light is known as Geometrical Optics

2. Light gets reflected

When the light traveling in a medium is incident on another medium, part of the light is sent back into the first medium. This is reflection. The surface separating the two media is the reflecting surface. Sometimes this surface is coated (silvered) to increase reflection. When the surface is smooth and polished it is a regular reflection giving rise to an image. Irregular reflection (scattering) occurs when the surface is not smooth.

Laws of reflection

First Law: The incident ray, the reflected ray and the normal ray at the point of incidence on the reflecting surface are all in the same plane (Fig. 2.1).

Second Law: The angle of incidence is equal to the angle of reflection.

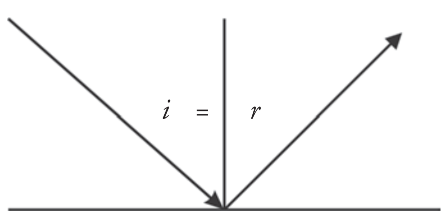

Fig. 2.1

The most important application of reflection is in the plane mirror. The use of such mirrors for cosmetics is well known. The image formed on a plane mirror is virtual (not real). It is of the same size as the object and is formed as far behind the mirror as the object is in front of it. The image has left / right inversion.

Plane mirror is used in refraction cubicles to reduce the length of the cubicle to half its length. However the Snellen's chart used with plane mirror will have objects with left right inversion so the patient sees the correct image inside the mirror.

3. Light gets refracted

When light travelling in one medium enters another there is deviation (bending) in its path. This is known as refraction which arises because of differences in the speed of light in different media.

Laws of refraction

First Law: The incident ray, the reflected ray and the normal ray at the point of incidence on the refracting surface are in the same plane (Fig. 2.2).

Second Law: The ratio of the sine of the angle of incidence to the sine of angle of refraction is a constant which is known as the refractive index of the second medium with respect to the first medium. (sin i / sin r = constant).

Refractive index

It is the ratio of speed of light in air to the speed of light in the medium. The speed of light in air is

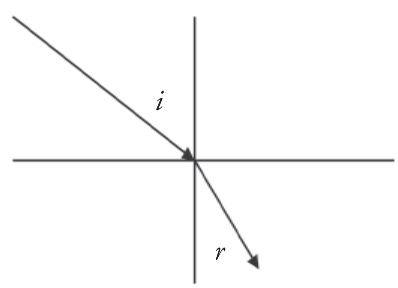

Fig. 2.2

maximum (180,000 m/s). Hence the refractive index of a medium is always greater than 1.

For air n = 1, for water n = 1.33, for glass n = 1.5

Prisms and lenses used in ophthalmic practices are refraction devices.

Prisms

A prism is a transparent triangular piece of glass or plastic. It has with two plane (flat) refracting sides, an apex (top) and a base (bottom) (Fig. 2.3). A ray of light incident to a prism is always bent towards the base of the prism. The image formed appears displaced towards its apex.

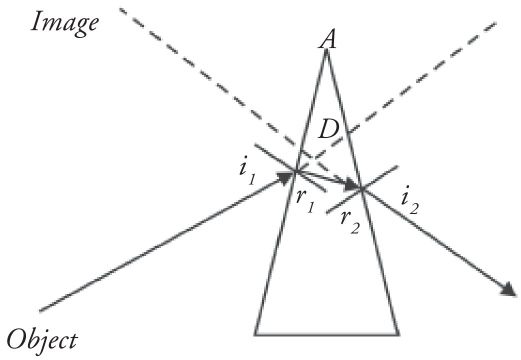

Fig. 2.3

$n = \sin i_1/\sin r_1 = \sin i_2/\sin r_2$

Angle of deviation $D = (i_1+i_2) - (r_1+r_2)$,

Angle of prism $A = r_2+r_1$

$D = i_1+i_2 - A$, When A is small, $D = (n\text{-}1)\ A$

For glass $n = 1.5$,

$D = (1.5 - 1)\ A = A/2$

The magnitude of the prism effect depends on the angle of the prism. Prisms are used to measure and also to correct muscular imbalance in patient's eyes.

Prism diopter

Prism power is measured by the extent of deviation produced as a light passes through it. If the displacement of the image of an object located 100 cm away from the prism is x cm when seen through the prism its power is x Δ (prism diopter) (Fig. 2.4).

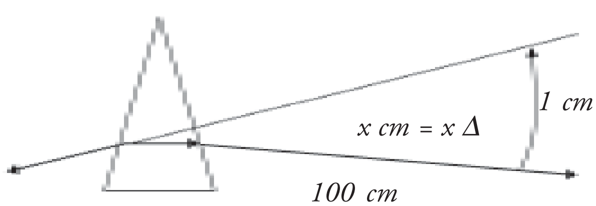

Fig. 2.4

Lens

A lens is a transparent medium bounded by two curved surfaces or one curved surface and a plane surface. Its most common application is correcting certain problems in eye sight.

Lenses can be of six different types (Fig. 2.5):

1. Biconvex lens - both sides are convex
2. Plano-convex lens - one side is plane, the other side is convex
3. Meniscus lens - convex meniscus: meniscus shaped with greater convex curvature
4. Biconcave lens - both sides are concave
5. Plano-concave lens - one side is plane and other side is concave
6. Meniscus lens - concave meniscus: meniscus with greater concave curvature

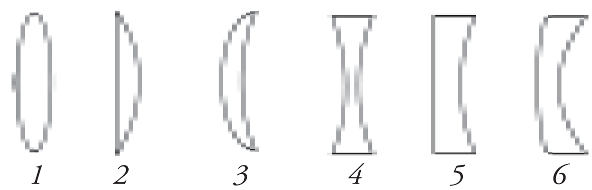

Fig. 2.5

To understand the working of lenses consider two prisms placed base to base. Light rays through them coverage (come together) at some point on the other side of the prism. Similarly if two prisms are placed together apex to apex, the ray will diverge (spread apart) on the other side of the prism (Fig. 2.6).

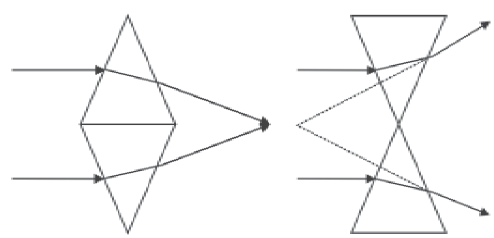

Fig. 2.6

In most applications the curved surface lenses are spherical (part of a sphere) and such lenses are called spherical lenses.

Lenses that converge a beam of light are known as converging, convex or positive lenses while those that diverge a beam of light are known as diverging, concave or negative lenses.

Some important terms relating to lenses

Optical centre: It is a point on a lens where a ray of light passing through it goes straight (there is no deviation).

Principal axis: It is the line joining the centres of curvature of the two curved sides of the lens. In case of plano-convex or plano-concave lenses it is perpendicular to the flat surface from the centre of curvature of the other curved surface.

Focal point (Principal focus): A beam of light parallel to the principal axis of a lens after refraction converges towards a point on the principal axis (convex lens) or appears to diverge from a point on the principal axis (concave lens). This is called the focal point. There are two focal points on either side of a lens at equal distances from the optic centre.

Focal length: The distance of the focal point from the optic centre is the focal length.

Power of a lens: The reciprocal of the focal length measured in metre units is the power of the lens in diopter (D = 1/ f). It is taken as positive for convex lenses and negative for concave lenses.

Focal length	Power
1 m	1 D
2 m	(1/2) = 0.5 D
(1/2) = 0.5 m = 50 cm	2 D
3 m	(1/3) = 0.3 D
(1/3) = 0.3 m = 30 cm	3 D

Power of a lens is the sum of powers of its two surfaces.

For a curved surface power P = (n – 1) / r, r being the radius of curvature of the curved surface measured in meter units.

For biconvex lens

$P_1 = (n - 1) / r_1$; $P_2 = (n - 1) / r_2$

Power of the lens: $P = P_1 + P_2 = \{(n - 1)/r_1\} + \{(n - 1)/r_2\}$

$P = (n - 1) (1/r_1 + 1/r_2)$

For a plano convex lens: The plane surface has no power. For the curved surface $P_1 = (n - 1) / r_1$, the total power is $P = (n - 1) (1/r_1)$

These are known as the lens maker's formula.

Formation of images in lenses

Two rays are used to locate the image. A ray of light passing through the optic centre goes undeviated. A second ray of light, parallel to the principal axis, after refraction in case of convex lens converges and proceeds in the direction of the focal point on the other side. In concave lens it diverges and appears to come from the focal point on the same side.

Characteristic of the image formed using a concave lens for all locations of the object

Image is formed on the same side of the lens as the object; virtual, erect and smaller in size (Fig 2.7). Concave lens is used in the correction of short sight (myopia). The eyes of a person wearing such a lens will appear smaller. This is one reason why people requiring high negative powers prefer contact lens instead of spectacle lens. Also the object seen through such a lens will appear farther than where they are actually located.

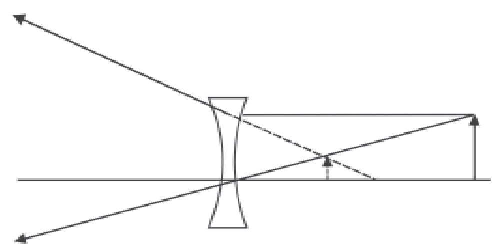

Fig. 2.7

Characteristic of the image in convex lens

Case (i): Object located between the lens and principal focus (Fig. 2.8).

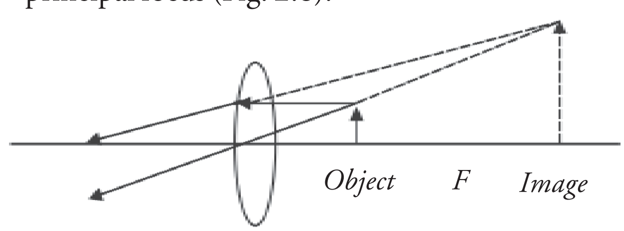

Fig. 2.8

Image if formed on the same side of the lens as the object; virtual, erect and magnified. This is the principle of a simple microscope, single loop and hand -held magnifier.

Case (ii): Object located between the principal focus (F) and twice the focal length (2F) on one side.

Image is formed beyond 2F on the other side, real, inverted and magnified (Fig. 2.9).

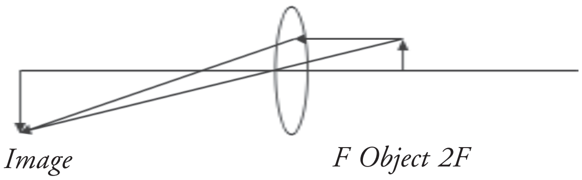

Fig. 2.9

Case (iii): Object beyond 2F on one side

Image is formed between F and 2F on the other side, real, inverted and smaller in size. Convex lens is used in the correction of long sight (hypermetropia / hyperopia). Objects seen through such a lens appear farther than where they actually are (Fig. 2.10).

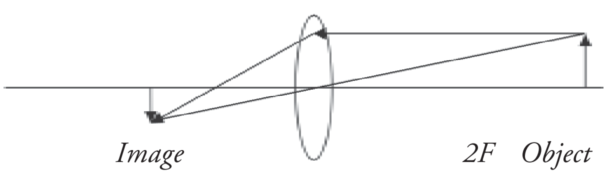

Fig. 2.10

Quick test for lenses

To distinguish between positive and negative lens look at an object at a distance from the lens and move the lens gently. If the image also moves in the same direction (with motion) it is negative lens. If the image moves in the opposite direction (against motion) it is positive lens.

Prism power in lenses: Prentice rule

A spherical lens has prism power for every point in it except for the optic center, at which the prism power is zero. In plus lenses, the prism power bends light rays toward the optic axis, and in minus lenses, it bends away from the optical axis. Prism power increases with the distance of the point from the principal axis.

Using the principle of similar triangles it can be shown that the prism power corresponding to point A at a distance 'y' from the principal axis is the product of the lens power and the distance y. This is Prentice rule (Fig. 2.11).

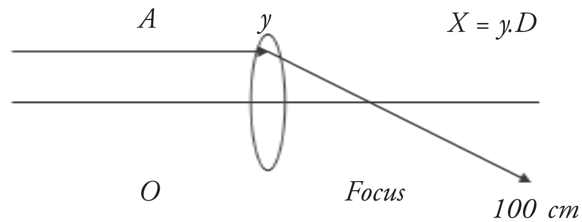

Fig. 2.11

This has application in designing the reading lens part of bifocal spectacle lens for patients with presbyopia. The prism effect helps in bending the rays up to avoid looking down through the reading lens and in reducing the convergence of the eye required for looking at close objects.

Decentration

Prism effect comes into play when the distance between the optic centres of the spectacle lens is not the same as the inter pupillary distance (IPD) of the patient. Looking through such spectacle lenses will cause discomfort. This is known as decentration.

Cylindrical lenses

Lenses in which one of the curved surfaces is cylindrical are known as cylindrical lenses. They are used in correcting astigmatism (Fig. 2.12).

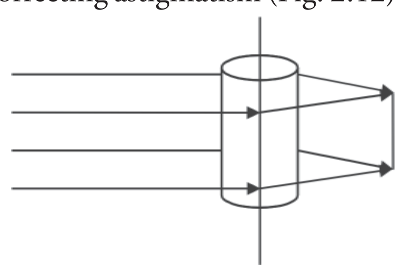

Fig. 2.12

A cylinder has no curvature in a direction parallel to its axis. So it has no refractive power in that direction. It is curved in the direction perpendicular to its axis and therefore has a refractive power. The refractive power of a cylindrical surface is also $P = (n - 1) / r$, as in the case of spherical surface, r being the radius of curvature of the cylinder. With a cylindrical lens one gets a focal line instead of a focal point.

Astigmatism arises when one of the patient's eyes has different powers in different axes. The extra power needs to be added or subtracted in any required axis with the help of positive or negative cylindrical lens.

Other properties of light

Some of the other properties of light are as follows. They arise because of the wave nature of light.

4. Scattering

Particles of dust, moisture, scratches on mirror, lens and prism surfaces cause scattering (irregular reflection) of light. Scattering results in loss of brightness and glare.

5. Interference

Light waves of same wavelength from different sources undergo interference. The waves reinforce (add up) producing brightness or destroy each other producing darkness. The interference effect is used in antireflection coating on the surfaces of spectacle lenses.

6. Diffraction

Because of the wave nature, light bends. This is known as diffraction. Since the wavelength of light is very small the bending is also very small and light appears to travel in straight line path. The diffraction effect limits the clarity of the final image formed in optical instruments including the eye.

7. Polarisation

Light waves are transverse in nature. The vibrations of electric field (or magnetic field) that constitute light are at right angles to the direction of propagation of light. Ordinary light is unpolarised and has vibrations in all directions. Unpolarised light passing through a device known as Polaroid has the vibration confined to one direction. Reflection of light (unpolarised) from some surfaces also gives rise to polarised light (Fig. 2.13).

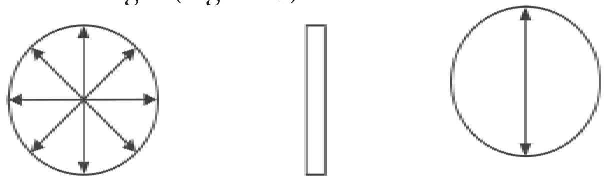

Fig. 2.13

When polarised light is viewed through a polaroid there is variation in the brightness of light seen through it depending on its orientation. The light is even cut off in two orientations. This property of Polaroid to cut out strongly polarised reflected light is used in special sun glasses known as Polaroid glasses.

Vergence

This is a useful concept used by optometrists in their calculations (Fig. 2.14).

A parallel beam of light neither converges nor diverges. Its vergence is defined as zero.

A converging beam of light has positive vergence while a diverging beam has negative vergence. The vergence of a beam is measured in dioptre units. The vergence of a beam at a location is the reciprocal of the distance of the location in meter units from the point where the beam converges or appears to diverge.

A positive lens having a power + D introduces a positive vergence of D to a parallel beam of light while a negative lens of power – D introduces a negative vergence of D to a parallel beam of light.

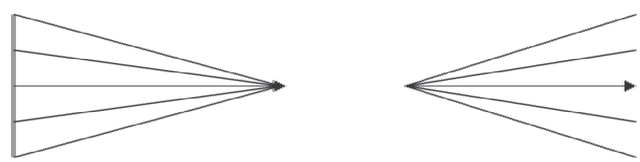

Fig. 2.14

Summary

The OA has learned about general optics and this will help them later to measure the visual acuity of patients and give prescriptions for spectacles.

Student exercise

Answer the following

1. *What are the properties of light?*
2. *What is refraction?*
3. *What are the laws of refraction?*
4. *Write short notes on:*
   - *Prisms*
   - *Lens*
   - *Focal point*
   - *Prentice rule*
5. *Illustrate with drawings the formation of images in lenses.*
6. *How to calculate the power of lens?*
7. *What is polarisation?*
8. *Explain decentration*

CHAPTER 3 VISUAL ACUITY

CONTENTS

Definition and standard of visual acuity
- Snellen's chart: principles and construction
- Distant visual acuity testing
- Vision assessment in children
- Testing methods of near visual acuity

Colour vision
- Introduction
- Classification of color vision and deficiencies
- Tests for color vision

GOAL

To enable the opthalmic assistants (OA) to learn the basic aspects of recording vision and learn the practical aspects of recording acuity of vision which reflects the overall visual potential of the patient's eyes

OBJECTIVES

The OAs will be able to
- Define visual acuity
- Explain types of visual acuity
- Discuss the ways of recording visual acuity
- Explain the principles and practical aspects of recording acuity of vision by Snellen's chart
- Interpret the vision of Snellen's visual acuity chart
- Practice pinhole acuity testing

CHAPTER 3
Visual Acuity

Definition

Acuity of vision is defined as the power of the eye to see a smallest object or letter clearly and distinguishably at specified distances.

Visual acuity is the medical term for sharpness of vision. It deals with the sharpness or discrimination of central vision, rather than the extent or clarity of peripheral vision.

Standard of visual acuity

Vision should be tested with and without glasses on a standard chart.

Each eye should be tested independently. A normal eye can easily distinguish two points separated by an angle of one minute to the eye. This is the standard of normal visual acuity. Perfect acuity of vision requires two other basic factors the light sense and colour sense. The acuity of vision is tested by standard vision chart known as Snellen's chart.

The Snellen's chart is used almost universally in testing the acuity of vision. The chart consists of Snellen's optotypes specially formed letters of the alphabet arranged in rows of decreasing letter size. The size of the letters is standardised so that letters in each row will be clearly legible at a designated distance to a person with normal vision.

Snellen's chart

Principles of Snellen's chart

The chart consists of a series of letters of diminishing size as seen in the picture (Fig 3.1). Each letter is of such a shape that it can be enclosed in a square. The size of the square is five times the thickness of lines composing the letter. The square subtends an angle of five minutes at a specified distance.

The Snellen's chart should be at a distance of six metres or twenty feet. The rays of light from that distance are parallel for practical purposes. Half this distance may also be used, but in that case the test types should be seen reflected through a plain mirror, kept at a distance of three metres or ten feet from the patient. This test could be carried out in a room with a length of three metres and a breadth of minimum one and a half metres. If six and half metres of length is available, the chart could be fastened at eye level on a light, uncluttered wall that has no windows near by. The general illumination of the room should not be less than one - fifth the illumination of the chart.

Fig. 3.1 - Snellen's chart

The chart could be placed above the patient's head. The patient looks at a mirror hung on the opposite wall. The light from the chart travels to the mirror and then reflects from the mirror to the patient's eyes, and thus an available room space of 3 metres can be converted optically into one of 6 metres.

The letters are so constructed that the angle of one minute is formed when

1. First letter is at 60 metres distance
2. Second line is at 36 metres distance
3. Third line is at 24 metres distance
4. Fourth line is at 18 metres distance
5. Fifth line is at 12 metres distance
6. Sixth line is at 9 metres distance
7. Seventh line is at 6 metres distance
8. Eighth line is at 5 metres distance

The right eye is tested conventionally first, except where the patient's complaint is particularly of defective left eye vision ,in which case the left eye is assessed first. The patient reads down the chart as far as he can and then this is repeated with the other eye. Lastly both eyes are tested together. If the visual acuities of the 2 eyes are about equal it is usually found that they reinforce each other so that the binocular vision is slightly better than the uniocular.

Types of visual acuity

- Distant visual acuity
- Near visual acuity
- Pinhole visual acuity

Distant visual acuity

It is the ability of a person to distinguish an object or letter whose rays are parallel and where no accommodation is required.

Various distant visual acuity charts are:

In adults

- Snellen's chart
- ETDRS chart (Log MAR chart)

In illiterates

- E - chart / pictures chart
- Landolt's broken rings chart
- Multiple pictures chart

In children

- Cake decorations
- Teller acuity cards
- Allen Picture cards
- Sheridan Gardiner testing
- Keeler's preferential looking tests
- Cardiff's charts

Things needed for the test

- Snellen's chart with rows of letters
- (for those who can read)
- E chart (for illiterates)
- Trial set

Trial set consists of

- Trial frame
- Retinoscopy mirror
- Convex (+) spherical and cylindrical lenses
- Concave (-) spherical and cylindrical lenses
- Pin hole
- Occluder
- Red and green glasses
- Prisms
- Slit and Maddox Rod
- Cross cylinder

Distant visual acuity testing

This procedure measures the patient's distant vision by testing their ability to read a character at a standard distance from a specified chart. The size of the letter in each row should be clearly legible at a graded distance to a person with normal vision.

Step by step procedure

Patients who wear glasses or contact lenses may be tested with and without optical correction. Test and record the visual acuity in each eye separately, beginning with the right eye.

1. As explained earlier in the chapter, position the patient 6 metres from an illuminated Snellen's chart
2. Have the patient cover the left eye with an occluder or the palm of the hand. Alternatively, you may hold the occluder over the patient's left eye. With either method, be sure the eye is fully

covered and that the occluder is not touching the eye. Observe the patient during the test, to be sure the patient is not peeping around the occluder. This is especially important with children. If they are asked to cover the eye with fingers, patients tend to read through the gaps

3. Ask the patients to read the letters from left to right on every other line down the chart until the patient misses more than half the letters on one of the lines. If a tumbling E-chart is being used, ask the patient to indicate the symbols visible on the smallest line by stating the direction or pointing the fingers in the direction which the E points
4. Note the smallest point where more than half of the letters are read correctly and record the corresponding acuity (printed at the left of each line on the standard Snellen's chart) in the patient's record, as well as the number of letters missed for example 6/9-2
5. If the patient is not able to read even the top letter of the Snellen's drum, you can stand 3 metres away from the patient, and ask the patient to count fingers. If he is not able to do so, go nearer slowly and note, at what distance he is able to count fingers
6. If the patient is not able to count fingers less than half metre, slowly wave your hand close to the patient's face. If the patient recognises it, it should be recorded as visual acuity is HM. If the patient can not even detect the hand movements, light is shown on the face and if the patient is able to say that light is there or not, it is recorded as PL+ (perception of light). If the patient is able to say from which direction the light comes it can be noted as "accurate PR" (projections of rays). If they are unable to say the direction, you note it as "inaccurate PR". On the contrary, if the patient could not recognise light, it is recorded as NOPL Same procedure is followed for the other eye.
7. Record the acuity value for each eye separately, with and without correction
8. Pinhole test is conducted if the patient's visual acuity is less than 6/6 . This test helps the examiner differentiate poor vision caused by refractive errors or due to an eye disease. Generally vision that can be improved with a pin hole can be improved by spectacle lenses

Interpretation of visual acuity

- Visual acuity is recorded as a fraction. The numerator indicating distance in metres at which the patient can read clearly the smallest possible letters/characters in the chart and the denominator indicating the distance in metres at which a normal person can read the same letters / characters in the chart
- The normal visual acuity is 6/6
- If the patient is unable to read 2 letters of the last line it should be indicated as 6/6-2
- If the patient is unable to read last line at 6 metres but reads the previous lines then visual acuity is 6/9
- If the patient is unable to read last two lines but able to read other letters, the visual acuity is 6/12
- If unable to read last three lines then visual acuity is 6/18
- If unable to read last four lines then visual acuity is 6/24
- If they can read only the first 2 lines the visual acuity is 6/36
- If the patient is unable to read even the first line, the visual acuity is less than 6/60
- If the patient is not able to read even the top letter of the Snellen's drum, he is asked to count fingers, and the visual acuity is recorded as the distance at which he is able to count fingers (CF3 mts or 3/60)

Snellen's chart is useful and most accurate in literate people above the age of 6 years. For illiterates and children below 6 years of age other test charts based on Snellen's principles are useful (Fig 3.2). Test of Albini and Landlot' broken ring test(C) is most useful in age group above 4-6 years and in all illiterate people (Fig. 3.3). The patient is required to show the direction in which the ring or legs of E are seen by them.

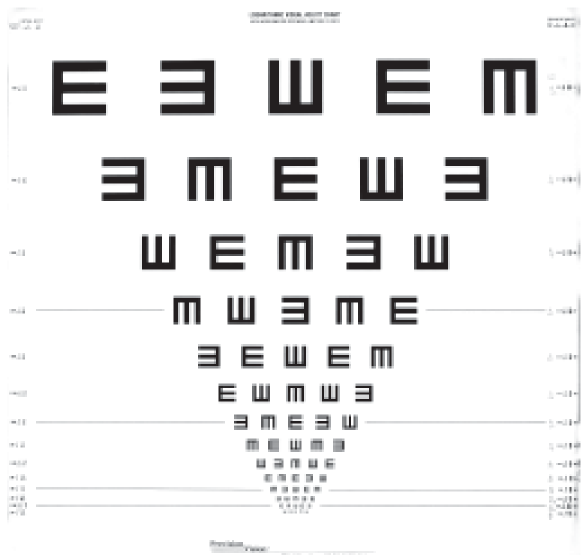

Fig. 3.2 - E chart

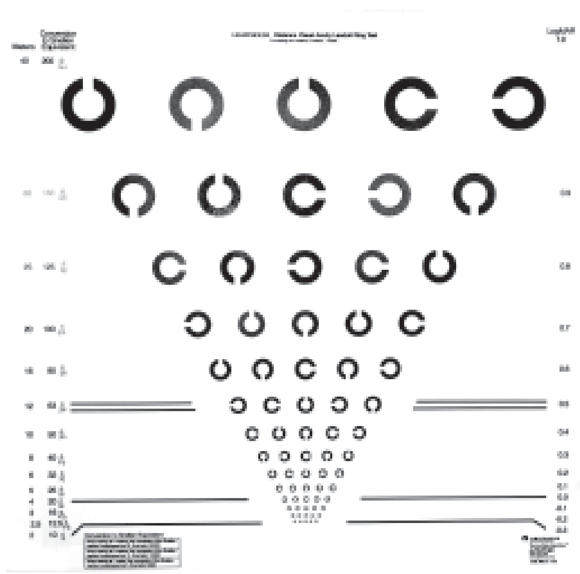

Fig. 3.3 - Broken ring chart

Along with these two tests Beale Collin's picture test type (which depicts picture of day to day things in a child's life) or Sjogren' hand test can be successfully used in small children aged 4-6 years. As in all these tests the size of the symbols suitably corresponds to Snellen's letters and so the visual acuity is noted in the same manner.

Vision assessment in children

The pre-school vision test or the Allen picture card test consists of seven black and white line drawing of birth day cake, telephone, horseman, teddy bear, automobile, house and tree (Fig. 3.4). These line drawings are drawn on a plastic (10cmx10cm) white cards. The child patient will be shown at a closer distance so that he recognizes and identifies them.

Fig. 3.4 - Allen chart

Afterwards with the room fully illuminated these plates are then shown to him from a distance of 6 metres. The distances relate to Snellen's grading. This test can be successfully used for the age group3 to 4 years.

New York light house flash card test was previously used with children with low vision or amblyopia (Fig 3.5). There are only 3 symbol flash cards with line drawings of open umbrella, an apple and a house. These are printed on separate flash cards. They will be in 7 different sizes from 20/200 to 20/10. The test is done at a fixed distance of 3.60 metres. Fook's symbol test was familiar geometrical designs as test targets. For example circles, squares, triangles of different sizes drawn on wooden cubes or printed chart formats.

Fig. 3.5 - Flash card

Miniature toy test was previously used with handicapped children and low intelligence patients. It used 2 sets of miniature objects. One set with examiner standing at 10 feet away and the patient is asked to pickup similar objects from his own set. The object chosen are small toy automobile, planes, charts, knives, spoons etc. Sometime the same object like spoons, etc. is in 2-3 size so as to check the grade of vision.

This test can be successfully used in children of age group 2-3 years, but it does not give accurate estimate of visual acuity. In one year old infants who have well developed hand-eye coordination visual acuity can be tested with coins, Block candy test, Ivory ball test, graduated size ball tests etc. The basic principle in the coins or block candy test is simple; the child picks up only those candy beads which he can see easily. Thus when coins or beads of different sizes are shown to him, he picks those he can see. This test gives very approximate estimate of visual acuity for near.

In ivory ball test – 5 ivory balls of ½ inch to one and half inch diameter sizes are rolled and spinned to a distance of 20 feet. The child is expected to fetch the balls which he can easily see. In graduated size ball test the balls are rolled in front of the child and examiner notes the quality of fixation reflexes in relation to the size of balls.

Infant's relative behavioral response to occluding of one eye gives a significant amount of estimate whether vision is grossly defective in one eye as compared to the other. It is observed how a child responds when their right eye is covered and then their left eye is covered. If the child fusses or becomes more violent in one situation then the other – it means that vision in the seeing eye is defective as compared to other.

Cake decoration

Small colored sweet balls of 1mm diameter are used to decorate cakes (Fig 3.6). This is used to check the visual acuity of children. Twelve months old children can pick up small objects and eat. Child is shown the cake decoration in examiner's or mother's hand and encouraged to pick up and eat them. The test is then repeated with only 1-2 sweet sugar balls after covering either eye alternatively. Ability to see the sweet indicates the vision of 6/24 at the testing distance.

Fig. 3.6 - Cake decoration

Keeler acuity test (preferential looking)

This test is based on the principle that a child prefers to look at pattern and not plane surface (Fig. 3.7). The child sits comfortably on the mother's lap. The child is shown a coarse grating card at 38cm. The examiner looking through a peep hole, make the decision as to whether the child is looking at the grating. The finest grating that the child prefers to look is taken as acuity limit.

Fig. 3.7 - Keeler acuity card

Cardiff visual acuity test (vanishing optotype)

The cards have six shapes which are easily recognisable (house, fish, dog, duck, train) positioned either at the top or bottom half of a card (Fig 3.8). The cards are caliberated to give visual acuity of equivalent of 20/20 to 20/200 at 1 metre viewing distance. When the child is comfortably seated the cards are presented at eye level at a distance of 1 metre. The examiner watches the eye movements towards the shape. If the child is looking at the shape, then the next card is presented. This procedure is continued until no definite fixation is observed. The test is performed at 1metre distance but altered to ½ metre if the child is unable to see the first card.

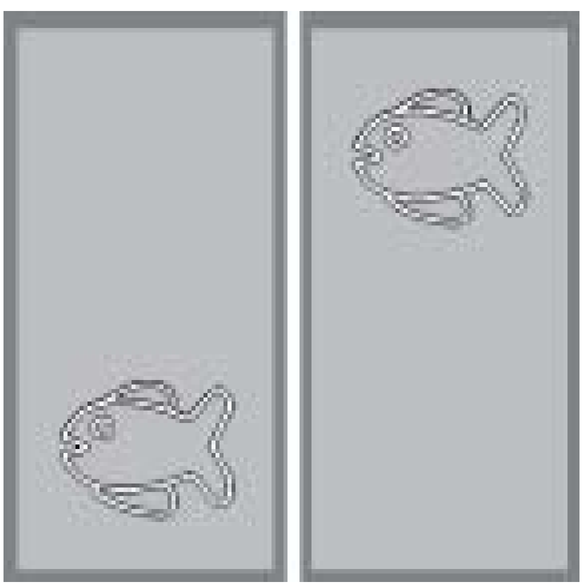

Fig. 3.8 - Cardiff acuity cards

Sheridan gardiner test (matching test)

This test uses letters which children can recognize and copy at an early age. The letters V T O H X A U are used and are shown to the child one at a time on flip card (Fig. 3.9). The child is given a key card showing all the letters and he has to point the letter he sees. After explaining the procedure to the child the test can be done at 6 metres or 3 metres. Sheriden Gardiner test is the most accurate of the illiterate vision test in children.

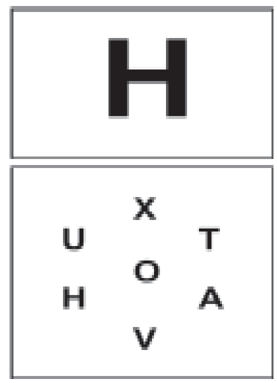

Fig. 3.9 - Sheridan gardiner chart

Basic torch examination

After examination of visual acuity it is important to do a general torch examination to record and note position of the orbit, eye balls, relative position of ocular structure, and any gross abnormality in these should be noted. With closer attention the following points are recorded.

1. Position and size of eye balls and orbital socket
2. Position of eye lids, shape, size, contour, margins, palpebral fissure and eye lashes
3. Position of the puncta in upper and lower lid near nasal canthi of both eyes
4. Position and texture of conjunctiva, presence of abnormal redness, discharge at canthii, follicles and papillae especially on the palpebral conjunctiva

5. Surface and texture of cornea, its shape, size, presence of surface opacities and irregularities, etc
6. Depth of anterior chamber, floaters in aqueous (if any)
7. Iris – position, colour, pattern, texture
8. Pupils position, shape and pupillary reflex - direct and consensual
9. Reflex from lens in pupillary area, presence of any opacity in pupillary area

Testing methods of near visual acuity

It is the power of the eye to clearly see and distinguish smallest object or letters from a normal readign distance. For practical considerations the normal reading distance is considered to be 40 cms.

When the distance vision has been tested, the visual acuity at reading distance is investigated. Snellen's constructed a set of letters of graded sizes and thicknesses on the same principles as his distant types, and this is the most scientifically accurate test. In this type the letters in the 6/6 line subtends an angle of 5 minutes at an average reading distance. This may be called the "Snellen's equivalent" for near vision. Such a test however has never become popular and graded sizes of letters of pleasing types have been habitually employed. The first test of this kind was suggested by Jaeger in 1867. The Jaeger card has print samples of different sizes. The card is held at 32 cms. The results of visual acuity tests are used to prescribe eye glasses or other corrective measures.

How to perform the near acuity test?

Patients who wear glasses or contact lenses should wear them for the test. The near vision should be checked with and without glasses.

1. Instruct the patient to be seated
2. After the patient is comfortably seated, printed test card is given to them
3. Ask the patient to hold the test card at the distance specified on the card, usually 40 cms
4. Have the patient cover the left eye with an occluder or the palm of the hand
5. Ask the patient to read with the right eye the line of the smallest characters legible on the card
6. Repeat the same procedure with the other eye occluded
7. Record the near acuity value for each eye separately

Pinhole visual acuity

The pinhole disc is a small circular disc with a small central opening that reduces the peripheral rays and allows the central rays to reach the retina. This opaque disc has 1.2mm hole in the middle. A 0.55 mm hole actually reduces visual acuity due to diffraction. 1.32mm pinhole is the best. The standard trial pin hole is 1mm in size.

The pinhole permits the most central rays to enter and provide a good image, just as the pinhole camera gives a fine image without a lens system. The pin hole serves to differentiate visual loss caused by refractive errors from poor vision resulting from disease of the eye. In the latter condition vision will not improve when a pinhole disk is placed before the eye.

Colour vision

The colour of any object is determined by the wave length emitted or reflected from the surface. White light is a mixture of wavelength of the visible spectrum. Colour is perceived by three populations of cone photoreceptors in the retina which are sensitive to light of short (blue), middle (green), or long (red) wave length.

A congenital colour vision defect occurs if a cone pigment is absent or if there is a shift in its spectral sensitivity. Hence, deuternopia, protonopia, and tritenopia indicate absence of green, red and blue cone function, and deuteranomaly, protonomaly and trianomaly indicate a shift in the corresponding cone sensitivity. The X chromosome carries the blue pigment gene. 8% of men and 0.5% women have a defect of the red / green system; the most common is deuternomaly which occur in 5% of men and 0.3% of women. Triton defects are rare.

Congenital color defects characteristically affect particular parts of the colour spectrum. Acquired colour defects occur through out the spectrum but may be more pronounced in some regions.

For example, acquired optic nerve disease tends to cause red- green defects. An exception occurs in glaucoma and in autosomal dominant optic neuropathy which initially causes predominantly blue- yellow deficit; it has recently been found that visual field loss in glaucoma is detected easier if perimetry is performed using a blue light stimulus on a yellow back ground. Acquired retinal disease tends to cause blue yellow defects. Clinical tests of colour vision are designed to be performed in illumination equivalent to afternoon daylight in the northern hemisphere.

The following tests are done to detect colour vision defects and they are;

- Fransworth Munsell (FM) 100 hue test
- D-15 test
- Ishihara pseudo isochromatic test plates specific test for congenital red-green defects

Colour vision tests

The impaired ability to perceive colour is most commonly an inherited condition, passed from the mother to a male child. Optic nerve or retinal disease may also cause defects in colour vision. For the majority of patients with impaired colour vision, the colour red appears less bright than for normal individuals, preventing accurate perception of colour mixtures that include red. While a deficit in colour vision is not usually disabling, it can hinder individuals from pursuing certain specialised careers.

Evaluation of color vision is often performed with pseudo isochromatic colour plates. (Insert the picture) Each eye is tested separately. Patients are instructed to look at a book of these plates, which display patterns of colored and grey dots .Patients with normal colour vision can easily detect numbers and figures composed of and embedded in, the multicolored dots. Patients with colour vision deficits cannot distinguish the numbers and the figures. Various combinations of colors are used to identify the nature of the colour vision deficit. The 15-hue test, or Farnsworth-Munsell 100 hue test, provides a more precise determination of colour vision deficits. The test consists of 15 pastel-colored chips of similar brightness but subtly different hues, which the patient must arrange in a related colour sequence. The sequence is obvious to patients with normal vision, but patients with colour deficiencies make characteristic errors in arranging the chips.

Attitude

1. Explain to the patient what you are going to do and how they can co-operate for the visual acuity test
2. In cases, like injury / infection / redness / corneal ulcer, check the patient carefully and try to send them as early as possible, to the doctor
3. Special attention should be given to children and patient with mental depression, while assessing visual acuity
4. Listen carefully to the patient while they speak out their health problems and treat them with patience and compassion in case they do not cooperate

Summary

In this unit the OA has learned the different types of charts used to test the visual acuity of all age groups. It is given in detail the procedure to be followed and how the readings or findings are to be recorded.

Key points to remember

- *Wash your hands thoroughly after testing any infected patient*
- *Occluder is a hand held paddle used to cover one eye during a test*
- *Visual acuity test should be performed with a bright illuminated chart*
- *Pinhole paddle; a hand-held paddle with small viewing holes, used to determine whether spectacle lenses are likely to improve vision.*
- *Projector; required if a projected image of the test chart is to be used.*
- *Mirror; required to obtain the correct optical distance between the patient and the chart when the physical distance is too short.*
- *Snellen's chart is for those who know the alphabet or numbers.*
- *The tumbling E chart is for the illiterate patients*
- *Charts with silhouetted pictures to identify - Allen chart*
- *Letter matching tests (20 to 10 feet) – the children need not know the letter but they need only to match whatever letter you point to.*
- *Teller acuity cards - with vertical black and white stripes (gratings) to test the visual acuity of infants and preverbal toddlers (the examiner watches for a shift in gaze through a pinhole in the card)*

Common abbreviations for visual acuity measurement

V,VA	-	Visual acuity
OD	-	Oculus dexter (right eye)
OS	-	Oculus sinister (left eye)
CC	-	Cum correction, with correction (eye glasses or contact lenses
CC	-	Sine correction, without correction (eye glasses or contact lenses)
Ph	-	Pinhole
HM	-	Hand motion
PR	-	Projection of rays
PL	-	Perception of light
FCF	-	Finger counting close to face
NOLP	-	No light perception

Student exercise

Answer the following

1. *What is visual acuity?*
2. *What is the principle of the Snellen's chart?*
3. *List the types of distance acuity charts?*
4. *List the various charts used for paediatric vision assessment?*
5. *Define color vision?*
6. *List the types of test done to detect defects in color vision?*

CHAPTER 4 REFRACTIVE ERRORS AND MANAGEMENT

OUTLINE

Myopia
- Definition
- Aetiology
- Clinical types
- Symptoms and complications
- Management

Hypermetropia
- Definition
- Aetiology
- Clinical types
- Accommodation in hypermetropia
- Symptoms and complications
- Management

Astigmatism
- Definition
- Aetiology
- Types
- Symptoms
- Correction of astigmatism

Presbyopia
- Definition
- Causes, incidents and risk factors
- Signs and test
- Symptoms
- Evaluation

GOAL

To impart the ophthalmic assistants basic knowledge of refractive errors, causes and types. To give basic concepts of evaluation and correction techniques.

OBJECTIVES

The OAs will be able to
- Define hypermetropia, myopia and astigmatism
- Discuss the causes of hypermetropia, myopia and astigmatism
- Perform the evaluation techniques
- Demonstrate possible ways of correction

CHAPTER 4
Refractive Errors and Management

Refractive errors are the most common eye disorders and not a disease. A refractive error means that the shape of the human eyes do not refract the light rays correctly on the retina resulting blurred vision.

Emmetropia is a normal refractive condition of the eye in which the parallel light rays from infinity comes to a focus exactly on the retina without any accommodative changes. So the vision is clear at all distances.

In case the rays are focused either infront or behind the retina, then it is termed as ametropia. It can be classified as short sightedness or myopia and long sightedness or hypermetropia.

Myopia

Myopia is one type of refractive error where the parallel rays of light are brought into focus in front of the retina when accommodation is at rest. This is also called short sightedness or nearsightedness. Nearsightedness is an error of visual focusing that makes distant objects appear blurred.

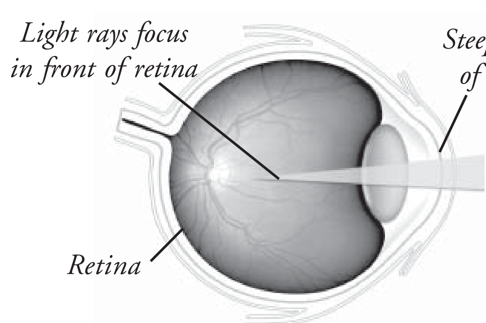

Fig. 4.1 - Myopia

Aetiology

1. Axial myopia - is due to increase in the antero-posterior length of the eye ball
2. Curvature myopia - is due to increases in curvature of cornea or one or both the surfaces of the lens. Increases of 1 mm causes a refractive change of 6D
3. Index myopia - a change of refractive index in the lens results in index myopia
4. Positional myopia - this is due to anterior placement of lens

Optical condition

In myopia, the parallel rays of light fall in front of the retina and cause a blurred image to fall on retina. So the distanct object appears blurred. In order to see clearly the object is brought closer and the divergent rays come to focus on the retina. This makes the far point in the myopic eye at a finite distance. This distance decreases with the increase in the degree of myopia. Therefore the near object is focused without an effort of accommodation. For these reason myopes can suffer from convergence insufficiency and exophoria.

Clinical types of myopia

Congenital myopia: It is present at birth and may be unilateral or bilateral. Bilateral congenital myopia may be associated with squint.

Simple myopia: It is the most common type of myopia, results from the normal biological variation in the development of the eye. The power of glasses increases, usually during the years of study in schools and colleges and then remains steady. This type of myopia is not associated with any degenerative change in the eye.

Pathological myopia: In this condition, the myopia rapidly progresses and subnormal visual acuity persists even with correction and there are degenerative changes in the retina. Near-sightedness affects males and females equally, and those with a family history of nearsightedness are more likely to develop it. Most eyes with nearsightedness are entirely healthy, but a small number of people with myopia develop a form of retinal degeneration.

Acquired myopia: This occurs due to exposure to various pharmaceuticals, increase in glucose level, nuclear sclerosis, and increase in curvature of the cornea in conditions such as corneal ectasias. The other types of acquired myopia are:

Pseudo myopia: This type of myopia is called as false appearance of myopia that occurs due to excessive accommodation and spasms of accommodation.This type of myopia usually manifest the execessive amount of myopia and decreased amount of hypermetropia.It could cause severe headache with asthenopic complaints.

Night myopia: In night myopia, the eye has difficulty seeing in low illumination even though the daytime vision is normal. This occurs due to increase in sensitivity to the shorter wavelengths of light. Younger people are affected more than the elderly.

Space myopia: This type of myopia occurs when the individual has no stimulation for distance fixation.

Symptoms

- Blurred vision or difficulty in seeing distant objects (Children often cannot read the blackboard, but easily read a book).They tends to go near the objects to see clearly
- Eye strain
- Headaches (uncommon)
- Squinting tendency
- Close working habits

Tests

A general eye examination or standard ophthalmic exam may include:

1. Visual acuity, both at a distance (Snellen's), and close up (Jaeger)
2. Refraction test to determine the refractive power accurately
3. Cycloplegic refraction may be required in few conditions to confirm the final prescription
4. Color vision test to exclude color defect.
5. Muscle balance test
6. Slit lamp examination of the eyes
7. Measurement of the intra ocular pressure of the eyes
8. Retinal examination

Complications

1. If a person with nearsightedness has flashing of lights, floating spots, or a sudden loss of any part of the field of vision, it may be a retinal detachment.
2. Retinal atrophy patches in the macula cause loss in central vision.

Expectations (prognosis)

Early diagnosis of myopia is important, since a person can suffer socially and educationally by not being able to see well at a distance. Any degree of myopia that is occurring in a child under the age of 4 requires immediate observation. In high degree of myopia the prognosis is always guarded. It is usually based on the appearance of fundus and the acuity of vision after correction.

Management

Myopia is easily corrected by concave lens for eyeglasses or contact lenses. The lens diverge the incoming light rays, so that they will be properly focused on the retina.

Surgical treatment

There are also a number of techniques available for reshaping the cornea (the front surface of the eye), in order to reduce its power and thus correct the myopia. One technique (known as orthokeratology or 'Ortho-K') uses rigid contact lenses to change the shape of the cornea. Other techniques use surgery to remove tissue from the cornea, leaving it with a flat surface.

There are several surgical procedures that reshape the cornea, shifting the focus point from in front of the retina to on to the retina.

Radial keratotomy is a surgical procedure popular in recent past. Now it is almost completely replaced by LASIK, in which an excimer laser is used to reshape the cornea. Refractive surgeries are recommended for persons aged between 20 and 40 years.

Students exercise

Answer the following

1. *Define myopia.*
2. *What are the causes of myopia?*
3. *What are the clinical types of myopia?*
4. *Explain the optical condition in myopia.*
5. *Explain the treatment modalities.*

Hypermetropia

Definition

Hypermetropia is an error of refraction in which parallel rays of light from infinity come to a focus behind the retina, when accommodation is at rest.

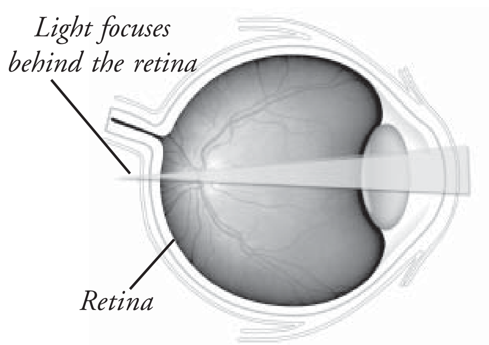

Fig. 4.2 - Hypermetropia

Optical condition

Whether the hypermetropia is due to a decrease in the length of the eye ball or decrease of curvature of cornea or due to change in refractive index, the optical effect is the same, parallel rays from infinity come to focus behind the retina, and the diffusion circles which are formed on the retina result in a blurred and indistinct image.

Accommodation eye

Parallel rays are brought to focus on the retina, by the normal lens in the eye becoming more complex. This is called accommodation.

Hypermetropic eye

Parallel rays of light are brought to focus upon the retina, by increasing the refractivity with a convex spectacle lens. The degree of hypermetropia is given by the power of the correcting lens.

Types of hypermetropia

- Axial hypermetropia
- Curvature hypermetropia
- Index hypermetropia

Axial hypermetropia : When the anterior / posterior length of the eyeball is shorter than normal. (Normal axial length is 24mm). A decrease of 1mm in axial length produces a hypermetropia of 3.0D.

Curvature hypermetropia : When the curvature of the cornea or lens is flatter than normal. An increase of 1mm in its radius of curvature produces a hypermetropia of 6.OD.

Index hypermetropia : When the refractive index of the media is less than normal

- Corneal refractive index - 1.37
- Refractive index of the cortex of lens - 1.38
- Refractive index of the nucleus of lens - 1.40

Clinical types of hypermetropia

1. Congenital hypermetropia
2. Simple or developmental hypermetropia
3. Acquired hypermetropia

Congenital hypermetropia

This is rare. It is usually associated with other congenital anomalies of the eyeball like microopthalmas.

Simple or development hypermetropia

It is the most common type. A newborn baby is hypermetropic but with age, the eye ball grows in size and the hypermetropia is gradually diminished. If the growth of the eyeball is retarded then hypermetropia persists.

Acquired hypermetropia

This is found in aphakic conditions, commonly following extraction of the lens. This hypermetropia is usually high about + 10.0 D.

Effect of accommodation on Hypermetropia

Total hypermetropia

Total hypermetropia (T.H)

Latent Hypermetropia (L.H)

Manifest hypermetropia (M.H)

Facultative hyperopia (F.H)

Absolute hyperopia (A.H)

TH =MH+LH

MH=FH+AH

TH - Total hypermetropia

LH - Latent hypermetropia

MH - Manifest hypermetropia

FH - Facultative hypermetropia

AH - Absolte hypermetropia

The hypermetropia which is seen after complete paralysis of accommodation, after the application of atropine

TH=MH+LH

Latent hypermetropia

It is the amount of hypermetropia which is corrected by normal physiological tone of the ciliary muscle. It is strong in young age and slowly declines with age.

Manifest hypermetropia

The remaining portion which is not corrected by the normal physiological tone of the ciliary muscle, is called manifest hypermetropia. It is the hypermetropia that remains uncorrected in normal circumstance. That is when accommodation is not being actively used, or, in other words it is the total hypermetropia minus the latent hypermetropia. This manifest hypermetropia is again made of two components.

1. Facultative hypermetropia
2. Absolute hypermetropia

Facultative hypermetropia: It is the part of hypermetropia, which can be corrected by an additional effort of accommodation or excessive strain of the ciliary muscle.

Absolute hypermetropia : It is the part of hypermetropia which cannot be overcome by active exertion of accommodation.

Symptoms of hypermetropia

1. Head ache
2. Eye strain
3. Distance blurred vision
4. Difficulty in doing prolonged close work

Treatment of hypermetropia

1. By prescribing correct convex lenses
2. Contact lenses
3. Lasik

Scientific correction of hypermetropia

Donder's formula

To be used for correcting manifest hypermetropia.

Formula : Rx=MH+1/3 LH

Donder's Formula is useful to determine the actual amount of hypermetropic correction in different cases.

- Even if the patient has mild headache associated with the problems of asthenopia then the final correction will be based on this formula Rx = MH +1/4 LH
- If the patient has headache and the problem of difficulty in reading and other near vision tasks then the correction will be Rx=MH+1/2 LH
- If the patient has esotropia then we have to give full correction, Rx will be Rx = MH + LH

For example, If the patient having vision 6/9 improves with +0.50DSph to 6/6, by fogging method, patient reads 6/6 with +2.0 DSph and after a cycloplegic refraction patient reads 6/6 with +3.5DSph. Find MH, AH, FH, LH, and TH

AH = +0.5 DS

MH = +2.0 DS (By fogging method)

And TH = +3.5 DS (By cycloplegia)

MH = AH+FH

FH = MH – AH

= +2.0 DS - +0.5 DS = + 1.50 DS

TH = MH +LH

LH = TH-MH

= 3.5 DS – 2.0DS = +1.5 DS

So final correction by Dondler's formula

Rx = MH+1/3 LH

= +2+1/3X1.5

= +2+0.5 = +2.5DS

Complication of hypermetropia

Uncorrected hypermetropia leads to esophoria, which later on may develop into esotropia.

Hypermetropia with esophoria - To give full correction

Hyperopia with exophoria - To give under correction

Hypermetropic individuals often have shallow anterior chamber. They have increased predisposition to develop narrow angle glaucoma.

Astigmatism

Astigmatism is a type of refractive error where the refraction varies in different meridians. Consequently the rays of light entering in the eye cannot converge on a focus point, but form focal lines.

Aetiology

1. Corneal astigmatism is the result of abnormalities of curvature of the cornea.
2. Lenticular astigmatism is rare. It may be: -
   - Curvature due to abnormalities of curvature of lens as seen in lenticonus.
   - Positional due to tilting, or oblique placement of lens as seen in subluxation.
   - Index astigmatism occurs rarely due to variable refractive index of lens in different meridian.
3. Retinal astigmatism, due to the oblique placement of macula, is seen occasionally.

Types

Broadly, there are two types of astigmatism,

- Regular astigmatism
- Irregular astigmatism

Regular astigmatism

The astigmatism is regular when the refractive power changes uniformly from one meridian to another. Depending upon the axis and the angle between the two-principle meridians, regular astigmatism can be classified into the following three types.

Horizonto-vertical astigmatism

In this type the two principal meridians are placed at right angles to one another and those are in the horizontal (180 +/- 20) and vertical planes (90+/- 20). It is of further two types

With the rule astigmatism: When the vertical meridian is more curved than the horizontal meridian, this is known as with the rule astigmatism. Sometimes it is physiological due to pressure of the eyelid on the cornea. Up to 0.50D we can ignore the error, as it does not cause many symptoms.

This can be corrected either by a – (minus) cylinder x 180 or + (plus) cylinder x 90.

Against the rule astigmatism: The horizontal meridian is more curved than the vertical meridian. This is known as inverse astigmatism or against the rule astigmatism. It cause more symptoms and should be corrected for minimal error.

This can be corrected either by – (minus) cylinder x 90 or + (plus) cylinder x 180.

Oblique astigmatism

When principle meridians are at right angles, but are not vertical and horizontal.

Bi-oblique astigmatism

When principle meridians are not at right angles but crossed obliquely.

Refractive types of regular astigmatism

Depending upon the position of the focal lines in relation to the retina, regular astigmatism is further classified into three types,

Simple astigmatism

Here the rays are focused on the retina in one meridian and in front or behind the retina on the other meridian, as in simple hypermetropic (Fig 4.3b) or simple myopic (Fig 4.3a) astigmatism.

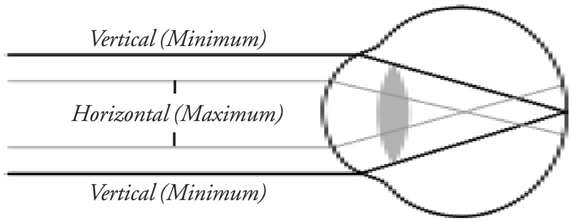

Fig 4.3a Simple myopic astigmatism

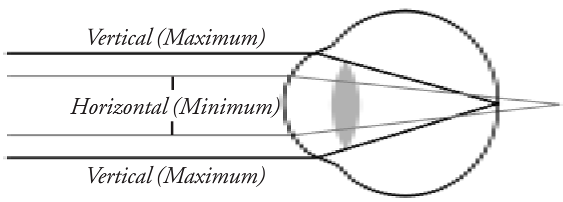

Fig. 4.3b - Simple hypermetropic astigmatism

Compound astigmatism

Here neither of the two foci lies upon the retina but are placed in front or behind it. The former is known as compound myopic (Fig. 4.4a), the later as compound hypermetropic astigmatism.

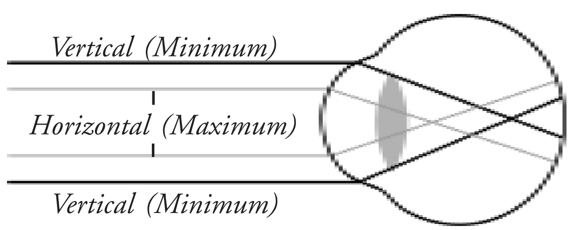

Fig 4.4a Compound myopic astigmatism

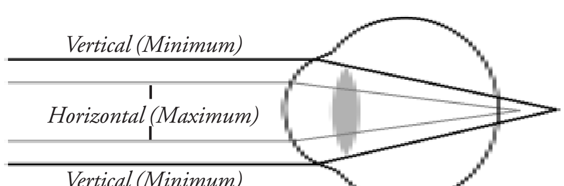

Fig. 4.4b - Compound hypermetropic astigmatism

Mixed astigmatism

One focus is in front of and the other behind the retina, so that the refraction is hypermetropic in one direction and myopic in the other (Fig. 4.5).

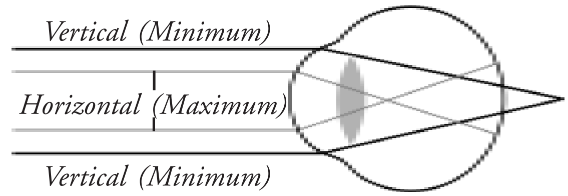

Fig. 4.5 - Mixed astigmatism

Appearance of image in astigmatism - Sturm's conoid

Sturm's conoid is a series of images formed by astigmatic surface, which have two meridians of different curvature. The more curved meridian refracts rays greater than the less curved meridian. Rays refracted by more curved meridian come to focus earlier than those refracted by less curved meridian. It forms two focal lines (B and F). Distance between these two focal lines is known as focal interval (BE). Circle of least diffusion is formed when rays refracted by both meridians have equal and opposite tendencies. At this point the most clear image is formed. Images in between and beyond the focal lines are blurred and elliptical (Fig. 4.6).

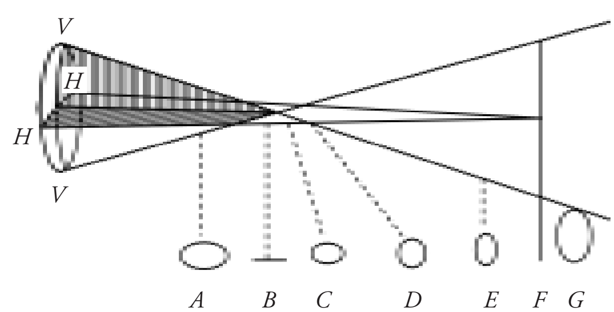

Fig. 4.6 - Sturm's conoid

Irregular astigmatism

Irregularities in the curvature of the cornea cause Irregular Astigmatism. The principal meridians are not at right angles. Every meridian in the cornea has a separate type of refraction; we can never correct the error by spectacles. This type of astigmatism is called irregular astigmatism (Fig. 4.7).

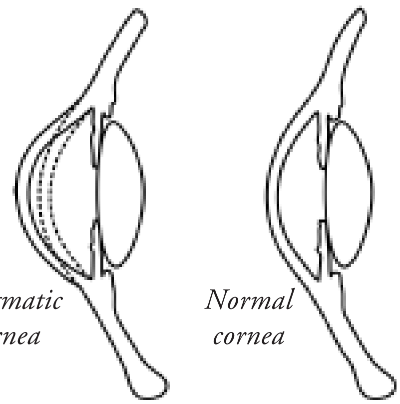

Fig. 4.7 - Irregular astigmatism

Symptoms

- Defective vision.
- When they look at a straight line either it is blurred or the line can be tailed off at the end
- Headache is an important complaint
- Giddiness
- Torticollis - permanent tilting of head

Tools used in evaluation of astigmatism

- Keratoscopic examination by placidos disc.
- Retinoscopy by concave mirror/streak
- Use of astigmatic fan or Maddox rod
- Stenopaeic slit or pinhole
- Keratometry
- Jackson cross cylinder.

Astigmatic fan

Astigmatic fan is a construction of vertical lines at a different angle meridian from 0 to 180 degrees. When a patient with astigmatic error looks at the fan some lines seem to be clearer than others, which help to detect the axis of astigmatism (Fig. 4.8).

Jackson's cross cylinder

The cross cylinder is a sphero-cylinder lens in which the power of the cylinder is twice the power of the sphere and of the opposite sign. It is used to refine power and axis of cylindrical power.

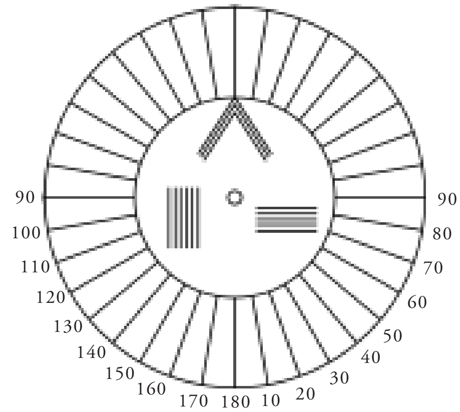

Fig. 4.8 - Astigmatic fan

Stenopic slit

The stenopaeic slit can be used to determine the refraction and principle axis in astigmatism. The slit aperture acts as an elongated 'pin hole', only allowing light in the axis of the slit to enter the eye.

Placido's disc

This is a flat disc bearing concentric black and white rings. A convex lens is mounted in an aperture in the center of the disc.

Treatment

Regular astigmatism

Optical correction

- Spectacle (concave – convex cylinder lens)
- Contact lens (toric lens - prism balastic lens)

Surgical

- Keratomiluesis
- Excimer laser

Irregular astigmatism

Hard/semi-soft contact lens

- Keratoplasty in central area of conical cornea
- Excision of scar + replacement by graft

Summary

Astigmatism is a type of refractive error where no point focus is formed on the retina. Two main types of astigmatism are regular and irregular astigmatism.

'With the rule'{ – (minus) cylinder x 180 or + (plus) cylinder x90} and 'against the rule' {– (minus) cylinder x 90 or + (plus) cylinder x 180} astigmatism are the types which are of more interest as we can understand patient symptoms. Refractive types includes simple, compound and mixed astigmatism. Optics of astigmatism can be explained by sturm's conoid. To find the axis of astigmatism we can use stenopic slit, placido's disc, astigmatic fan and some techniques of retinoscopy. We can use JCC to refine power and axis of astigmatism. Cylindrical and spherocylindrical lenses can be used to correct astigmatism. Contact lens and surgery are the other options.

Key points to remember

- *Minimum cylinder, maximum comfort.*
- *Give minus cylinder for more comfort.*
- *For high cylinder, it is better to do keratometry*
- *Refine axis and power before finalizing prescription*
- *Check binocular comfort subjectively*

Student exercise

Answer the following

1. *What is astigmatism? What are the possible causes of astigmatism?*
2. *What do you understand by 'with the rule' and 'against the rule' astigmatism?*
3. *What are the refractive types of astigmatism?*
4. *What is JCC? Write its uses.*
5. *What are the possible ways to correct astigmatism?*

Presbyopia

Presbyopia is an age related progressive loss of the focusing power of the lens. This results in difficulty in reading and seeing near objects.

Causes, incidents, and risk factors

- The focusing power of the eye, which depends upon the inherent elasticity of the lens, gradually decreases in old age.
- This causes inability to read at normal reading distance (33 cm to 40cm)
- People usually notice the condition around age 40; after they realise that they need to hold reading materials further away in order to focus.

Signs and tests

A general eye examination will be performed including measurements to determine a prescription for glasses or contact lenses.

Tests may include:-

- Visual acuity
- Refraction
- Muscle integrity
- Slit lamp
- Retinal examination

Symptoms

- Inability to focus near objects
- Likes to read in brilliant illumination when the pupil will be forced to constrict
- Eye strain
- Headache

Factors affecting close work

1. **Pupil size** - Smaller pupils increase the pinhole effect, which increases the depth of focus
2. **Lighting** - Small print is easier to read in bright light. The contrast is improved and the reflected light may constrict the pupil, improving the depth of field
3. **Print size and print distance** - large print is easier to read
4. **Task requirements** - An accountant will need better near vision than a garbage worker
5. **Secondary task considerations** - A person wants to increase the near working distance in one pair of glasses rather than buy two pairs of glasses
6. **Body type and position** - some people, particularly those with long arms, like to hold reading materials further away than others do. In this case the add power will be less
7. **Previous correction** - Many people don't tolerate an increase in add power greater than 0.75D at any one time

8. **Low ametropia** - Uncorrected low hypermetropes complain of reading difficulty at an earlier age than uncorrected low myopes.
9. **Health and medications** - Diabetics typically need near correction at an earlier age and need stronger add power than is normal for their age group.

Age	Expected add power
38 yrs	+ 0.75 DS
40 yrs	+1.0 DS
45 yrs	+ 1.50 DS
50 yrs	+ 2.0 DS
55 yrs	+2.5 DS
60 yrs and above	+3.0 DS

Variations of accommodation with age

Amplitude of	Age			
Accommodation	Early Age 14 D	36 Yrs 7 D	45 yrs 4 D	60 yrs 1D
Near point	7 cm	14 cm	25m	1m

Evaluation of presbyopia

Treatment

Presbyopia can be corrected with appropriate lenses, so that his accommodation is reinforced and the near point is brought within the useful working distance.

- Know the working distance of the patient for proper addition
- Refraction
- Determine the amplitude of accommodation
- Supplement this by lens - allowing him a sufficient reserve of accommodation

For example

Emmetropic working distance	-	25 cm
Requires amplitude of accommodation	-	4 D (100/25)
Near point receded at	-	50 cm
Accommodation	-	100/50 = 2D
Keep 1/3 reserve for comfort	-	1/3x2 = 0.66
Available accommodation (2/3 of amplitude)	=	1.3D (2-0.66)
Required lens	=	4-1.3 D=2.7 DS

Key points to remember

- *Presbyopic spectacle should never be prescribed mechanically based on age*
- *Lenses must be comfortable*
- *Vision for the particular work for which their spectacle is intended must be kept in mind.*
- *Start with an addition of +0.75D*
- *Better to under correct than over correct*
- *Lenses that bring the near point closer than 28cm are rarely tolerated.*
- *Demand for higher correction than convergence should be added with base in prism*
- *Patient with early cataract can read with +3.50 D or + 4.0D addition*
- *Usual discomfort for presbyopic optical correction is due to over correction*

Types of corrective spectacle for presbyopia

1. Single vision reading glasses
2. Bifocals - where glasses are given for near and distance
3. Trifocals - where glasses are given for distance, intermediate and near vision
4. Varifocals - progressive addition lens
5. Monovision correction- one eye is corrected for distance and the other eye for near.

Student exercise

Answer the following

1. *Define presbyopia.*
2. *What are the symptoms of presbyopia?*
3. *Describe the treatment for presbyopia*
4. *Mention the important points to be noted while prescribing spectacles for presbyopia*
5. *What are the types of spectacles that could be prescribed for presbyopia?*

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CHAPTER 5 ANISOMETROPIA, ANISEIKONIA AND AMBLYOPIA

OUTLINE

Anisometropia
- Clinical types
- Treatment

Aniseikonia
- Aetiology
- Clinical types
- Symptoms and testing
- Treatment

Amblyopia
- Clinical types
- Treatment

GOAL

To equip the ophthalmic assistant (OA) with knowledge about anisometropia, aniseikonia and amblyopia and their treatments

OBJECTIVES

The OAs will be able to
- Define anisometropia, aniseikonia and amblyopia
- Conduct tests for each defect
- Suggest appropriate treatment for each defect
- Discuss the importance of follow up

CHAPTER 5
Anisometropia, Aniseikonia and Amblyopia

Anisometropia

Anisometropia is one of the binocular optical defects. Anisometropia arises because of the difference in refractive error between two eyes. A small degree of anisometropia occurs commonly when there is a small amount of astigmatic error. Each diopter difference between the refraction of the two eyes causes 2% difference between the two retinal images.

Aetiology

Congenital and development anisometropia

This occurs due to differential growth of the two eyeballs.

Acquired anisometropia

1. Uniocular aphakia occurs after caratoconous lens removal
2. From trauma to the eye
3. Due to inadvertent surgical treatment of refractive error

Vision status in anisometropia

Binocular vision: Binocular vision is present in small degrees of anisometropia. An anisometropia of about 1.5 D to 3 D is tolerated depending upon the individual.

Alternate vision: Alternating of vision occurs when one eye is emmetropic or moderately hypermetropic and the other eye is myopic. The emmetropic or moderately hypermetropic eye is used for distance vision and the myopic eye is used for near vision. These patients are usually comfortable and never have to make an effort of either accommodation or convergence.

Uniocular vision: When the refractive error is high in one eye compared to the other, then the high degree refractive error eye receives continuously blurred images compared to the other eye. Due to this the eye receiving blurred image is suppressed and develops amblyopia. This type of amblyopia is called anisometropic amblyopia.

Clinical types

Simple anisometropia

In simple anisometropia one eye is emmetropic and the other eye is either myopic or hypermetropic.

Compound anisometropia

In compound anisometropia both eyes have refractive error. The refractive error may be hypermetropic or myopic, but one has a higher refractive error than the other.

Mixed anisometropia

When the refractive error of one eye is hypermetropic and other eye is myopic it is mixed anisometropia. This is also termed antimetropia.

Simple astigmatic anisometropia

When one eye is normal and the other has simple myopic or hypermetropic astigmatism it is termed simple anisometropic astigmatism.

Compound astigmatic anisometropia

When both eyes are astigmatic but of unequal degree, it is called compound astigmatic anisometropia.

Mixed astigmatic anisometropia

When one eye has hypermetropic astigmatism and the other eye has myopic astigmatism.

Clinical test

The visual status is assessed by using either FRIEND test or Worth's Four Dot test.

FRIEND test

An illuminated word FRIEND is present in the Snellen's vision box. The alternate letters in the word FRIEND are illuminated with green and red colour. The letters F, I, N are in green and R, E, D in red colour. Red and green goggles are placed in front of the eye such that red is placed over the right eye and green is placed over the left eye. The patient sees only red letters through the right eye and green letters through the left eye. From the patient's response we can determine whether the patient is using both eyes or not.

Responses

1. If the patient reads FRIEND at once the patient has binocular vision
2. If patient reads either FIN or RED, the patient has Uniocular vision with the eye which has the corresponding glass
3. If the patient first reads FIN and then RED, then he has alternating vision

Worth four dot test

This test is similar to the FRIEND test. This test has four dots. Of these four dots, one dot is red in colour, two are green and one is white. The patient wears the red and green goggles, red in front of the right eye and green in front of the left eye and views the box with four lights.

Results

1. When all four lights are seen they have normal binocular single vision
2. When all the four lights are seen with the presence of a manifest squint then they have abnormal retinal correspondence
3. When they see only two red lights, it indicates left eye suppression. If they see only three green lights, it indicates they have right eye suppression
4. If they see two red lights, alternating with three green lights it indicates presence of alternating suppression
5. If they see five lights (two red lights and three green lights) it indicates diplopia

Treatment

Optical

- Contact lens is the best choice for anisometropia
- In children with anisometropic amblyopia and refractive error correction, occlusion therapy should also be given
- Anisometropic spectacles were given for the correction of anisometropia but these spectacles are obsolete now

Surgery

- Implanting intraocular lens for unilateral aphakia
- Removal of crystalline lens for unilateral high myopia
- Refractive corneal surgeries for unilateral myopia, astigmatism and hypermetropia

Student exercise

Answer the following

1. *Define anisometropia.*
2. *What are the causes and types of anisometropia?*
3. *What are the different types of tests used for anisometropia?*
4. *What is the visual status in anisometropia?*
5. *Explain various treatment modalities for anisometropia.*

Aniseikonia

Aniseikonia is one of the binocular optical defects. Aniseikonia (A = not + iso = equal+ konia = image) is a condition in which the size and shape of images of the two eyes are unequal. Aniseikonia of 3% or more becomes clinically significant.

Aetiology

Optical aniseikonia: This occurs due to inherent or acquired anisometropia of high degree.

Retinal aniseikonia: Retinal aniseikonia may develop due to:

- Widely separated arrangements of the visual elements
- Any retinal oedema causing separation of retinal elements

Clinical types

The difference in the images can be classified as:

1. **Symmetrical**: It is the difference in the image size perceived in each eye

  a) Overall - the difference is the same in all dimensions
  b) Meridional - the difference is greater in one meridian compared to the other
2. **Asymmetrical aniseikonia**: it is the difference in the image shape perceived in each eye
  a) Regular: progressive increase or decrease in size across the visual field

Symptoms

- Headache
- Asthenopia
- Photophobia
- Reading difficulty
- Nausea
- Vertigo
- Diplopia
- Distorted space perception

Testing of aniseikonia

Space eikonometer

The degree of aniseikonia is exactly measured using space eikonometer. This instrument is expensive.

Rule of thumb

- If aniseikonia is associated with anisometropia which is of refractive then the difference in image size will be about 1.5% per diopter of anisometropia
- If anisometropia is due to axial then the difference in image size will be about 1% per diopter

Treatment

Optical aniseikonia

These treatments are available for aniseikonia which arises due to anisometropia

- Contact lenses
- Implanting IOL for unilateral aphakia
- Refractive corneal surgery
- Aniseikonic spectacles - these are expensive and difficult to make

Retinal aniseikonia

- Due to any causative disease, treating the cause corrects the aniseikonia

Student exercise

Answer the following

1. *What is aniseikonia?*
2. *What are the causes for aniseikonia?*
3. *What are the clinical types of aniseikonia?*
4. *What is the rule of thumb for testing aniseikonia?*
5. *What are the treatment modalities of aniseikonia?*

Amblyopia

Amblyopia means reduced vision in a normal anatomical eye. No organic cause can be detected for amblyopia.

Amblyopia develops during early childhood. Children under nine years of age whose vision is still developing are at high risk for amblyopia. Generally the younger the child, the greater the risk.

There are many reasons for amblyopia and they are as follows:

- Squint/strabismus
- Large difference in the power of each eye
- Cataract
- Severe ptosis
- Premature birth
- Heredity
- Any disease that affects the eye

Amblyopia develops because one eye is turned as in squint, and two different pictures are sent to the brain. In a young child, the brain learns to ignore the image of the deviated eye and see only the image of the better eye. Similarly when there is difference in refractive error of each eye the blurred or defocused image formed by the eye with more refractive error is ignored by the brain.

For the retina to capture the images, it needs adequate light and visual stimulus. This being absent due to cataract, either in one eye or both, results in amblyopia.

Amblyopia can often be reversed if detected and treated early.

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As soon as amblyopia is detected, active measures should be taken to treat it. Cooperation of the patient and parents is required to achieve good results. If left untreated or not treated properly the reduced vision becomes permanent and cannot be improved by any means.

Mechanism of amblyopia

- Abnormal binocular interaction
- Vision deprivation

Characteristics of an amblyopic eye

- Reduction in visual acuity
- Eccentric fixation
- Crowding phenomenon
  - Visual acuity is better when the test letters are viewed singularly rather than in a series

Types of amblyopia

- Strabismic amblyopia
- Anisometropic amblyopia
- Ametropic amblyopia
- Stimulus deprivation amblyopia
- Meridional amblyopia

Strabismic amblyopia

Strabismic amblyopia is seen in patients having squint since birth, unilateral constant squint, who strongly use one eye for fixation. It is more common in esotropes.

Example: A patient has right esotropia

Vision: Right eye: 2/60 nig nip

Left eye : 6/6 nil glass

In this case the patient will prefer only the left eye for fixation.

Anisometropic amblyopia

Anisometropic amblyopia occurs in an eye having a higher degree of refractive error than the other eye. It's occurs more in hyperopes than in myopes.

Hypermetropic amblyopia - More than 2-3 Diopters

Myopic amblyopia - More than 5 Diopters

Example 1: Right eye 6/6 nil glass

Left eye 6/60 with + 3.0DSPH 6/24 nig nip

(Left eye - Anisohypermetropia)

Example 2: Right eye 3/60 with – 9.00SPH / -1.0 x 90 6/36 nip

Left eye 6/9p with – 0.75Dsph 6/6

(Right anisomyopia)

Ametropic amblyopia

Occurs in patients with bilateral uncorrected high refractive error.

Hyperopia of more than + 5.0D

Myopia of more than - 10.0D

Example 1: Right eye 5/60 with + 7.0Dsph 6/36 nip

Left eye 4/60 with + 8.0Dsph 6/36p nip

Example 2: Right eye 6/60 with - 11.0Dsph 6/18

Left eye 2/60 with - 12.0Dsph 6/18/ nip

Stimulus deprivation amblyopia

It is caused by an eye being deprived of visual stimulus. It is important to alleviate the cause as soon possible.

Example 1. Ptosis (Drooping of upper eyelid)

2. Corneal opacity

3. Cataract

Meridional amblyopia

Occurs in patients with uncorrected astigmatic refractive error. It can be bilateral.

Example : Right eye 6/12 with - 1.0 X 180 6/6

Left eye 6/60 with -4.0 X 180 6/18 nip

(Left eye meridional amblyopia)

Treatment of amblyopia

The earlier the intervention, the better the prognosis for amblyopia. Patients have a better prognosis when treated before 5 years of age.

After 8 years of age, however the chance of significantly improving the vision in amblyopia is small.

Visual development and amblyopia

1. Critical period - One week to 3 - 4 months of age
2. Visual plasticity - Birth to 7 year of age
3. Extended plasticity - more than 10 years of age

Treatment

If any refractive error is present give new correction

- Occlusion
- Atropine therapy (penalisation)

Correction of refractive error

If there is any refractive error we have to give full cycloplegic correction before starting treatment.

Occlusion

Occlusion refers to closure of the normal eye with patch or ground glass, thus forcing the child to use the amblyopic eye to stimulate visual development. It can be either occlusion of light or both light and forms.

Total occlusion

With the help of direct patching of the eye both light and form occlusion is done.

Partial occlusion

With the help of cello tape or ground glass over the normal eye, only the form of objects are not seen, but the light is seen.

Full time occlusion

The ratio adapted is 3:1. Three days occlusion to normal eye and 1 day occlusion to amblyopic eye.

This type of patient uses ground glass (or) cello tape.

Part time occlusion

Patient does patching for a few hours only 6hrs/day to normal eye.

Occlusion is done from a few hours to full time depending upon the age of the patient and type and severity of the amblyopia.

Follow up

Patients who are patching their eyes need periodic follow up. Duration of treatment may extend from months to years. If the patient is not coming for follow up, but continuously patching, then normal eye can become amblyopic. Follow up is very important for occlusion patients. Follow up period depends upon the eye and type of occlusion therapy.

Atropine therapy (Penalisation)

Topical atropine 1% is used to dilate pupil and paralyse accommodation. This is used to blur the normal eye. Atropine therapy (penalisation) is used to selected cases only.

Surgery

In case of stimulus deprivation amblyopia, early surgery is needed.

- Ptosis correction
- Squint correction
- Cataract removal with IOL

Student exercise

I. True or false

1. *Amblyopia can be treated by surgical correction*
2. *Occlusion therapy is more effective in childhood*
3. *Strabismus amblyopia occurs due to change in the refractive status of the eye*
4. *In occlusion therapy the good eye is patched.*
5. *Stimulus deprivation amblyopia can be due to corneal opacity*

II Match the following

1. *Amblyopia* - *Refractive error*
2. *Meridional* - *Ptosis*
3. *Stimulus deprivation* - *Normal eye*
4. *Ametropia* - *Lazy eye*
5. *Occlusion* - *Astigmatism*

III Answer the following

1. *What is amblyopia?*
2. *What is occlusion therapy?*
3. *What are the types of amblyopia?*
4. *What is meridional amblyopia?*
5. *What is the treatment for amblyopia?*

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CHAPTER 6 ACCOMMODATION AND ITS ANOMALIES

CONTENTS

Accommodation
- Definition
- Changes in accommodation with age
- Controlling accommodation
- Anomalies of accommodation
- Treatment

GOAL

To enable the ophthalmic assistant's (OA) understand accommodation, the methods used to control it, anomalies of accommodation, their symptoms and treatment

OBJECTIVES

The OAs will be able
- To define accommodation
- To differentiate physical and physiological accommodation
- To discuss the mechanism of accommodation
- To measure the range and amplitude of accommodation
- To access the positive and negative portion of accommodation
- To connect the symptoms with treatment

CHAPTER 6

Accommodation and its Anomalies

Definition

Accommodation is the mechanism by which the eye changes refractive error by altering the shape of its crystalline lens.

Mechanism of accommodation

The essential feature of accommodation is an increase in the curvature of the lens which affects mainly the anterior surface. This alteration in shape inverses the convergent power of the eye, so that the focus can be altered as and when required.

Types of accommodation

- Physical accommodation
- Physiological accommodation

Physical accommodation

The ability of the lens to alter its shape is called physical accommodation. It is measured in diopters.

Physiological accommodation

The power of the ciliary muscle to contract is called physiological accommodation. Physiological accommodation is the cause and physical accommodation is the effect.

Characteristic features of accommodation

1. Range
2. Amplitude

Range of accommodation

Distance between the far point of accommodation and near point of accommodation is known as range of accommodation.

Amplitude of accommodation

The dioptric difference between the far point of accommodation and near point of accommodation is known as amplitude of accommodation.

Far point

The clear image at maximum distance from the eye is called the far point of accommodation. In emmetropes it is at infinity.

Near point

The clear image at closest distance from the eye is called near point of accommodation.

Positive portion of relative accommodation (PRA)

A measure of maximum ability to stimulate accommodation while maintaining clear single binocular vision.

Negative portion of relative accommodation (NRA)

A measure of maximum ability to relax accommodation while maintaining clear single binocular vision.

PRA is tested using minus lens and NRA is tested using plus lens. PRA should be greater than NRA, otherwise the patient will have asthenopic symptoms while doing near work.

Changes in the eye during accommodation

Inner changes

- Ciliary muscles constrict
- Anterior surface of the lens increases its curvature, which increases the dioptric power of the crystalline lens

Other changes

- The pupil constricts. This increases the depth of focus and also eliminates peripheral rays which diminish spherical aberration
- Both eyes will converge

Unaccommodative state is maintained due to the following factors:

- Elastic force of the lens
- Elastic elements of the ciliary body
- Toughness of zonules and capsules

Accommodation is helped by

- Elasticity of lens
- Contraction of ciliary muscles
- Plasticity of the capsule and zonules which relax when the ciliary muscles contracts.

During the act of accommodation the following phenomenon occurs

- Lens decreases in equatorial diameter Centre of lens protrudes forward
- Relative flattening at the periphery of the lens
- Lens increases in thickness.

Changes in accommodation with age

As age advances, the amplitude of accommodation decreases. This is due to change in the consistency of the lens, which becomes harder with advancement of age. At about 40 years, a normal person cannot read when the reading material is about 33 cm away from the eyes. This is called presbyopia. (Normal reading distance - 33cm).

Amplitude of accommodation with age

Age	Accommodation in diopter
5 yrs	16D
10 yrs	14D
15 yrs	12 D
20 yrs	10D
25 yrs	8.5D
30 yrs	7.0D
35 yrs	5.5D
40 yrs	4.5D
45 yrs	3.5D
50 yrs	2.5D
55 yrs	1.75D
60 yrs	1D

Accommodation in refraction

Hypermetropia

Hypermetropic patient will accommodate continuously to see a clear image. This excessive accommodation will result in pseudomyopia.

Pseudomyopia

The accommodative spasm causes blurry distance vision after prolonged near work. The individual may appear myopic.

Myopia

Myopic patients have clear near vision. There is no need for accommodation.

In hypermetropia

- Range of accommodation: normal
- Amplitude of accommodation: greater

In myopia

- Range of accommodation: less
- Amplitude of accommodation: shorter

Controlling accommodation

If accommodation is not controlled, refractive error may vary while evaluation is performed.

There are two ways to control accommodation

- Cycloplegia
- Fogging method

Cycloplegic drops

These drops have a temporary paralyzing effect on the ciliary muscles.

Cycloplegics are drugs used to paralyse the ciliary muscles and also to dilate the pupil. Cycloplegic refraction is necessary in young children, especially for hypermetropia.

- Cyclopentolate is a good cycloplegic. Allow enough time for the full cycloplegic effect; 20-30 minutes
- Homotropine - action up to two days

- Atropine - Action up to 2 weeks, or sometimes even more (21 days). This is used therapeutically also

Fogging

This method is used to control accommodation during a manifest refraction. This test is not needed for all patients. The objective of fogging is to blur the vision in the eye being tested to about 6/36. This is done by increasing the convex (+) spherical lens or by reduction of concave (-) spherical lens power. The convex (+) power is reduced before the eye or concave (-) power is added in steps of 0.25 D until the visual acuity is improved to the maximum.

Anomalies of accommodation

They are four types:

- Excessive accommodation
- Insufficiency of accommodation
- Spasm of accommodation
- Ill sustained accommodation

Excessive accommodation

Excessive accommodation is associated with excessive convergence and is found most frequently in younger people.

Spasm of accommodation

Tone of ciliary muscle is increased and a constant accommodation effort is expanded by the para sympathetic nervous system. Pseudomyopia is produced.

Insufficiency of accommodation

In this condition, the patient's accommodative amplitude is consistently lower than what is normal for his/her age. This condition is also called premature presbyopia.

The insufficiency may be of:

a. Lenticular origin
b. Ciliary origin

Ill sustained accommodation

Amplitudes are normal, but rapidly diminish with age. When the patient uses his eyes for near, for a long duration, his accommodation fails, near point recedes gradually and his near vision becomes blurred.

Paralysis of accommodation

i) Artificial – by drug : a) Atropine b) Homatropine
ii) Due to diseases :
    a) Paralysis of oculomotor nerve
    b) Paralysis of ciliary muscle due to any cause. Usually it is accompanied by paralytic dilatation of pupil.

Inertia of accommodation

Some difficulty is noted altering the range of accommodation, manifested as difficulty in changing focus from distance to near and near to distance. This is a rare condition.

Symptoms

Associated with close work;

1. Asthenopia
2. Transient blurred vision for near
3. Photophobia
4. Abnormal fatigue
5. Headache
6. Watering
7. Difficult sustaining near visual function
8. Dizziness
9. Abnormal working distance
10. Orbital pain

Treatment

Orthoptic exercise

- Prism glasses (Bases out)
- Convex (+) power glasses
- Accommodative flipper

Clinical findings in accommodation problems

Condition	Symptoms	Findings	Etiology	Ocular treatment
Accommodation fatigue	Blurred near vision	Normal NPA which decreases with repeated testing	Refractive errors, medication, illness, non-specific	Spectacle correction/ reading exercises
Accommodation failure (insufficiency, ill-sustained)	Blurred near vision	Decreased NPA, heterophoria	Refractive errors, local eye trauma, medication illness, non-specific	Spectacle correction/ reading exercise, fusion exercise
Accommodative paralysis	Blurred vision, micropsia, diploia	Decreased NPA, heterophoria, tropia	Trauma, medication, neurologic / medical	Spectacle correction/ reading exercise, base-in prism
Accommodative spasm	Blurred, fluctuating vision, diplopia, asthenopia	Increased NPA, pseudomyopia, variable eso	Psychogenic, trauma neurologic / medical	Cycloplegics (or) miotics Spectacle correction / reading exercise

NPA - Near Point of Accommodation

Students exercise

True or false

1. *Accommodation is the mechanism by which the eye changes its size* ( )
2. *There are three types of accommodation* ( )
3. *The amplitude of accommodation declines with age* ( )
4. *cycloplegic drops have a temporary paralyzing effect on ciliary muscle* ( )
5. *Asthenopia is not a symptom of accommodation insufficiency* ( )

Match the following

1. *PRA*	-	*Exercise accommodation*
2. *NRA*	-	*Accommodative flipper*
3. *Fogging*	-	*Minus lens*
4. *Accommodation weakness*	-	*Lens*
5. *Pseudomyopia*	-	*Controlling accommodation*

Answer the following

1. *What is accommodation?*
2. *What are the symptoms of accommodation problems?*
3. *What are the types of accommodation?*
4. *What is the anomaly of accommodation?*
5. *What is the treatment for accommodation?*

CHAPTER 7 CLINICAL REFRACTION PROCEDURES

CONTENTS

Principles of retinoscopy
- Evaluation and types of retinoscope
- Design of self-illuminated retinoscope

Procedures in performing the retinoscopy

Subjective refraction
- Trial lens methods
- Pin hole test
- Stenopic slit
- Duochrome test
- Binocular balancing test

GOAL

To enable the ophthalmic assistant's (OA) the basic techniques of retinoscopy and to know how to neutralise spherical refractive errors and to know the basic concepts of retinoscopy. To recognise the presence of astigmatism, to identify the correct axis of astigmatism

OBJECTIVES

The OA will be able
- To state the necessity of objective refraction
- To tell the history of retinoscopy
- To explain the types of retinoscope available
- To describe the design of streak retinoscope
- To discuss the optics of retinoscopy
- To demonstrate working lens and correcting lens concept
- To define working distance
- To perform to neutralisation of spectacle lenses
- To explain the techniques to find power and axis of cylinder

CHAPTER 7

Clinical Refraction Procedures

Retinoscopy

Retinoscopy is an objective method of measuring the optical power of the eye. A retinoscope is used to illuminate the inside of the eye, and to observe the light that is reflected from the retina. These reflected rays alter as they pass through the optical media of the eye, and by examining just how these emerging rays change, we determine the refractive power of the eye.

We describe retinoscopy as objective because we evaluate the eye as an optical instrument, initially ignoring any information the eye transmits to the brain. Thus retinoscopy does not depend on the patient's vision or judgment.

Retinoscopy reduces refraction time and error by quickly determining the appropriate correcting lens, minimising the decisions the patient must make to refine the correction. Retinoscopy proves invaluable when patients cannot cooperate (infants, mentally retarded persons).

Evolution of Retinoscopy

- In 1859, Sir William Bowman commented on the peculiar linear fundus reflex he saw when viewing astigmatic eyes with H. Helmhohz' new ophthalmoscope
- In 1873 Cuignet introduced the clinical use of retinoscopy in quantifying determination of refractive status
- In 1878 Landolt attempted to explain the optical concept underlying retinoscopy
- In 1880 Parent updated the optical theory of retinoscopy and initiated the name retinoscopy
- In 1920, Jack C. Copeland designed the streak retinoscope with rotating bulb to turn the streak to all ocular meridians. His original model was patented in 1927. He popularised the streak technique and revolutionized retinoscopy

Types of retinoscope

Reflecting (mirror) retinoscope: Mirror retinoscope is inexpensive and the most commonly used. A source of light is placed above and behind the patient. It may consist of single or plane mirror or a combination of plane and concave mirrors. There is a central aperture in the mirror (3-4mm in diameter) through which light enters the observer's eye

Self-illuminated retinoscope: These are costly but handy. These have become more popular recently. Two types of self-illuminated retinoscopes are available.

1. **Spot retinoscope:** This projects light as a small circular beam on the retina
2. **Streak retinoscope:** This projects light as a streak on the retina. This is popular as it makes determination of cylindrical power and axis easier

Design of self-illuminated retinoscope

It consists of two systems. Projection system and Observation system

Projection system

This consists of the following parts-

- **Light source:** A bulb with a linear filament that project a line or streak of light. Turning the sleeve on the instrument rotate the bulb, which in turn rotate the projected streak. This turning sleeve and rotating the light streak is called meridian control
- **Condensing bulb:** Resting in the light path, the lens focuses rays from the bulb on the mirror
- **Mirror:** Placed in the head of the instrument, the mirror bends the path of light at right angle to the axis of the handle. A beam projects from the head of the instrument

- **Focusing Sleeve:** This varies the distance between the bulb and lens to allow the retinoscope to project rays that either diverge (plane mirror effect) or converge (concave mirror effect). Hence, the sleeve is also called vergence control. In most instruments, the sleeve changes the focus (vergence) by moving the bulb up and down
- **Current source:** This is provided by a corded handle (connected to a transformer stepped down to 2.5v to 3.5v) or battery handle

Observation system

Peephole

Light reflected by the illuminated retina enters the retinoscope, passes through an aperture of the mirror and come out through the peephole at the rear end of the head. When we move the retinoscope we see movement of the streak /spot projected on the retina while looking through the peephole

Optics of retinoscopy

Before going into detail of the working principles of the retinoscope, understanding the far point concept of refractive error and its correction are necessary.

'Far Point' concept

Far point (FP) of an eye is defined as that point in space that is conjugate (corresponding to) with the fovea, when accommodation is relaxed. In retinoscopy retina is illuminated, locating the far point (FP) in space that is conjugate with it. If rays falling on retina come from infinity, it is known as emmetropia (normal vision)

- For emmetropia FP is at infinity
- For hypermetropia FP is beyond infinity
- For myopia FP lies somewhere in between infinity and the eye

While correcting refractive errors put the FP point at infinity.

'With movement'

If the emerging rays have not converged to a point the retinal reflex will move in the same direction as the streak is moved (Fig. 7.1 and Fig. 7.2).

'Against movement'

If rays have come to FP and diverge, the reflex will move opposite to movement.

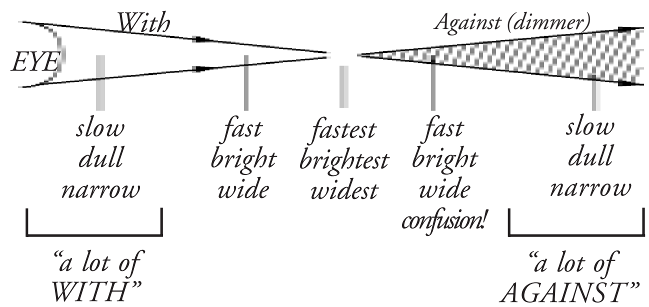


Fig. 7.1 - Characteristic of retinal reflex on both sides of neutral point

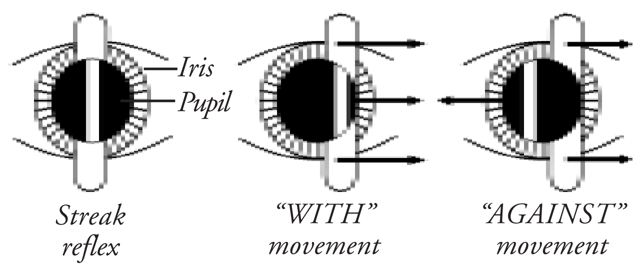


Fig. 7.2 - Movement as seen while rocking the scope

Principle

In retinoscopy, 3 stages are present.

- **Illumination stage:** Light is directed into the patient's eye to illuminate retina
- **Reflex stage:** An image of the illuminated retina is formed at the patient's far point
- **Projection stage:** Moving the illumination across the fundus and noting the behavior of the luminous reflex locate the image at the far point

As the plane mirror effect is preferred universally, here image formation by plane mirror will be discussed.

Illumination Stage

At this stage light is thrown from retinoscope to illuminate the retina (Fig. 7.3).

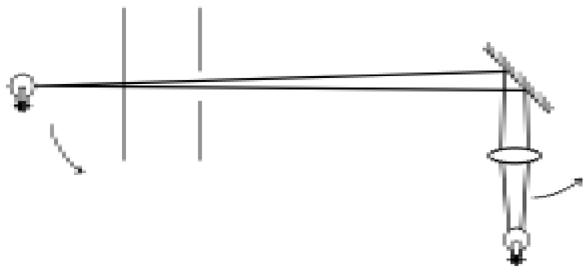


Fig. 7.3 - Illumination stage

Reflex stage

An image A1B1 of the illuminated retina is formed at the patient's far point. This image may be constructed using three rays (Fig. 7.4, Fig. 7.5 and Fig. 7.6).

- A ray from point A of the retina R on the principal axis of the eye, which leaves the eye along the principal axis
- A ray from retinal point B, off the principal axis, which travels parallel to the principal axis as far as the principal plane, P, of the eye, where it is refracted to pass onward through the anterior principal focus, Fa, of the eye
- A ray from retinal point B which passes undeviated through the nodal point

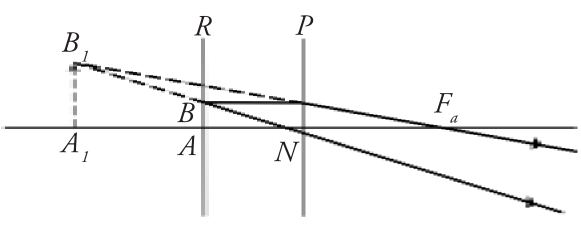


Fig. 7.4 - Reflex stage - hypermetropia

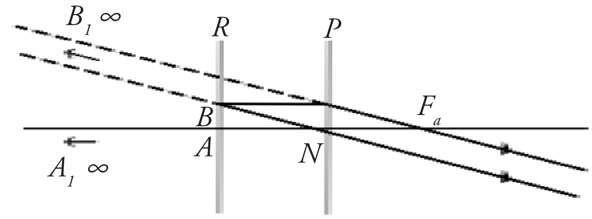


Fig. 7.5 - Reflex stage - emmetropia

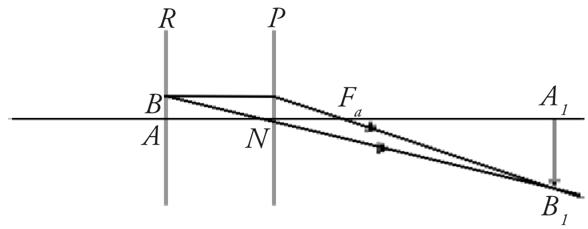


Fig. 7.6 - Reflex stage - myopia

Projection stage

In hypermetropia and emmetropia the luminous reflex seen in the patient's pupil moves in the same direction as the illuminating light- a "with movement" indicated by arrow in the figure (Fig 7.7, Fig. 7.8 and Fig 7.9).

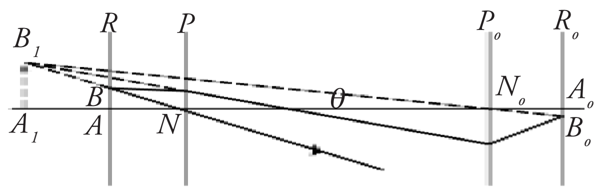


Fig. 7.7 - Projection stage - hypermetropia

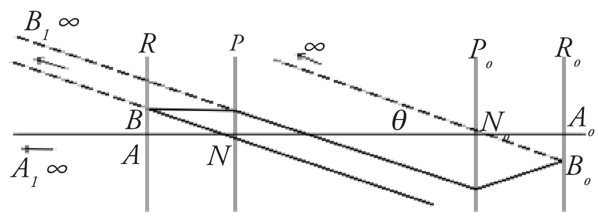


Fig. 7.8 - Projection stage - emmetropia

The point of reversal or neutral point of retinoscope is reached when the patient's far point coincides with the observer nodal point.

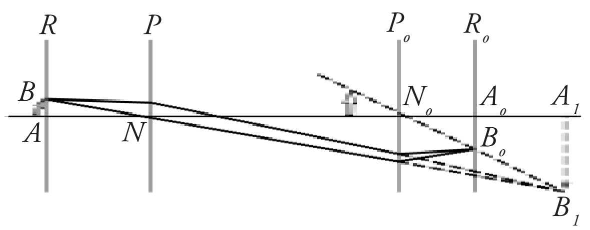


Fig. 7.9 - Projection stage - myopia less than 1.50D

No image of B1 can be formed on the observer's retina and at this point no movement of the reflex can be seen in patient's pupil. The observer sees a diffuse bright red reflex. This is because the movement of the reflex is infinitely rapid.

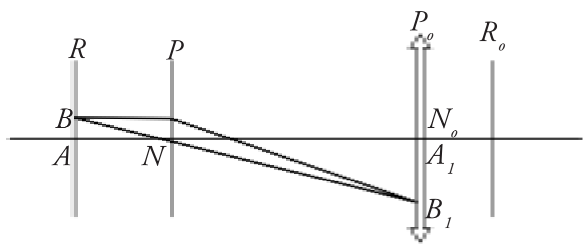


Fig. 7.10 - Myopia -1.50D

When the patient's myopia exceeds the dioptric value of the working distance, the image A1B1 falls between the patient and observer.

The diagram shows that the luminous reflex now appears to move in the opposite direction to the illuminating light, "against movement". Once again the luminous reflex appears to move more rapidly as the point of reversal is approached.

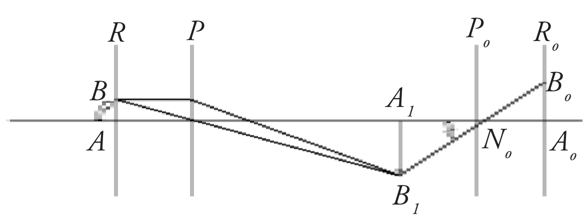


Fig. 7.11 - Myopia greater than -1.50D

Prerequisite for retinoscopy

- A dark room
- Retinoscope
- A trial set
- A trial frame
- Distance fixation target preferably distance vision charts

Procedures in performing retinoscopy

- The patient sits at a distance of 1meter/66 centimetre (as convenient to retinoscopist)
- Patient is asked to fix at a distant target to relax accommodation
- Then light is thrown on the patient's eye from retinoscope
- By rocking the light slowly the characteristics of the reflex are observed

Characteristics of moving retinal reflex

Speed: In low degrees of refractive error the movement of the reflex is fast, whereas in high degrees of refractive error the movement is slow.

Brilliance: In low degrees of refractive error the reflex is bright whereas in high degrees of refractive error the reflex is dull.

Width: In low degree of refractive error the reflex is wide whereas in high degree of refractive error the reflex is narrow.

Working lens (neutralising lens)

Far point optics defines refractive error in terms of correcting lens that put the FP at infinity. But it is impossible to sit at infinity. Infinity can be simulated at any distance by placing a working lens before the eye. The power of this lens must equal examiners dioptric distance from the patient. The working lens makes the scope as if it were at infinity. For example, if the examiner sitting at 1meter distance has to put a working lens 1D in front of the eye, this 1D lens puts them at infinity and now neutralising can start.

Correcting lens

Use of the appropriate working lens places us at infinity. Correcting lens is the lens that will bring FP to the examiner. Whatever correcting lens brings the FP to infinity is the measure of refractive error (ignoring the power of working lens).

- Plus lenses pull FP towards the eye
- Minus lenses push FP away from the eye

Working distance

66 cm (26”) is a convenient working distance (roughly arm’s length) with suitably bright reflex. Dioptric value (1.5) is a round number to subtract. Error of 5cm in either direction causes error of only 0.12 D. If less working distance is used, (25cm) an error of a few centimeters can cause error up to 0.50D. Whereas more working distance (1 meter) reduce reflex. In dim light, it is difficult to change lenses from the trial frame (Fig. 7.12).

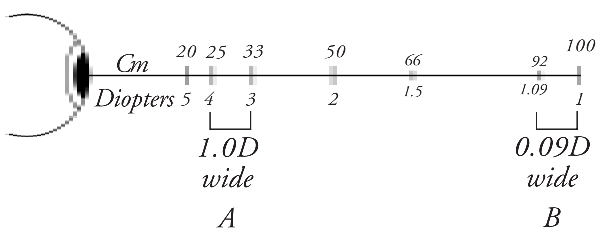


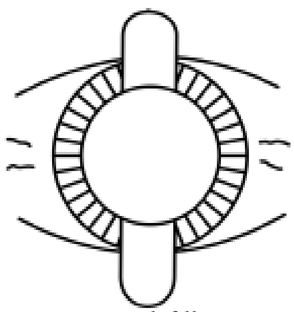
Fig. 7.12 - Dioptric distances. Compare the width of spaces A and B. Each is 8cm. , yet there is tenfold difference in dioptric width

Neutralisation

In against movement, the far point is in between the examiner and the patient (Fig. 7.13). Therefore to bring the far point to the examiner’s pupil, minus lenses should be placed, in front of the patient’s eye. Similarly, in case of with movement, plus lenses should be placed in front of the patient’s eye. When the neutralization point is reached there is no movement of reflex. This leads to simple clinical rules:

- If with movement is seen add + lens (or subtract minus)
- If against the movement is seen add minus lenses (or subtract plus lenses)

Lens power should be added or subtracted until neutrality is reached.



Pupil fills

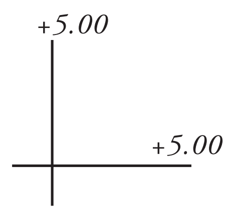
Fig. 7.13 - Neutralization

Finding spherical power

Sphere

When both principle meridians require the same correcting power.

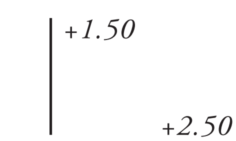
e.g..



Finding cylindrical power

With two spheres

Neutralise one axis with one spherical lens. If the 90-degree axis is neutralised with a +1.50D sph and the 180-degree axis is neutralised with 2.50D sph., the gross retinoscopy will be +1.50Dsph /+1.0cyl 90degree. The examiners working distance should be subtracted from the sphere to obtain the refractive correction.



With a sphere and cylinder

First neutralise one axis with an appropriate spherical lens. (In order to keep working using 'with reflexes', neutralise the less plus axis first). With this spherical lens in place, neutralise the other axis 90 degrees away with a cylindrical lens at the appropriate orientation. The spherical - cylindrical gross retinoscopy may be read directly from the trial lens apparatus.

With two cylinder

Although it is possible to use two cylinders at right angles to each other for the gross retinoscopy, there is no advantage of this variant over the spherocylinder combination.

Finding cylinder axis

Break

Break is observing the alignment between the reflexes in the pupil and the band outside it. When the streak is not parallel to one of the meridians, the band of light in the pupillary area lies in a position intermediate between the bands outside the pupil and that from the axis cylinder. The axis even in the case of low astigmatic errors can be determined by rotating the streak until the break disappears. The correcting cylinder should be placed at this axis (Fig. 7.14).

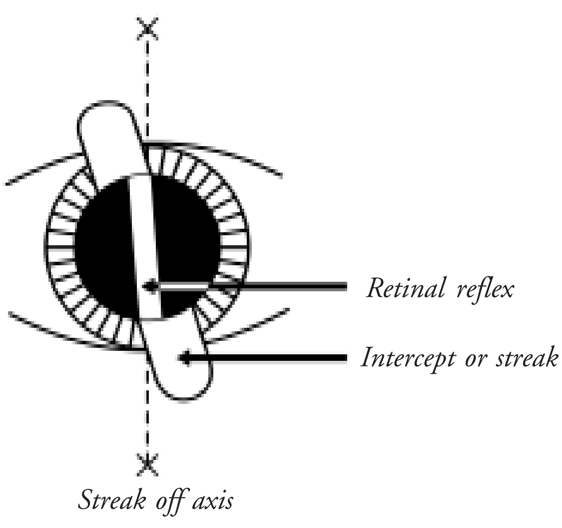


Fig. 7.14 - Break

Width

The width of the streak varies as it is rotated around the correct axis. It appears narrowest when the streak aligns with the true axis.

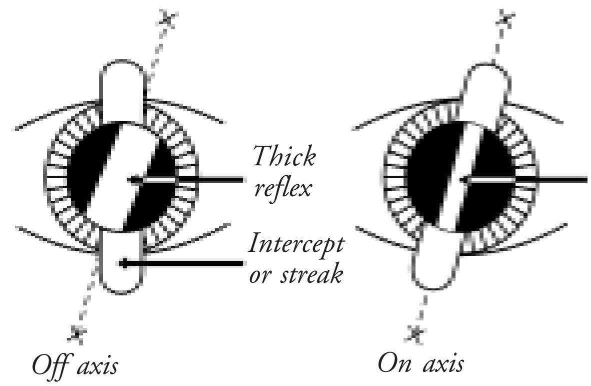


Fig. 7.15 - Break

Intensity of reflex

The intensity of the line is brighter when the streak is on the correct axis.

Skew

Oblique motion of the streak reflex may be used to refine the axis in small cylinders. If the streak is off axis, it will move in a slightly different direction from the pupillary reflex (Fig. 7.16). The reflex and streak move in the same direction (both at the right angle to the orientation of the streak) when the streak is aligned with one of the principle meridians.

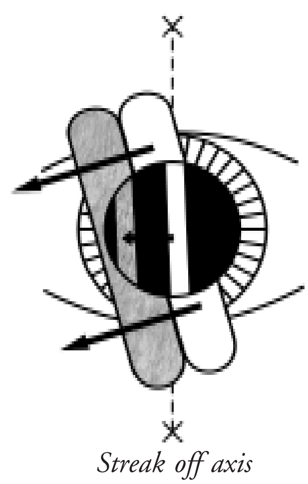


Fig. 7.16 - Skew

Straddling

This technique is performed with the estimated correcting cylinder in place (Fig. 7.17). The retinoscope streak is turned 45 degrees from the axis in both directions, and if the axis is correct the width of the reflex will be equal in both off axis positions. If the axis is incorrect, the width will be unequal in the two positions. The axis of the correcting cylinder should be moved towards the narrower reflex and straddling performed again.

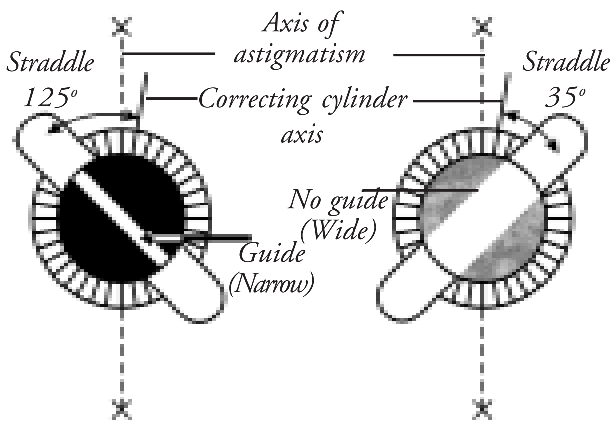


Fig. 7.17 - Straddling

Pin-pointing axis

We can pin-point exact axis by reducing the sleeve width and checking the axis with trial frames.

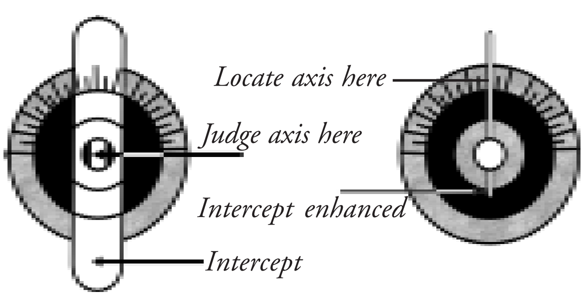


Fig. 7.18 - Pinpointing axis

Tips

- *It is easier to work with the brighter, sharper with image; it is preferable to over minus the eye, and obtain with reflex and then reduces the minus (add plus) until neutrality is reached*
- *Be aware that the full dull reflex of high refractive error may be confused with the pupil neutrality reflex or with dull reflexes seen in patients with hazy media, high plus or minus, and check again*
- *Confirm the neutralization point by adding +/- 0.25D to observe the change of movement*

Summary

Retinoscopy is an objective method of measuring the optical power of the eye. Jack C. Copeland popularised streak retinoscopy. Though mirror and spot retinoscopes are still in use, the streak retinoscope is most popular. Streak retinoscope aids in finding the correct cylindrical power and axis. Optics behind retinoscopy are simple. The retina is illuminated to locate the far point and neutralise it by using correcting lens. If working lens are used it is not necessary to subtract working distance from the power obtained from neutralisation. 66 centimeters is the standard working distance used universally as distance error is minimal. Using different techniques like skew, straddling and pin-pointing correct cylindrical axis is found.

Student exercise

Answer the following

1. *Why is retinoscopy known as objective retinoscopy? What is its significance?*
2. *Describe the design of the streak retinoscope.*
3. *What is the far point? What are the stages involved in retinoscopy?*
4. *Why is 66 centimeters working distance used?*
5. *What are the special techniques used in finding axis of cylinder?*

Subjective refraction

Subjective refraction comes after objective refraction. Patients are asked to approve or refine the objective findings. In subjective examination, the patients are asked what lenses help them to see well. It includes optical science; it also involves physiological conditions of the eye and socio-economical background and psychological state of the patient.

Definition

Subjective refraction is the term applied to the technique of comparing one lens against another according to the patient preference, using changes in the vision as criterion to arrive at the dioptric lens combination that results in maximum visual acuity. (Polasky, 1991)

Factors influencing the response of the patient

- Refractive status of the eye
- Pathological condition of the eye
- Neurological condition of the eye
- Socio-economic background of the patient
- Intelligence of the patient
- Emotional state of the patient

Gaining patient confidence

Being a good retinoscopist does not always make a good refractionist. It's the patience and the expertise of dealing with patience that are required skill. Put the patient at ease by gaining their confidence. They will cooperate wholeheartedly.

- Ask patients simple questions and frame easy choices for them
- Explain to the patient what the retinoscopist prefer is the outcome. Since there is no right or wrong answer, there cannot be mistakes
- Give time for the patient to think and decide
- Be friendly with the patient

Pre-requisite for subjective testing

- Dark room
- Illumination
- Proper sitting arrangement
- Visual acuity chart (distance and near)
- Trial set
- Trial frame
- Jackson's cross cylinder
- Astigmatic dial

Trial-set accessories

- Occluder
- Pinhole
- Stenopaic slit
- Maddox rod
- Red and green glass
- Prism

Pinhole

Pinhole accessory consist of an opaque disc with a pinhole (PH) of 1 to 2mm in diameter in its center.

Optical function of pinhole

The pinhole allows the passage of only central rays of light. This permits the formation of a clear retinal image.

Size of pinhole

Size of PH may vary

Smaller PH: (diameter less than 1mm) introduces diffraction and further restricts retinal illumination, resulting in dim, unfocused retinal image.

Large PH: (diameter greater then 2mm) approximate human pupil and is ineffective.

Ideal PH: 1.32mm diameter is most effective (Lebensohn, 1950) because it produces the smallest blur circle size.

Multiple pinholes: Michaels (1985) suggested use of multiple pinholes in order to boost retinal illumination and ease the patient use.

Use of pinhole - assuring optical quality of the eye

Use of the pinhole allows the eye's potential visual acuity to be expressed. Vision with PH is compared to vision without pinhole.

- If patient's vision improves with pinhole, the patient has an uncorrected refractive error
- If patient's vision does not improve then patient may have a pathological defect or neurological defect

Point to be noted: When size of the pupil is small use of the PH will be of little diagnostic value (Hyperopia, aging, miotics)

Stenopic slit

The Stenopic slit consists of a rectangular aperture ranging from 0.5mm to 1.0mm in width and up to 15mm in length.

Optical function of stenopic slit

The width of the stenopic slit approximates that of pinhole and is assumed to limit admission of light rays to approximately one meridian. Thus the stenopaic slit acts like a pinhole to reduce the size of blur circle in the meridian at right angle to the slit, yet allows blur circle size to be unchanged in the meridian coincident with it.

Use

- To find astigmatic power and axis
- To measure vertex distance

Finding astigmatic power and axis

Stenopic slit is placed in front of the eye and rotated until position of better visual acuity is found. Then the position is fogged and unfogged to get best visual acuity. This position represents axis of the cylinder. When the slit is rotated to the other principle meridian, visual acuity is poorer in this position. This position is fogged and unfogged until the best visual acuity is reached again. The difference between powers found for the two primary meridians is the cylindrical component of refractive error with its axis perpendicular to the second slit position.

Measurement of vertex distance

Vertex distance can be measured using Stenopic slit. A thin ruler is entered through the slit to touch the eyelid of closed eye. The distance between the Stenopic slit and eyelid is the vertex distance. 1mm is to be added for thickness of closed eyelid.

Red and green lens

Red and green lenses are primarily used before an eye to interrupt fusion in the assessment of binocularity. These are used for Worth four dot test, FRIEND test and stereopsis.

Maddox rod

Maddox rod consists of a series of powerful convex cylindrical lenses, mounted side by side in a trial lens. The glass of Maddox rod is tinted red (Fig. 7.19).

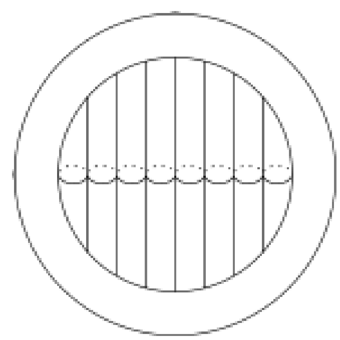


Fig. 7.19 - Maddox rod

Optical function of maddox rod

Maddox rod is placed in front of one eye. Patient sees a white spotlight kept at infinity. When light passes parallel to axis of cylinder, it goes undeviated and brought to focus by eye (Fig. 7.20).

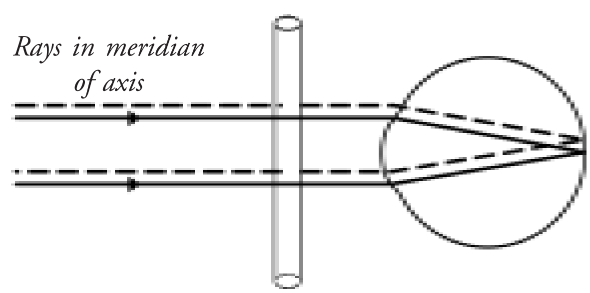


Fig. 7.20 - Optics of maddox rod. Light in the meridian parallel to the axis of maddox rod

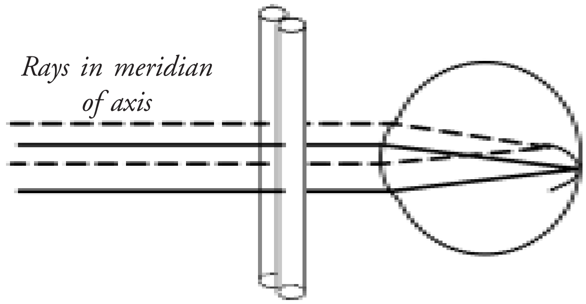


Fig. 7.21

The Maddox rod consists of a series of plus cylinders, forming a row of foci on the retina. These foci join up and are seen as a line of light, which lies at 900 to the axis of the Maddox rod.

Light incident on the Maddox rod in the meridian perpendicular to its axis is converged by each cylinder to a real line focus on the retina.

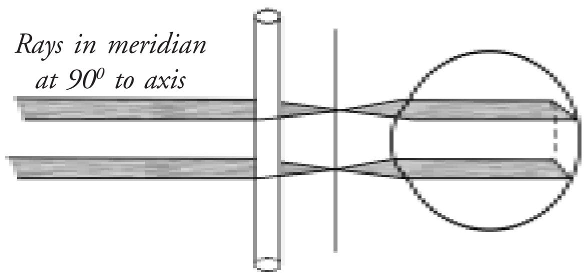
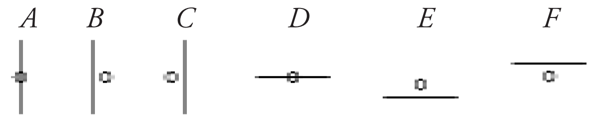


Fig. 7.22

Use

Maddox rod is used in the diagnosis of phoria and tropia.

- Maddox rod is conventionally placed in front of the right eye.
- A distant white spot light source is viewed through both eyes.
- Right eye sees the red line at 900 to the axis of Maddox rod, left eye sees the spotlight.
- • Two eyes see dissimilar images, dissociated, allowing any muscular imbalance to become manifest.



A Horizontal orthoporia
B Exophoria (The patient has crossed diplopia and this indicates an exophoria ('X'ed dioplopia = exo))
C Esophoria
D Vertical orthoporia
E Right hyperphoria
F Right hypophoria (= left hyperphoria)

Fig. 7.23 - The patient's view (Maddox rod before the right eye)

Steps of subjective refraction

- Starting point
- Control of accommodation
- Astigmatic correction
- Monocular spherical end point
- Binocular balance

Starting point

The corrections of refractive error determined by the objective technique are placed into the lens aperture of trial frame. The objective results acts as a starting point from which the subjective refraction can take place. Alternatively, the habitual spectacle correction or result of previous subjective refraction may suffice as the starting point. The geometrical center of the trial lens of 1cm apertures are aligned with the patient's visual axis and the appropriate vertex distance and pantoscopic angles are achieved.

Control of accommodation

Controlling accommodation (i.e. relaxing accommodation) is essential because fluctuating accommodation may confuse retinal focus presented by each change of lens combination. Accommodation may be controlled by three classic means: - Cycloplegic refraction, Non Cycloplegic refraction and Fogging

Cycloplegic refraction

Cycloplegic refraction means refraction under cycloplegia of ciliary muscle. Cycloplegic eye drops (atropine, cyclopentolate and tropicamide) are instilled to achieve cycloplegia (paralysis) of ciliary muscles, which results in full relaxation of accommodation.

It is recommended when patients have the following situations:

- Asthenopic symptom
- Hypermetropia
- Convergent strabismus
- Active accommodation

As accommodation is fully relaxed, patients accept more plus correction. This correction results in blurred vision after the effect of cycloplegia diminishes. Drug correction is done on total correction accepted by the patient. Sometimes a second refraction is required after the effects of cycloplegia have cleared.

Drug correction

It is an arbitrary modification of the result of cycloplegic refraction for giving spectacle prescription. We subtract a value depending on the nature of Cycloplegic used.

Non-Cycloplegic refraction

In this case the patient is asked to fix at a distant large target. This relaxes accommodation adequately.

Fogging technique

In this technique the initial objective is to blur the vision by adding plus(+) spherical lens or reduction of minus(-) spherical lens to reduce visual acuity to Snellen's 6/36 .Then plus power is reduced before the eye or minus power is added in steps of 0.25D until visual acuity improves to the point that the patient can distinguish small letters of chart presented at distance. This process is called unfogging.

Astigmatic correction

The major effort in subjective refraction is to determine the astigmatic component of refractive error. Hence a large number of techniques have been developed for the accurate measurement of astigmatism. There are two main techniques usually followed.

Testing astigmatism under fog

In this technique a spherical correcting trial lens combination is placed in front of each eye. This places foci of both principal meridians in front of the retina. Then astigmatic dial is used to find the axis of cylindrical component of error (Fig. 7.24).

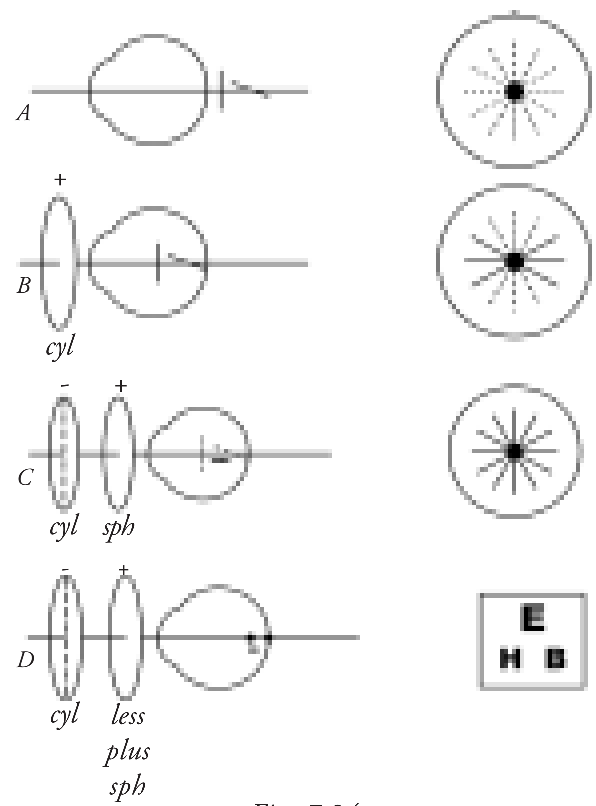


Fig. 7.24

A Retinal image of astigmatic dial as viewed by an eye with compound hyperopic astigmatism

B Fogging to produce compound myopic astigmatism

C Conoid of strum collapsed to a single point as minus cylinder of appropriate power is added

D Minus sphere is added or plus sphere is subtracted to produce sharp image

Technique

- Obtain best-corrected visual acuity using sphere
- Fog the eye to about 6/60 by adding plus sphere
- Ask patient to note blackest and sharpest line of astigmatic dial
- Add minus cylinder with the axis perpendicular to the blackest and sharpest line until all lines appear equal
- Reduce plus sphere (or add minus sphere) until best acuity is obtained with visual acuity chart.
- All lines of the dial now appear equally black and sharp

Testing astigmatism without fog

The major technique in use today for determination of axis and power of cylindrical component of refractive error is JCC (Jackson Cross Cylinder), also known as flip cross technique. This technique does not require the eye to be fogged for proper performance. In fact the technique is best performed when the circle of least confusion is on the retina.

Jackson cross cylinder

JCC was first described by Jackson in 1887 for determination of power and 1907 for axis of cylinder.

Construction of JCC

It is a spherocylinderical lens in which the power of the cylinder is twice the power of sphere and of opposite sign. E.g. +0.50DSph is combined with –1.0DCyl. This results in a net power meridional refractive power of +0.50DC in one meridian and –0.50Dc in the other meridian.

The principle meridians are marked at the periphery of the lens to be visible by the examiner. The handle is attached midway between two marked meridians.

Technique

Axis check

- Position the cross cylinder axis 450 from the principal meridian of the correcting cylinder
- Determine preferred flip choice
- Rotate the axis towards the corresponding axis of cross cylinder (plus cylinder axis rotated to + cylinder axis of JCC, minus cylinder axis rotated to - cylinder axis of JCC)
- Repeat until two flip choices are equal.

Power check

- Align JCC axes with the principal meridians of correcting cylinder (Fig. 7.25 and Fig. 7.26)
- Determine preferred flip choice
- Add or subtract cylindrical power according to the preferred position of cross cylinder
- Compensate for change in position of the circle of least confusion by adding half as much sphere in the opposite direction.

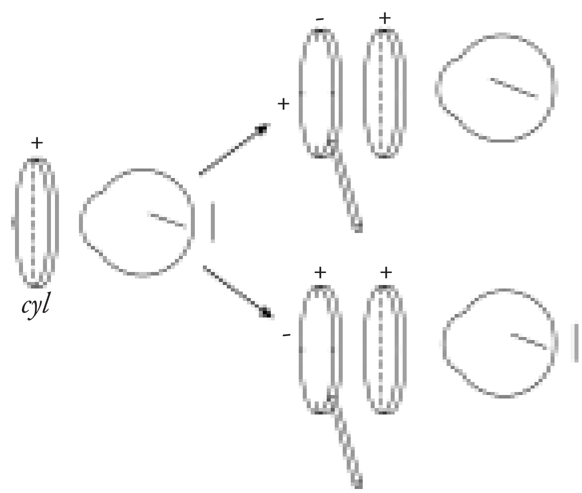


Fig. 7.25

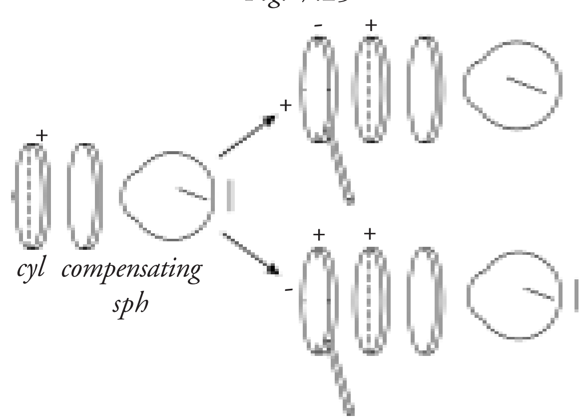


Fig. 7.26

Monocular spherical end point

Duochrome test

This test is used to find the monocular endpoint of refraction (Fig. 7.27). Each eye is tested separately to find out if the eye is over corrected or under corrected. This test was introduced by Brown (1927), but it lapsed into disuse until reintroduced by Freeman (1955).

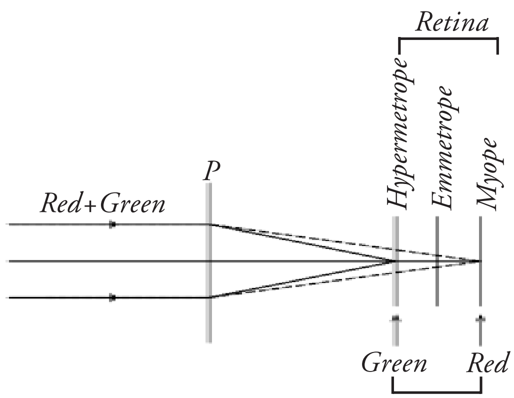


Fig. 7.27 Duochrome test

Principle

Chromatic aberration, the basis of the test, occurs because different wavelengths of light are bent to a different extent. The longer wavelength (red) is refracted less than the shorter (green). If the letters on the red side stand out more, add minus power; if the letters on the green side stand out more, add plus power. Neutrality is reached when the letters on both backgrounds appear equally distinct.

Technique

- One eye is occluded
- Subject is asked to note whether the letters on the chart are equally visible or prominent on both backgrounds or more visible or prominent against one of the backgrounds
- Vision is slightly fogged by adding plus(+) sphere monocularly in 0.25DS steps until red background letters become more prominent
- This should occur in only one / two increments of plus power unless the eye has been over corrected
- The plus powered sphere before the eye is reduced until both background letters appear equally distinct. This represents optimum correction
- Next reduction causes green to be more prominent

Binocular balancing

Binocular balancing is not only balancing the visual acuity, but also balancing accommodation

Technique

Place the final distance correction in the trial frame with the patient viewing 6/18 line target with both the eyes.

Add +0.75 D sphere to both eyes and ask the patient whether the vision became blurred. This step is fogging.

Tell the patient to keep both eyes open. One eye is covered then the other eye and the patient is asked which eye sees better.

Add +0.25 D sphere to the better seeing eye and repeat the above step. Continue until both eyes are equally blurred. Slowly defog until the patient can read the 6/6 line.

Points to be noted after duochrome test

If a change in lens power produces immediate reversal of choice from red to green, spherical power that gives better perception of green is the appropriate end point. This especially occurs in young patient with active accommodation.

- Older patients are red biased because of the changes in crystalline lens.
- This test is equally relevant for patients with color deficiency as chromatic aberration is still present in their eyes. Instruct the patient to evaluate the prominence of letters, not colors.
- Instruct patient to notice clarity, darkness, definition of black letters not their background as intensity of chart colors may vary among different manufactures.

Students exercise

Answer the following

1. *Explain the difference between subjective and objective refraction.*
2. *List three factors that influence patient response in subjective refraction.*
3. *Why is the control of accommodation important?*
4. *What ocular medication is used in refraction?*
5. *Explain how to refine the cylindrical axis.*
6. *Describe the duochrome test.*
7. *Explain with diagram the optical function of Maddox rod.*

CHAPTER 8 OCULAR MOTILITY AND STRABISMUS

CONTENTS

GOAL

To enable the ophthalmic assistant (OA) understand the basic physiology of extra ocular muscles and their actions. To examine and document findings which will in turn help the ophthalmologist to efficiently treat the patient.

OBJECTIVES

The OA will be able to

- Describe the extra ocular muscles and their action
- Discuss about squint and the different types of squint
- Evaluate various components of muscle balance like accommodation and convergence fusion and stereopsis binocular vision, convergence and fusion exercise

CHAPTER 8
Ocular Motility and Strabismus

Introduction

Squint is misalignment of the eyes where the two eyes are pointed in different directions. It is manifest if it is visible and latent if it is controlled and not visible. Manifest squint again can be either present all the time (constant) or occasionally (intermittent). A manifest squint is otherwise termed heterotropia. The importance of detecting and treating squint as early in life as possible is to avoid irrecoverable vision loss due to a condition called amblyopia which has been described.

Extra ocular muscles and extra ocular movements

There are fourteen extra ocular muscles, six inserted into each globe and responsible for movement of the eyes, and one inserted into each upper eyelid, responsible for raising it.

These muscles are:

1.	Rectus muscles	
	Horizontal recti	Lateral rectus
		Medial rectus
	Vertical recti	Superior rectus
		Inferior rectus
2.	Oblique muscles	Superior oblique
		Inferior oblique
3.	Lid elevator muscle	Levator Palpebrae Superioris

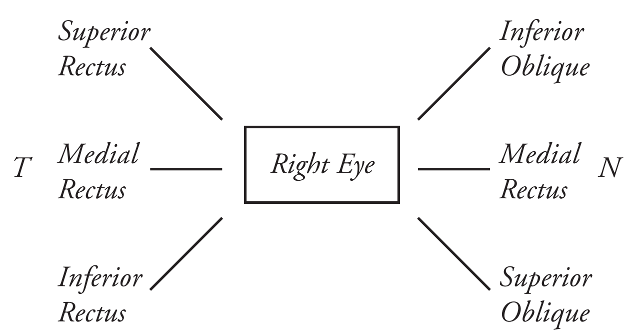
Nerve supply

The extra ocular muscles are supplied by the cranial nerves as follows: the sixth nerve supplies the lateral rectus, the fourth nerve supplies the superior oblique, the superior division of the third nerve supplies the medial rectus, the superior rectus and the levator muscle and the inferior division of the third nerve supplies the inferior rectus and inferior oblique.

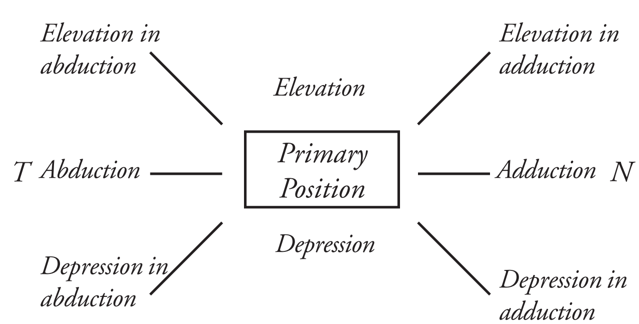
Actions of the extraocular muscles

Movement of the globe is brought about by relaxation and contraction of the extraocular muscles. Each muscle has a main action in one position of gaze which is termed the diagnostic position of gaze and also one or more secondary actions. When the eyes look straight ahead, they are in the primary position. As the eyes move away from the primary position, one or more muscles increase their contraction and others relax to allow movement to take place. The following two figures will show the direction of movement brought about by the various extra ocular muscles.

The Main action of the extra ocular muscles in the diagnostic position of gaze of the right eye, as seen by the examiner



Position of gaze of the right eye as seen by the examiner



T - Temporal, N - Nasal

The main and secondary actions are shown in the table below

Muscle	Main Action	Secondary Action
Lateral rectus	Abduction	None
Medial rectus	Adduction	None
Superior rectus	Elevation and abduction	Adduction and intorsion
Inferior rectus	Depression and abduction	Adduction and extorsion
Superior oblique	Depression and adduction	Abduction and intorsion
Inferior Oblique	Elevation and adduction	Abduction and extorsion

Duction

Duction is a movement of one eye, Abduction being outward movement, Adduction the inward movement (Fig. 8.1).

Supraduction and Infraduction apply to upward and downward movement respectively, but these latter terms are rarely used.

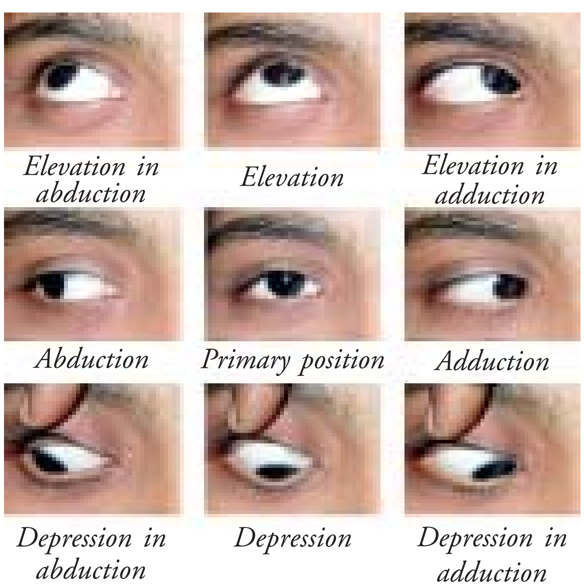


Fig. 8.1 - Duction movement of right eye

Versions

A version is a conjugate or parallel eye movement in which both eyes move in the same direction (Fig.8.2).

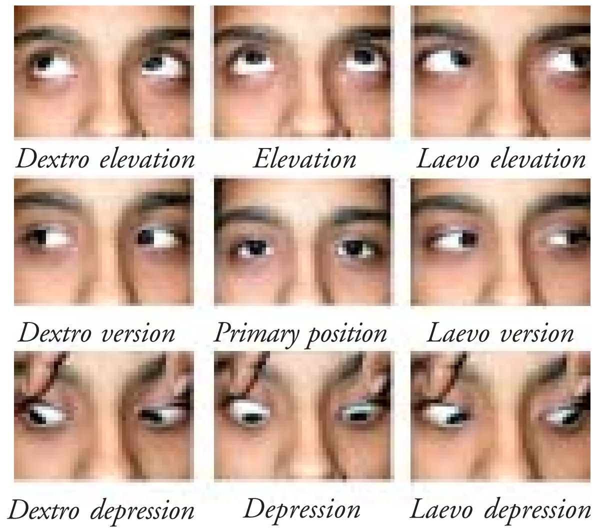


Fig. 8.2 - Versions

Versions are described as

- Dextroversion, both eyes move to the right
- Laevoversion, both eyes move to the left
- Dextroelevation, both eyes move up and to the right
- Dextrodepression, both eyes move down to the right
- Laevoelevation, both eyes move up and to the left
- Laevodepression, both eyes move down to the left

Vergences

A vergence is a disconjugate or non-parallel eye movement in which the eyes move in opposite directions (Fig. 8.3). They comprise;

1. Convergence, brought about by contraction of both medial rectus muscles
2. Divergence, brought about by contraction of both lateral rectus muscles

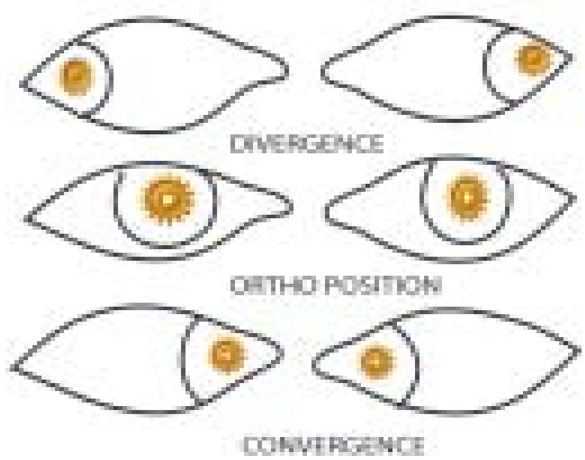


Fig. 8.3 - Horizontal vergences

Examination of ocular movement

Versions are tested routinely by asking the patient to follow a moving target into the diagnostic positions of gaze, observing the extent of movement of each eye. It is usual to test horizontal movement first, followed by vertical movement and oblique movements. .

Procedure

- The patient's head must be kept straight. It may be necessary to hold it, especially when testing a child
- The target must be easy to see and small enough to ensure accurate fixation on it. A small pen torch is ideal, but must not be too bright
- The target should be held about 40 cm from the patient's eyes and should be kept at eye level when testing horizontal versions
- Both eyes must be visible to the examiner. It may be necessary to raise the eyelids slightly to see the eyes as they look down, but the eyelid position must be observed before doing this, because abnormal lid movements are sometimes seen and must be noted
- The target should be moved smoothly at a moderate speed, not too fast for the patient to follow it. It must be moved to the extreme limits of gaze, otherwise small defects of movement can be missed

Results

If both eyes move equally and smoothly in all directions of gaze, to the extreme positions, the ocular movement is said to be "full".

- Underaction means a limitation of movement seen when the eye is directed into the diagnostic position of gaze
- Overaction means excessive movement of a muscle beyond its extreme limits in the diagnostic position of gaze
- Detection of slight underaction is easier if the movement of the suspected eye is compared with the same movement in the normal eye. For example, if the right eye is the suspected eye then comparing abduction of right eye with that of left eye will bring out even a small underaction of abduction in the right eye

Recording the results

The amount of limitation of movement is classified as slight, moderate, marked or no movement. This is documented with 1 to 4 (-) signs respectively.

Over action which again can be mild, moderate, marked or severe is documented with 1 to 4 (+) sign respectively.

Binocular vision

Binocular single vision

Binocular single vision (BSV) is the simultaneous use of the two eyes to give a single mental impression in ordinary seeing conditions. The images of the fixation object from each eye fall on the foveas and are fused to give a combined single image.

Components of binocular vision

Simultaneous perception is the ability to see the images projected from each eye at the same time.

Fusion is the ability to join two like images, one from each eye, and see them as one fused image.

Stereoscopic vision is the ability to appreciate that the fused image is three-dimensional.

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Patients with manifest squint may have simultaneous perception but lack the ability to fuse.

Fusion amplitude or fusion range

The fusion amplitude is the measure of the amount of vergence movement which can be maintained. The positive fusion amplitude represents convergence and the negative fusion amplitude represents divergence.

Stereoscopic vision

Stereopsis is the appreciation of depth. True stereopsis is obtained only when BSV is present,

Convergence and accommodation

Convergence

Convergence is a disconjugate movement in which both eyes rotate inward so that the lines of sight intersect in front of the eyes. It allows bifoveal single vision to be maintained at any fixation distance.

Convergence is well developed by 2-3 months of age. It is made up of four parts:

Tonic convergence: When a person is deeply asleep or unconscious, the eyes are normally divergent. This is called the position of rest. Tonic convergence brings the eyes from the position of rest to a straight position.

Proximal convergence: It is the response to the individual's knowledge of the nearness of the object.

Fusional convergence: It is induced by the desire for binocular single vision. It is responsible for maintaining BSV when heterophoria is present.

Accommodative convergence: It occurs in response to accommodation. This is the largest component of convergence. Even when accommodation is prevented by old age, accommodative convergence still occurs in response to the stimulus of blurred vision.

Near point of convergence

This is the point closest to the eyes at which convergence can be maintained. It is measured in centimeters (cm) from the corneal surface, most conveniently by apparatus such as the near point rule or RAF ruler. The normal near point is 8 cm.

Accommodation

Accommodation is the ability of the lens to adjust its convexity to the distance of the fixation object from the eyes, so that the image is sharply focussed.

Near point of accommodation

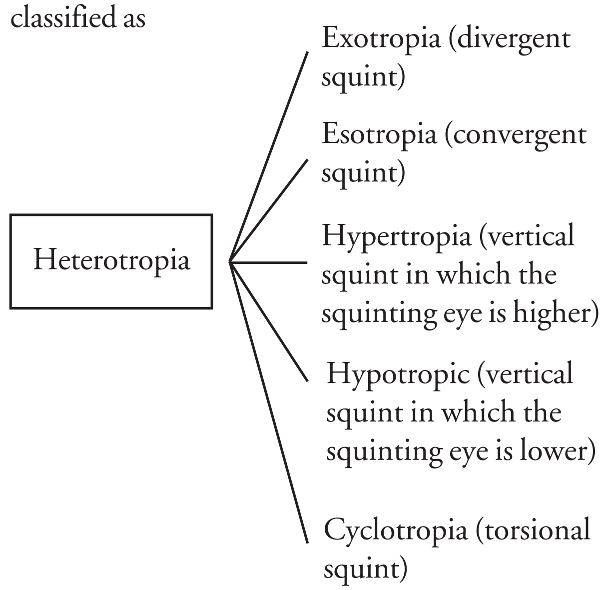
This is the point closest to the eyes at which clear vision can be obtained. It is measured in cm from the corneal surface, with each eye separately and with both eyes together. The near point ruler or RAF ruler can be used for this measurement. The normal near point depends on the age of the person tested.

Amplitude of accommodation

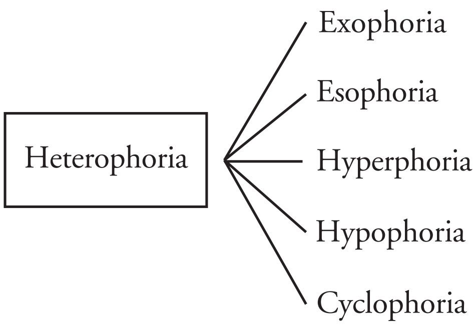
This is the total amount of accommodation which can be exerted, expressed in diopters (D). Like the near point, the amplitude depends on the person's age. Accommodation develops in early childhood and is reasonably accurate at 2-3 months when convergence develops. In normal subjects the amplitude is 16D at 16 years, it reduces to 8D at 32 years and at 60 years only one diopter remains.

Classification of squint

Tropia is manifest squint which can be broadly classified as



A latent squint is a phoria. Heterophoria includes all types of latent squint.



While doing the cover test the eye takes fixation from an outside position towards the nose. This is called exotropia. If the eye moves from an inward position towards the ear to take up fixation it is esotropia. Up to down means hyper and down to up means hypo.

Cover test

The cover test is the main method of detecting manifest and latent squint. It can be done for near (33cms) and distance (6metres) (Fig. 8.4).

Fig. 8.4 - Cover test at 33 cm

It requires:

- An adequate means of completely covering the eye. The best cover is a paddle type occluder which can be moved easily from one eye to the other
- Alternatively a card may be used
- Fixation targets for near and far fixation
- A vision chart for distance fixation

Method

The cover test is used in two ways, the cover/uncover test and the alternate cover test. Both are necessary and are usually performed in that order.

Cover/uncover test

The patient fixes on a spotlight held centrally just below eye level at 33cm (Fig. 8.5). The corneal reflections are noted and compared. The reflection on the squinting eye will be displaced, nasally in exotropia and temporally in esotropia.

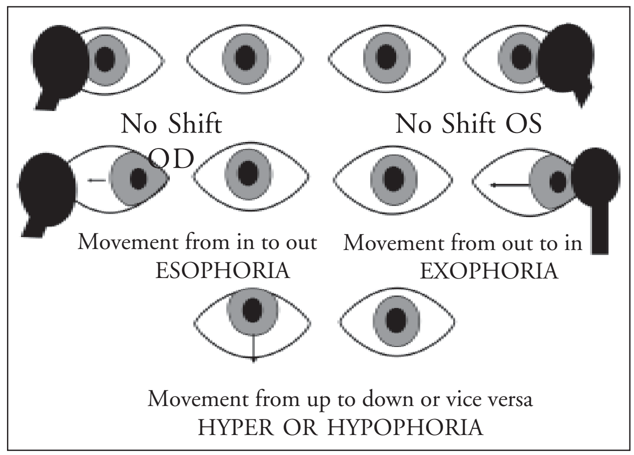


Fig. 8.5 - Cover / Uncover test

In manifest squint / cover test

One eye, for example the right eye is covered, and the behavior of the left eye is observed. The cover is then removed, still watching the left eye. If there is a manifest squint in the left eye, that eye will move to fixate when the right eye is covered. When the cover is removed it will return to its squinting position, unless the patient is able to alternate, when it may remain fixing while the right eye squints. The test must be repeated in all gazes. The examiner must be sure that the patient is fixing on the light. The test is repeated using a target at 6m.

In latent squint / cover / uncover test

One eye is covered and then uncovered as described above, but the behavior of the eye behind the cover is observed as the cover is taken away. In heterophoria the eye behind the cover deviates and then straightens as the cover is removed. This is done for each eye . The test is performed at 33cm and 6m, comparing the amount of deviation seen and noting particularly the recovery movement to regain BSV. This may be

- Rapid, when the eye straightens immediately after the cover is lifted
- Moderately rapid, when the eye starts to straighten immediately but moves less quickly
- Slow delayed, when the eye remains in a squinting position for a short time before starting to straighten

The importance of the speed of recovery is that it is a guide to the patient's ability to keep the heterophoria under control. A rapid recovery indicates good control whereas a slow or delayed recovery suggests that the heterophoria could cause symptoms or could become a manifest squint.

Alternate cover test

In this test the cover is changed from one eye to the other back and forth several times (Fig. 8.6). One or the other eye is covered throughout the test. The direction and amount of movement of each eye is noted as the cover changes. Because the patient never sees the target with both eyes at the same time, a recovery movement cannot occur, therefore this method cannot differentiate manifest and latent squint. Its purpose is to dissociate the eyes by preventing binocular vision in order to find the maximum angle of squint.

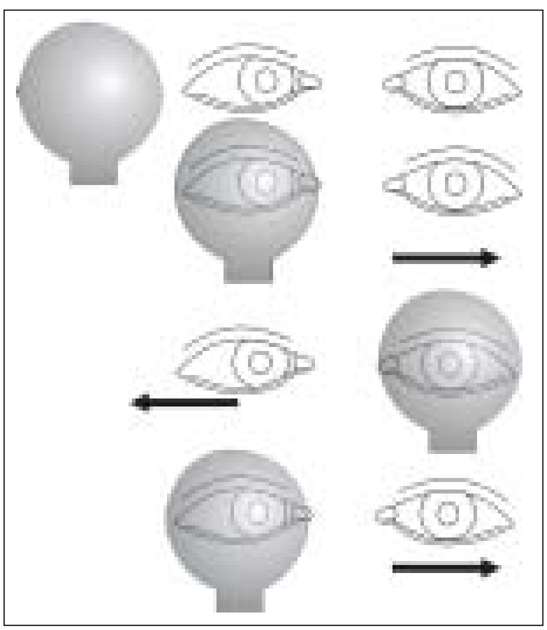


Fig. 8.6 - Alternate cover test

Precautions

- The examiner must give the patient time to fix steadily before removing the cover or changing it to the other eye
- The eye must be covered long enough to allow dissociation to take place and uncovered long enough to allow for possible recovery. If it is performed too quickly the correct diagnosis may be missed

Information obtained from the cover test

- The presence of a squint
- Whether it is manifest or latent

Manifest squint

- The type: exotropia , esotropia or vertical squint
- Whether it is constant or intermittent, unilateral or alternating

Latent squint

- The type of phoria
- The distance at which the phoria increases, for example, an exophoria may be larger for near than distance or larger for distance than near
- The degree of compensation, detected from the speed of the recovery movement

Measurement of the angle of squint (Tropia)

Methods using corneal reflections

Hirschberg test

This test is a method of estimating the angle of manifest squint from the position of the corneal reflections in the squinting eye (Fig. 8.7). It is assessed at 33cm. The patient fixes on a light held centrally at

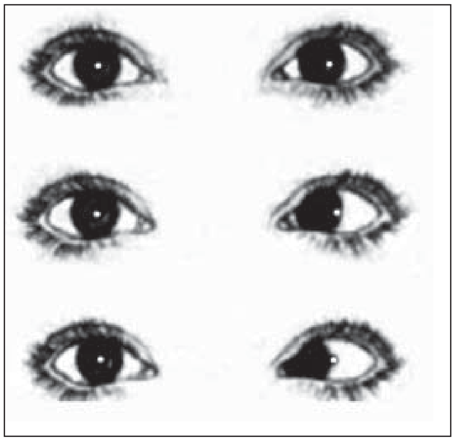


Fig. 8.7 - Hirschberg test

eye level at this distance and the corneal reflections are noted in both eyes. The reflection in the fixing eye will be central or slightly nasal in the large majority of cases. The reflection in the squinting eye will be displaced nasally in exotropia and temporally in esotropia. Each mm of displacement from the center of the cornea equals approximately 15 diopters of squint. The angle of squint is calculated by assessing the number of mms.

If for example, the reflection is midway between the center of the pupil and the limbus (the junction of the cornea and the sclera), the angle is approximately 40D (20). If it is at the limbus, the angle is 90D (45). This method is useful when the angle cannot be measured by prism cover test, usually when the angle is very large or the patient cannot cooperate.

Methods of measuring the angle of squint using neutralisation of movement

Prism cover test

The prism cover test is the first choice method of measuring manifest and latent squint using loose prisms or prism bars) (Fig. 8.8).

It requires:

- Prisms, usually in the form of horizontal and vertical prism bars. Loose prisms can also be used

A cover test is first performed to find

- The type and direction of squint
- The fixing eye in manifest squint
- Fixation in the squinting eye

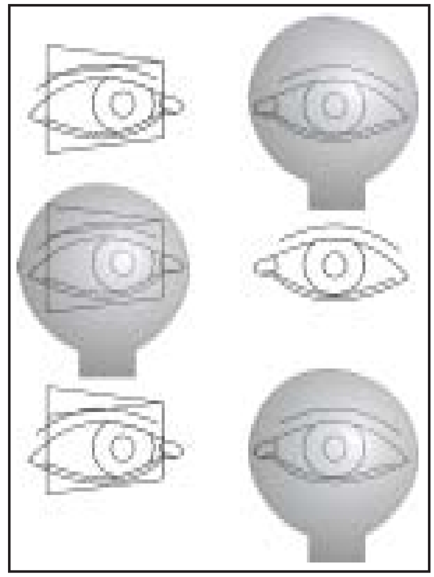


Fig. 8.8 - Prism cover test

Method

The patient fixes on an easily seen picture or letter at 33cm (Fig. 8.9). The prism bar is placed in front of the squinting eye in manifest squint or in front of either eye in latent squint. The apex of the prism is placed in the direction of the squint, base in for exodeviations, base out for esodeviations and base down in hypertropia. An alternate cover test is performed, slowly enough to give the patient time to fix through the prism, watching the movement of each eye as the cover is changed. The prism strength is adjusted until there is no movement, giving the

Fig. 8.9 - Prism cover test

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measurement of the angle in prism diopters. The procedure is repeated using a distant target.

The prism cover test is recorded as, for example:

PCT near 45D base out with glasses or 45D ET with glasses
distance 35D base out with glasses or 35D ET with glasses

Examiner's precautions

- Loose prisms are easier to interpret than a prism bar. The prism must be held upright with the back surface parallel to the plane of the face
- Prism must be kept straight. If it is tilted to one side the prism strength is changed
- The patient must look through the center of each prism
- The alternate cover test should be performed fairly slowly to give the patient time to fix on the target
- One or the other eye must be covered all the times to dissociate the eyes and to prevent binocular vision

Measurement of angle of squint (phoria)

Maddox wing

The maddox wing is used to measure heterophoria at 33cm (Fig. 8.10). The patient looks through two eye pieces at a metal plate at the base of the instrument. The plate is marked with two scales, one horizontal and the other vertical, both marked in prism diopters.

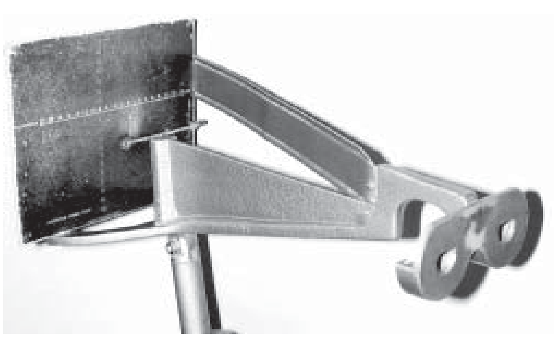

Fig. 8.10 - Maddox wing

A vertical white arrow points to the horizontal numbers and is used to measure horizontal phoria. Horizontal red arrow points to the vertical numbers and is used to measure vertical phoria. This arrow should be seen parallel to the horizontal numbers. If it is tilted cyclophoria is present. The arrow can be straightened by moving it up or down against a small vertical scale on the right side of the metal plate. The scale is marked in degrees to measure the amount of cyclophoria.

The right eye sees the horizontal and vertical scale and the left eye sees the vertical arrow pointing to the horizontal scale and a horizontal arrow pointing to the vertical scale. The eyes are therefore dissociated and any latent squint becomes manifest in order to measure the full deviation.

Precautions

Time must be allowed for full dissociation to take place.

The patient should wear glasses if they usually wear them for reading. It is sometimes easier to place lenses in the slots provided in the instrument's eye pieces, especially if bifocal spectacles are worn.

Maddox rod

The Maddox rod is a subjective method of measuring latent and some manifest squint. It is usually coloured red and consists of a number of parallel ridges which act as cylinders, converting a point source of light, a small spotlight, into a line image at 90 to the axis of the cylinders. The patient fixes on the spotlight with one eye and sees the line with the other eye. Fusion is impossible because the images are dissimilar, the eyes are therefore dissociated. The angle of squint is measured by using prisms to move the line until it passes through the light. The Maddox rod is generally used at 6m but can be used at other distances.

Method

- **To measure horizontal phoria**

  The rod is placed in a pair of trial frames with the ridges horizontal, giving a vertical red line.

The patient fixes on a spotlight at eye level and is asked where they see the line. In esophoria, it will be on the same side as the rod, in exophoria it will be on the opposite side. A prism bar is placed in front of the rod, base out for esophoria and base in for exophoria, and the prism bar is moved increasing the strength of prism slowly until the patient sees the line passing through the light

- **To measure vertical phoria**

  The ridges are placed vertically in the trial frames to give a horizontal line. The deviation is measured using a base down prism in front of the rod to measure hyperphoria or base up to measure hypophoria

Methods of measurement of convergence, accommodation and fusion amplitude

Near point rule (Royal air force ruler)

The near point rule (NPR) provides a convenient method of measuring convergence and accommodation (Fig. 8.11). It consists of a square metal rod 60 cm long with a face rest attached to one end. The top surface of the rod is marked out in cm to measure the distance from the patient's eyes.

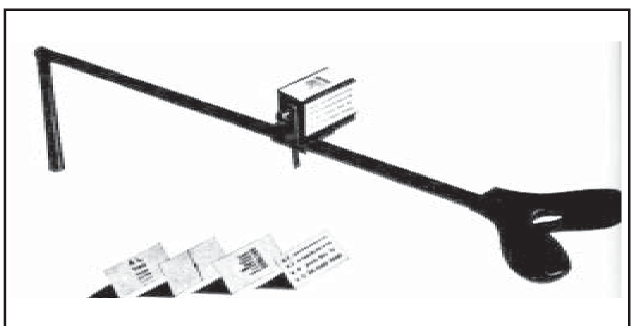

Fig. 8.11 - Near point rule (RAF rule)

The amount of accommodation in diopters (D) and an indication of the accommodation normally available at different age ranges are shown on the other slides. Targets for testing convergence and accommodation are mounted on each side of a sliding carrier which is moved along the rod. The targets consist of a vertical black line with a central fixation dot, used to measure convergence, and near test type and reduced Snellen's letters used to measure accommodation.

Method

The patient should be positioned with the selected target in a good light and with their eyes visible to the examiner. It is advisable to test convergence using a pencil or similar target before starting the test. Their near vision should also be known.

To measure convergence

- **Objectively** (i.e. according to the examiner's observations) the slide carrier is moved along the rod starting at a distance judged to be within the patient's convergence range, e.g. 20-25cm. The patient is told to fix steadily on the central dot on the line and the carrier is moved slowly towards his eyes. The observer notes:

  The near point of convergence (NPC), which is the distance at which one eye is seen to diverge. The test is repeated two or three times, noting if the NPC remains the same, improves or deteriorates. The diverging eye should be noted

- **Subjectively** (i. e. according to the patient's observations)

  The patient is asked to say when he notices the line become double or when he sees it move to one or the other side. This happens when the image is suppressed; the line moves to the side of the dominant eye. The subjective measurement is a more sensitive measurement; provided the patient is cooperative, he will notice movement of the line before the examiner sees movement of the diverging eye. The NPC may therefore be farther away when tested in this way: for example, NPC objectively 10cm, NPC subjectively 12cm.

  It is usual to measure convergence objectively first and then make use of the patient's observations(subjective) on retesting. The normal NPC is 10cm or better; it should be easily maintained at this distance.

Recording convergence

Examples: NPC 8cm, easily maintained

NPC 12cm with effort, LE diverges with L. suppression

NPC 12cm, RE diverges with diplopia; can rejoin with effort.

To measure accommodation

The aim is to measure the near point of accommodation (NPA) and compare it with the normal for the patient's age. The NPA is the closest distance at which clear vision is possible.

Accommodation can be measured with each eye separately and binocularly (when binocular single vision is present and convergence is sufficiently good). For this reason convergence should always be tested before measuring accommodation. The measurement is made with glasses if these are normally worn for close work.

Uniocular measurement

One eye is occluded and the patient is asked to read the smallest print they can see clearly. The type is moved slowly towards them until they notice that the print has started to become blurred. The test is repeated several times to assess if the NPA remains the same or deteriorates on repeated testing. The other eye is occluded and the test repeated, preferably using a different near test type.

Binocular measurement

The method is as described for uniocular measurement but with both eyes open .

Results

The NPA is recorded in centimetres uniocularly and binocularly if applicable. Usually the measurement is approximately the same uniocularly and binocularly. If the uniocular measurements are significantly better than the binocular measurement, it is probable that blurring with both eyes open is due to failure of convergence rather than failure of accommodation: The uniocular measurements are then taken into consideration rather than the binocular measurements. The normal NPA depends on the patient's age.

Precautions

The centimetre scale refers to the distance from the patients eyes: it is read from the back limit of the carrier and not from the actual target distance.

Testing accommodation is purely subjective.

Fusion amplitude (fusion range)

Convergence, divergence and vertical vergence can be measured with prisms, most easily with the horizontal and vertical prism bars. Convergence is measured with base out prisms, and is the positive fusion amplitude. It forms the greater part of the total horizontal fusion amplitude. Divergence is measured with base in prisms and is the negative fusion amplitude. Vertical vergence is measured using a vertical prism bar.

The fusion amplitude is usually measured at 33cm but should also be measured at 6m when indicated.

To measure the positive amplitude

The prism bar is placed base out in front of one eye. The patient fixes on a target held centrally, just below eye level at 33cm. An accommodative target, such as a picture or Snellen's letter, or, preferable, a light is used. The observer watches the patient's eyes as the prism strength is slowly increased. The eye behind the prism should converge and the other eye should remain fixed on the target. The bar should be moved slowly enough for convergence to take place, ensuring that the patient is looking through the center of each prism. The patient is asked to say when the target becomes double. The observer notes when one eye diverges. If diplopia is present the patient should be encouraged to fuse the images, as the prism is increased. It is sometimes helpful to move the target closer to their eyes to stimulate accommodation, which may be followed by convergence; the target can then be returned to 33cm and the prism strength increased until convergence can no longer be obtained.

Sometimes convergence fails because the patient does not understand what the patient has to do; it should be explained to them that they have to converge their eyes, just as they would if the target was moving towards them.

To measure the negative amplitude

The base in prism bar is placed in front of one eye. The eye behind the prism should move out and the other eye should remain fixed on the target as the prism strength is slowly increased. The observer should see one or the other eye move in when the limit of the negative amplitude is reached. The patient will probably see double when binocular single vision can no longer be maintained.

To measure the vertical amplitude

The vertical amplitude is measured only when hyperphoria is present. A vertical prism bar is placed base down in front of one eye. The prism strength is slowly increased until binocular single vision can no longer be maintained. The prism bar is then reversed so that the prism is base up and the process is repeated. The eye behind the prism will move in the direction of the prism apex in order to maintain binocular single vision, but the amount of movement is small and can be difficult to see. The patient should be asked to say when they see double and can no longer fuse the images.

Precautions

The patient must have binocular single vision in order to measure the fusion amplitude with prisms

They should be encouraged to rejoin the images when diplopia occurs and should be allowed time to do so.

The normal fusion amplitudes for near and distance in prism diopters are shown in the table:

Convergence		Divergence		Vertical vergence
Near	Dist	Near	Dist	Total
35/40	15	15	5/7	6

Investigation of binocular vision

Worth's lights (Worth's 4- dot test)

This test consists of four round lights, one red, two green and one white, as shown in Fig. 8.12 which are viewed through red and green glasses or goggles. The colours are complementary, so that the red and white lights are seen through the red glasses and the green and white lights through the green glasses. Only white lights are visible to both eyes simultaneously. The test is designed for use at 6m; scaled down lights are available for use at 50 cm and at 33cm. The test is done to obtain information about binocular vision. If the red light is infront of the right eye, the possible responses are:

- 4 lights, indicating binocular single vision, which can be normal
- 2 red lights, indicating left suppression
- 3 green lights indicating right eye suppression (as in the diagram)
- 5 lights, 2 red and 3 green, indicating a manifest squint without suppression. Normal retinal correspondence is likely

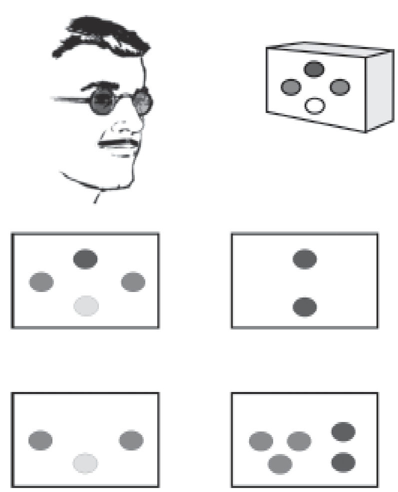

Fig. 8.12 - Worth's 4-dot test

Method

1. The patient should view the lights at eye level. The red and green glasses should be in place before the lights are shown. The patient is asked how many lights they see, then questioned about

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the colours of the lights. The results are recorded as, for example,

Worth's 4dot

Worth's 3 (R. suppression)

Worth's 5 (uncrossed/crossed)

2. Further information about binocular vision can be obtained if 5 lights are seen. If for example there is an esotropia and the patient has uncrossed diplopia of the lights, a base out prism can be used, preferably in the form of a prism bar, to find out if fusion of the lights is possible. The prism strength is adjusted to move the lights together. A patient with fusion should see 4 lights. The prism can be increased or decreased by 2 or 3 diopters and the lights should stay fused. If the patient has no fusion, he will see 5 lights, changing from uncrossed to crossed as the prism strength is increased. This information is important when planning treatment for squint

Precautions

- The patient, especially a child, should not be allowed to see the lights until they are wearing the glasses. If they know that there are four they may say that is what they see
- If the patient claims to see 4 or 5 lights, the examiner must make sure that all are lighted up. Occasionally it is possible to see lighted dots as black shapes
- If the patient sees 5 lights they should be asked if they see them all at the same time. Occasionally patients with alternating squint see 2 or 3 lights rapidly interchanging and will say they see 5
- BSV can also be tested with other instruments like Synoptophore and Bagolini striated glasses etc

Tests to measure stereoacuity

TNO test

Method

The test is done at 40cm. The patient wears the red and green glasses, on top of their own spectacles. They are shown the first plate, containing a butterfly in a field of random dots and asked how many butterflies they see. They should be asked to point to them to make sure they see the "hidden "butterfly. If they are correct, they can progress through the following plates until they are no longer able to see the stereoscopic target. The range of disparity is 480 to 15 seconds of arc. The result should be recorded as the smallest disparity the patient can see, for example "TNO 30' " (Fig. 8.13).

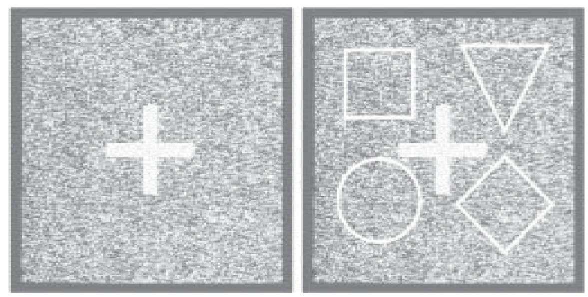

Fig. 8.13 - TNO test

Convergence deficiency, accommodative deficiency and heterophoria and their treatment

Convergence deficiency and insufficiency signs

1. Headaches, usually in the frontal area, and eye strain, caused by the effort needed to converge
2. Blurred vision and intermittent diplopia for near, caused by failure of convergence

Diagnosis

Convergence deficiency is diagnosed:

- From the patient's history of symptoms associated with close work
- By measuring the near point of convergence, easiest using a near point rule, repeating the measurement several times to see if the near point remains the same or if it moves further from the eyes on repeated testing
- The near point of accommodation, which can also be measured on the near point rule. The near point is the distance closest to the eyes at which

clear vision can be obtained. Accommodative deficiency or weakness can result in very similar symptoms to those described for convergence deficiency. Accommodation should be measured in each eye in turn and with both eyes together. If uniocular accommodation is normal for the patient's age and only binocular accommodation appears defective, this suggests that blurred vision is caused by defective convergence rather than defective accommodation

- The prism fusion amplitude or range. The positive amplitude will be poor in convergence deficiency, making it hard to maintain convergence
- By the cover test: The usual finding in convergence deficiency is slight exophoria for near, without significant deviation in distance. However, convergence deficiency can be associated with exophoria and, less commonly with esophoria. The speed of recovery to BSV should be recorded and the heterophoria measured using the prism cover test for preference
- By refraction: Small astigmatic or hypermetropic errors can cause similar symptoms to those already described, therefore the patient must be refracted and the refractive error corrected if necessary. Convergence should be reassessed after the spectacles have been worn for a few weeks

Treatment

Convergence deficiency is usually treated successfully by exercises to improve the near point and the positive fusion amplitude. The patient can be taught to do the exercises in the clinic and then practice them at home.

For diplopia: the patient must be able to appreciate diplopia when their convergence fails. Many patients can do this already, but a few suppress when one eye diverges. Diplopia can be taught using red and green glasses and a spotlight, which is moved closer to the eyes until one eye diverges: usually the patient will see 2 coloured lights; if not they can be shown where to look for the second light. Once they see two, the coloured glasses can be removed and they can try to see the lights without help. Most patients can do this without difficulty.

One pen exercise: Once the patient knows when his convergence fails, they can try to improve the near point by practicing convergence, bringing a pencil slowly towards their eyes, trying to keep it single. When diplopia occurs they can move it back a little and try to rejoin the images, then resume converging. They should be told to practice this several times 3 or 4 times each day. They should be warned that their symptoms may increase to begin with but should gradually improve as convergence gets easier.

Dot card

The dot card is used to improve convergence and can easily be made in the clinic. It consists of a strip of stiff cardboard about 30cm long with a line drawn down the centre of the card. A series of small circles is spaced out along the line, allowing 1-1½inches between each.

Method of use

The patient holds the card resting on the middle of his nose, tilted slightly downward. To exercise convergence the patient looks at each dot in turn, making sure that he sees it as a single dot, starting with the farthest dot, until he can no longer converge well enough to fuse the two dots. He should do this fairly slowly, returning to a slightly farther dot when his convergence fails and repeating the exercise.

As convergence improves, the patient should be able to change fixation quickly from a near dot to a far dot and back again.

The dot card is useful for patients with convergence deficiency to use at home in conjunction with stereogram cards, always practising the crossed position last to relax convergence.

Precautions

The patient must be given very clear instructions about the exercises they are to do at home, including the length of time he should spend on each and the

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number of times he should practice each day. He must demonstrate how to do each exercise before he leaves the clinic.

Accommodation weakness or insufficiency

Accommodative weakness gives rise to symptoms, especially if the patient does a lot of close work. These comprise

- Blurred vision, either for all close work or occuring after reading for some time
- Headache and eyestrain associated with close work

Diagnosis

- History and symptoms: the type and duration of the symptoms must be noted. Accommodative problems should always be suspected if the main symptom is blurred vision for near in a person under presbyopic age. The ophthalmologist will want to know about the patient's general health and if he is on any medication, as illness and certain drugs can sometimes cause the problem
- Measurement of the near point of accommodation, both uniocularly and binocularly, repeating each several times, using different test type if possible. The near point may come closer when the test is repeated. The diagnosis can be confirmed by using low power convex lenses (+1.0 or +0.50D). If accommodative deficiency is present, the print will become clear with the lenses. If a near point rule is not available, measurement can be made using a ruler and a reading test type
- The near point of convergence should also be measured. Poor convergence is sometimes associated with poor accommodation
- Refraction should be carried out, looking particularly for small degrees of hypermetropia or hypermetropic astigmatism
- Heterophoria should be detected by cover test and measured.

Treatment

- Any hypermetropia or astigmatism should be corrected. Correction of even a small amount of hypermetropia can help relieve the symptoms. The near point should be reassessed after the glasses have been worn for a few weeks
- Poor general health should be improved if possible
- Temporary convex lenses can be prescribed if there is no refractive error. Often one D or even 0.5 D is enough
- Convergence can be improved if necessary. It should first be reassessed with any glasses ordered as it can then improve spontaneously. In other cases improvement of convergence also results in improved accommodation

Heterophoria

Symptoms of heterophoria occur if the patient is unable to control the phoria easily. They comprise headache and eyestrain caused by the effort to maintain BSV and intermittent diplopia and blurred vision due to failure to control the phoria.

Diagnosis

- Cover test, noting the type and amount of heterophoria and the speed of recovery to BSV
- Measurement of the amount of heterophoria, preferably by prism cover test, alternatively the Maddox rod can be used for near and distance
- Measurement of the near points of convergence and accommodation
- Measurement of the prism fusion amplitude
- Refraction should be carried out and any significant refractive error corrected. The effect of spectacles should be assessed before considering further treatment, because the patient's symptoms may resolve once they are worn

Treatment

Orthoptic exercises

Heterotropia

- Some types of exotropia are treated with orthoptic exercises
- Some types of esotropia are associated with some amount of hypermetropia. When hypermetropia is corrected the esotropia disappears
- Esotropia is seen when the spectacles are removed. Constant tropias are to be treated surgically

Summary

This unit deals with squint or strabismus, which is mostly identified at the childhood. There is a misconception that squint is a sign of good fortune, but untreated squint will lead to lazy eye or amblyopia. Loss of vision is preventable if squint is detected and treated before two years of age. As the child grows older, it becomes more difficult to treat squint and establish binocularity. Cosmetically straightening the eyes is possible at any age.

There are no known preventive measures for squint, but misaligned eyes can be straightened and loss of vision from amblyopia can be prevented if treatment is begun early. The OA should know the different types of squint and their treatment. The OA must be able to identify the type of squint and must know to choose the appropriate examination to measure the level of vision and squint and make the task easy for the ophthalmologist.

Key points to remember

- *If BSV is absent, there is no possibility of presence of fusion and stereopsis*
- *If convergence weakness is identified, check accommodation uniocularly*
- *Exophoria is an indication of fusion weakness*
- *While checking ocular movements, both eyes must be visible to the examiner*
- *While checking cover test, the examiner must give the patient time to fix steadily before removing the cover or changing it to the other eye.*
- *Testing accommodation is purely subjective*

Student exercise

True / False

1. *Esotropia is a vertical deviation of eye* ( )
2. *Lateral rectus muscle is supplied by 3rd nerve* ( )
3. *Normal positive fusional range is 30 – 40 prism* ( )
4. *Version is conjugate or parallel eye movement* ( )
5. *Tropia is a constant squint* ( )

Fill up the blanks

1. *Medial rectus muscle is supplied by ________________ nerve*
2. *The actions of superior oblique muscles are ________________, ______________*
3. *Phoria is detected by ________________*
4. *Convergence and accommodation are measured by ________________*
5. *BSV is checked by ________________ test*

Answer the following

1. *Define squint.*
2. *List the names of the extra ocular muscles.*
3. *Describe how to check binocular vision.*
4. *What are the instruments used to check binocular vision and fusion?*
5. *How will you find squint ?*

CHAPTER 9 VISUAL FIELDS

CONTENTS

Normal visual field
Abnormal visual field
Field examination
Methods of estimating visual field

GOAL

To equip the ophthalmic assistant (OA) with knowledge of visual fields, visual pathways, visual field defects and various visual field testing methods

OBJECTIVES

The OAs will be able to

- Define the visual field parameters
- Discuss the principles of visual field
- Describe Traquair's concept of visual field
- Illustrate the visual pathway and typical patterns of visual field loss
- Define the terminologies associated with visual fields testing
- List the various types of visual field testing
- Demonstrate the method of performing different types of field tests

CHAPTER 9
Visual Fields

The visual field is that portion of space in which objects are simultaneously visible to the steady fixing eye.

Normal visual field

The normal monocular visual field is a slightly irregular oval, which measures, from fixation, approximately 60° upward and 60° inward, 70° downward and 100° to 110° outward.

The field of the two eyes together or the binocular field is a combination of the right and left monocular fields. The whole binocular field forms a rough oval extending to about 200° laterally and 130° vertically.

The extreme extent of the visual field is limited by the nose and the brows, but within the anatomic restrictions imposed by these structures, the normal field may be considered from a practical point of view as being made up of two portions:

1. The central field: that portion of the visual field within 30° radius of fixation
2. The peripheral field: The peripheral field makes up the remainder of the visual field

Normal monocular fields

Superior side	60° to 70°
Inferior side	70° to 80°
Nasal side	50° to 60°
Temporal side	100° to 110°

Normal binocular fields

Horizontal side	200°
Vertical side	110°

Physiological blind spot

This is an area of absolute scotoma (non-seeing area) within the boundaries of the normal visual field, and it corresponds to the region of the optic nerve head. It is located approximately 15° temporal to the fixation point and about 1.5° below the horizontal meridian. The normal measurement of the blind spot is approximately 5.5mm horizontally and 7.5mm vertically.

Traquair's concept

Traquair's definition of the visual field is that it is an island of vision in the sea of Blindness. The peak of the island represents the point of highest acuity, the fovea, while the 'bottomless pit' represents the blind spot, the optic disc.

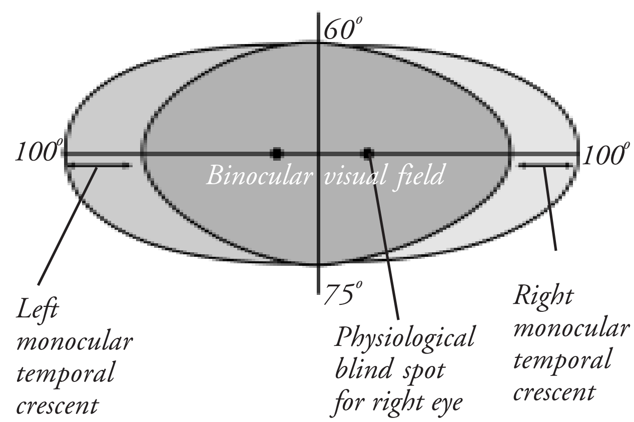

Fig. 9.1 - Binocular visual field

If we refer to Traquair's concept of an island hill of vision, the outline of the various contours of this hill may be projected upon a map as contour lines, which, in the nomenclature of perimetry are termed isopters. The central point from which these isopters are measured corresponds to the visual axis and is known as the point of fixation.

The isopters or contour lines are designated by the size and brightness of the stimulus and the distance at which it is viewed by the observer, expressed as a fraction. Thus isopter for a 1 mm. test object observed by the patient at a distance of 2 meters is expressed by the fraction 1/2000 and designates the specific area of the visual field within which the normal person should be able to see this stimulus.

Principle

The nasal field represents the temporal retina and the temporal field represents the nasal retina.

The visual pathways

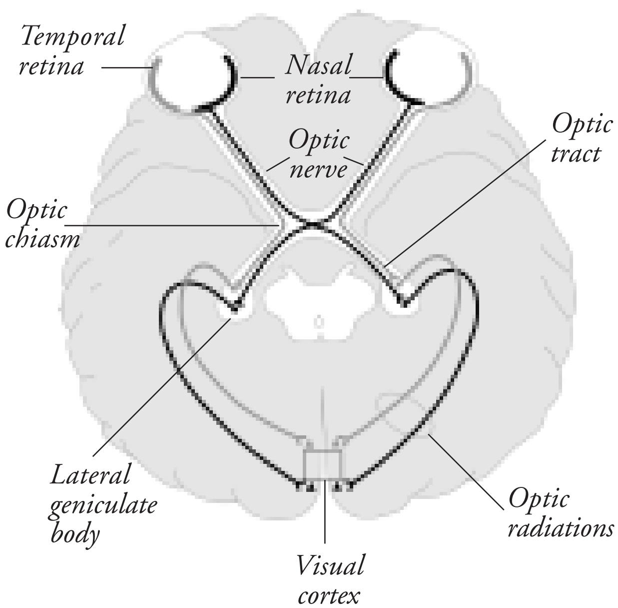

Fig. 9.2 - Visual pathways

- **The end organ:** Is the neural epithelium of the rods and cones
- **The first-order neurone**: Is the bipolar cell with its axons in the inner layers of retina
- **The second order neurone**: Is the ganglion cell of the retina. Its axon passes into the nerve-fibre layer and along the optic nerve to the lateral geniculate body.
- **The third-order neurone:** Originates in the cells of lateral geniculate body, and then travels by way of the optic radiations to the occipital cortex (visual centre).

The visual pathways thus consist of:

- Two optic nerves
- An optic chiasma
- Two optic tracts
- Two lateral geniculate bodies
- Two optic radiations, and
- Visual cortex on each side

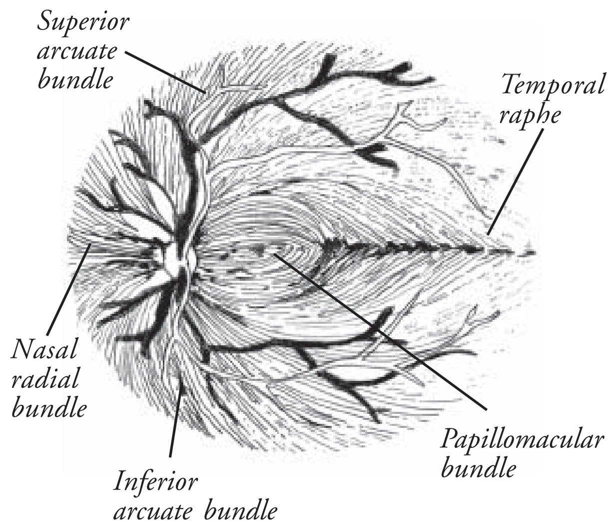

Fig. 9.3 - The distribution of the various nerve fibre bundles within the retinal nerve fibre layer

The distribution of the various nerve fibre bundles within the retinal nerve fibre layer

In general, the fibres from the peripheral retina enter the periphery of the optic nerve, and the fibres near the optic disc enter the central part of the nerve.

The fibres from the macular area forms the papillo-macular bundle, which has a separate course, partial decussation occurs where the nasal fibres cross at the chiasm.

The fibres of the temporal half enter the chiasm and pass to the optic tract on the same side, and then to the lateral geniculate body. The fibres from the nasal half enter the chiasm, decussate, and then pass to the optic tract of the opposite side, then to the lateral geniculate body.

The third-order neurons pass by the optic radiation into the corresponding occipital lobe. It follows that a lesion of the optic radiation, optic tract, or occipital lobe will cause blindness of the temporal half of the opposite side. Projecting this outward, such lesion will cause loss of vision in the opposite half of the visual field, a condition known as **hemianopia**.

Abnormal visual fields

Three basic defects of visual fields are;

- Contraction
- Depression, and
- Scotoma

Contraction

True contraction is relatively rare. To satisfy the definition of contraction, the area of the visual field that is defective must be totally blind to the stimuli, no matter how bright or how large a target is presented in that area. The edge of the defect must be the same regardless of the intensity of the stimulus.

Contractions may have various forms;

- General peripheral
- Partial peripheral
- Sector
- Partial hemianoptic
- Total hemianoptic and
- Scotomatous. They may be either monocular or binocular.

Depression

The great majority of visual field defects, both peripheral and central, are caused by depression and may be very marked (but not absolute) or very slight. It may involve only the extreme periphery or only the minutest portion of the fixation area. It may take an almost infinite variety of forms.

Visual field depression may be divided into

- General depression and
- Local depression.

General depression

General depression of the visual field is one in which all the isopters are smaller than normal and some of the internal isopters are missing. In fact the central isopters are the first and most severely affected.

Local depression

Local depression of the visual field is the most common type of defect. It may take many forms, including scotoma.

Scotomas

A scotoma is an area of partial or complete blindness within the confines of a normal or a relatively normal visual field (i.e.). it is a defective field surrounded by a normal field.

Types of scotoma

Absolute scotoma: An absolute scotoma will have the same field defect size regardless of the target size and brightness.

Relative scotoma: Relative scotoma has field defects that change with the target size and have sloping borders that indicates an active or on going field defect.

- **Positive scotoma:** Patient complaints of non-seeing area (e.g.) Central scotomas
- **Negative scotoma:** Examiner detects the non-seeing area (e.g.) blind spot enlargement

  Scotomas may be unilateral or bilateral.

Basic terminologies

Horizontal meridian: Horizontal line through fixation which divides superior and inferior visual fields.

Vertical meridian: Vertical line through fixation which divides left and right visual field.

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Isopter: Line connecting points of equal visual sensitivity

Scotoma: Area of reduced visual sensitivity

Arcuate or Bjerrum scotoma: Arching visual field defect within the area between 10 to 25 degrees in the superior and inferior field

Central scotoma: Defect involving fixation

Ceco-central scotoma: Defect encompassing the physiologic blind spot and fixation.

Para-central scotoma: Defect close to but not involving fixation

Altitudinal: Complete loss of either superior or inferior field nasal to the physiologic blind spot

Hemianopic / hemianopsia: Defect respecting the vertical meridian.

Quadranopic / quadranopsia: Defect respecting the vertical meridian involving only one quadrant.

Homonymous: Defect occupies the same side of visual space in both eyes.

Congruous: Bilateral hemianopic defects which are essentially identical; the fields can be superimposed on one another. Congruity indicates a more posterior location of the lesion.

Incongruous: Hemianopic defects which are not identical. Incongruity indicates an anterior lesion location.

Field defects in various parts of the visual pathways

Optic nerve: Blindness on side of lesion with normal contralateral field.

Chiasm: Bitemporal hemianopia.

Optic tract: Contralateral incongruous homonymous hemianopia.

Optic Nerve and Chiasmal junction: Blindness on side of lesion with contralateral temporal hemianopia or hemianoptic scotoma.

Posterior optic tract, external geniculate ganglion, posterior limb of internal capsule: Complete contra lateral homonymous hemianopsia or incomplete incongruous contralateral homonymous hemianopsia.

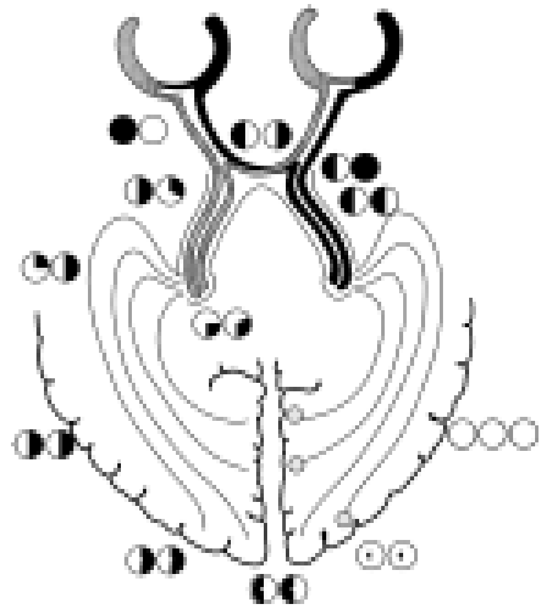


Fig. 9.4

Optic radiation: Anterior loop in temporal lobe-incongruous contralateral homonymous hemianopia or superior quardantanopia.

Medulated fibers of optic radiation: Contralateral incongruous inferior homonymous quadrantanopsia.

Optic radiation in parietal lobe: Contralateral homonymous hemianopia sometimes slightly incongruous with minimal macular sparing.

Optic radiation in posterior parietal lobe and occipital lobe: Contralateral congruous homonymous hemianopia with macular sparing.

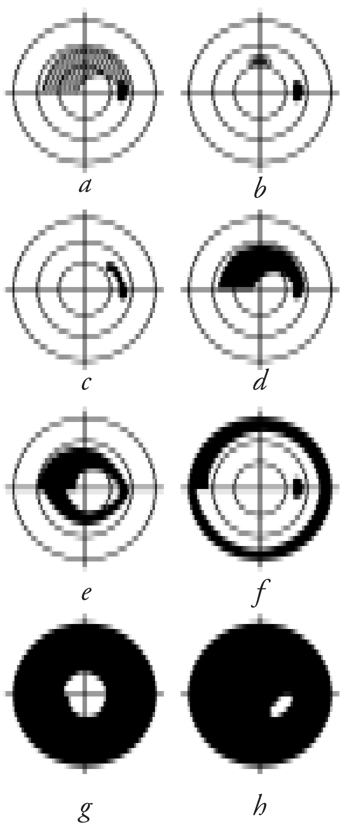
Mid portion of calcarine cortex: Contralateral congruous homonymous hemianopia with macular sparing and sparing of contralateral temporal crescent.

Tip of occipital lobe: Contralateral congruous homonymous hemianoptic scotoma.

Anterior tip of Calcarine fissure: Contralateral loss of temporal cresent with otherwise normal visual fields.

Glaucoma fields

More specific defects of glaucoma are,



a - Arcuate (Bjerrum area)
b - Superior paracentral scotoma
c - Seidel's scotoma
d - Bjerrum's (arcuate) scotoma
e - Double arcuate (ring) scotoma with superior central nasal step
f - Roenne's nasal step
g - Tubular field
h - Only temporal island of vision

Fig. 9.5 - Glaucomatous field defects

Isopter contraction: Peripheral isopter contraction may be significantly smaller prior to any field loss

Baring of the blind spot: (exclusion of the blind spot) is also considered to be an early field defect in glaucoma.

Angio-scotoma: Long, branching scotoma, above or below the blind spot, which are presumed to be the result of shadows created by large vessels, and are felt to be an early change.

Isolated paracentral scotoma: One or more isolated paracentral scotoma develop in the Bjerrum or arcuate area.

Seidel's scotoma: A sickle-shaped defect arises from the blind spot and tapers to a point in a curved course with concavity towards the fixation point.

Bjerrum's or arcuate scotoma: A relatively larger area of defect in the form of arching scotoma, which eventually fills the entire arcuate area, from blind spot to the horizontal median. With further progression, a double arcuate (ring or annular) scotoma will develop.

Roenne's nasal step: The arcuate defects may not proceed at the same rate in the upper and lower portions of the eye. Consequently, a step-like defect is frequently created where the arcuate defects meet at the median. This is called Ronne's nasal step and it is mostly a superior nasal step, as the superior field is involved more frequently.

Generalised constriction of peripheral field: Double arcuate scotoma leads to tubular field of vision (tubular vision) in which only the central vision remains clear.

Lastly, only a paracentral temporal island of vision persists, central vision being destroyed.

Ultimately, all the nerve-fibres are eventually destroyed with no perception of light.

Field examination

Perimetry

Perimetry is the procedure of estimating the extent of visual fields. Several types are available;

Kinetic perimetry

In this the stimulus of known size and luminance is moved from periphery towards the centre to establish isopters. Various methods of kinetic perimetry are: confrontation method, tangent screen scotometry, Lister's perimetry and Goldmann's perimetry.

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Static perimetry

The visual field can be plotted by using a stationary light target of variable brightness and size against a background whose luminance may be similarly adjusted (either photopic or scotopic conditions).

Example: Humphrey Visual Field Analyzer

In general, static perimetry is superior to the kinetic method for glaucoma patients, as it is more accurate and reproducible.

Methods of estimating the visual field

Confrontation method

The confrontation field test compares the boundaries of the patient's field of vision with that of the examiner, who is presumed to have a normal field. It is a rough, but very useful clinical test, which should be applied in every case, if there is any suspicion of a defect in visual field.

Performing the confrontation test

- Seat the patient at a distance of 2 to 3 feet from you. Confront (face) the patient, cover or close your left eye, and have the patient cover the right eye. You and the patient should fixate on each other's uncovered eye
- Extend your arm to the side at shoulder height and slowly bring two fingers from beyond your peripheral vision toward your nose into the field of vision midway between the patient and yourself. Ask the patient to state when the fingers are visible

  Repeat the process of moving fingers into the visual field from four different directions. If you picture a clock face in front of the patient's eyes, you perform the hand movement from about 2 O'clock, 4 O'clock, 8 O'clock, and 10 O'clock, each time bringing the fingers toward the center of the clock face
- The patient should see the fingers at the same moment you do in each of the four quadrants (upper-left, upper-right, lower-right and lower-left quarters) of the visual field. (Note: A quadrant of vision described from the patient's point of view). If the patient does not see your fingers at the same time you do, the breadth of patient's visual field in that quadrant is considered to be smaller than normal and additional perimetric studies are performed
- Record the patient's responses in the patient's chart by indicating simply that the visual field is comparable to yours or that it is reduced in any of the four quadrants for that eye
- Repeat the procedure as described with the patient's other eye and record the results similarly

Tangent Screen (Bjerrum screen)

Estimation of defects of central fields using tangent screen is termed as campimetry or scotometry. It is done to evaluate the central and para central area (30 degree) of the visual field. The tangent screen is 1 metre or 2 metres square. Accordingly the patient is seated at a distance of 1m or 2m respectively.

The screen has a white object for fixation in its centre, around which are marked concentric circles from 5 degree to 30 degree. The patient fixates on the central dot with one eye occluded.

A white target (1-10 mm diameter) is brought in from the periphery towards the centre in various meridians. Initially, the blind spot is charted, which is normally located about 15 degree temporal to the fixation point on a 1 m tangent screen. It will fall outside the 1m tangent screen at 2m. Doubling the testing distance and doubling the target size will double the scotoma size.

Note

- Fixation targets should be capable of variation from 1 to 100 mm. Circles of varying size are used for fixation when testing for small central scotomas
- White tape may be attached to the two upper corners of the screen so that they cross in the

centre when testing the large, dense, central scotomas. The patient fixates where they think the tapes will cross even though they cannot see the actual crossing point

Performing the tangent screen examination

- For a tangent screen examination, it is essential that the patient wears his glasses if he has a refractive error. This is not essential in perimetric examinations
- The examiner usually stands to one side and keeps his/her eye on the patient's eye to ensure that the fixation is absolutely maintained
- The test object, the size of which is correlated with the patient's visual acuity, is moved from the periphery towards the centre

Fig. 9.6 - Bjerrum screen

- The patient indicates when they see the test object either by making a verbal response, such as "yes", or by tapping a coin
- At all times the fixation of the patient should be checked
- The easiest way is to map out the patient's blind spot first, which is smaller and closer to the fixation point
- Check the patient's responses by rotating the test object out of view so that it is not visible to the patient at all
- Be careful when transferring the information from the felt screen to the chart because errors can occur
- Make sure you understand the proper degree of eccentricities and meridian placements on the stitched chart and the recording diagrams
- Mark the areas of scatter with a cross hatch and record the target size
- Evaluate each scotoma for depth with smaller and larger targets

Amsler grid test

The Amsler grid test determines the presence and location of defects in the central portion of the visual field. The Amsler grid is a printed square of evenly spaced horizontal and vertical lines in a grid pattern, with a dot in the centre. The chart grid and dot may be either white on a black background or black on a white background.

Performing the amsler grid test

- Have the patient hold a white-on-black test card about 16 inches away with one hand and cover one eye with the other hand, an occluder, or a patch
- Direct the patient to stare at the centre dot and to report if any portions of the grid are blurred, distorted, or absent. The patient should not move the gaze from the centre dot, so that the presence of any distortion can be assessed
- If they answer yes, you may repeat the test with black-on-white Amsler recording chart, on which you ask the patient to mark the location of visual difficulties.

- If test results are normal, state so in the patient's record. If abnormal, state so, and include the Amsler recording chart in patient's record. The patient with abnormal findings is a likely candidate for further studies. The patient may also repeat this convenient procedure independently at home and report changes to the ophthalmologist's office (the patient should perform the test monocularly, always at the same 16-inch distance and under the same illumination)

Perimeters

The screen may be either an arc or a bowl of a radius of 330 mm.

Lister's perimeter: A rotatable arc, capable of being revolved round a pivot, and along which a test object can be moved

Goldmann perimeter: A hemispherical bowl over which a target (a spot of light of adjustable size and illumination) can be directed.

The Goldmann perimeter is more standardised and preferable for glaucoma examinations, as, both the central and peripheral visual fields can be recorded.

The targets of the perimeter consists of circular white discs (or a spot of light) of diameters ranging from 1-10 mm. The isopters represent the limits of the field of vision with each target, and are accordingly labeled 1/330 (1 mm target at 330 mm distance, the radius of perimeter), 2/330. 10/330, etc.

Coloured discs or coloured spots of light are especially used for estimation of a differential field loss to colour. In normal conditions, the blue field is largest, slightly smaller is the white, and then followed by the yellow, red and green.

Automated perimeter

Automated perimetry was developed to standardize visual field testing and to increase the reliability of visual tests. Various manufacturers make automated perimeters based upon computerized projection systems and a LED (light emitting diodes) system. Automated perimeters can perform screening and diagnostic field tests and can use kinetic and static methods. These perimeters are most often used for static threshold testing.

The most widely used automated perimeter is the Humphrey Field Analyzer which has become the standard for visual field testing.

Demato campimeter

The demato campimeter is a recently developed visual field screening device that is non-automated but has the advantages of being relatively simple, portable and much less expensive than automated perimeters. It's low cost and simplicity makes it more likely to be used in visual screening than many current automated instruments.

The demato campimeter consists of a white test card on which there is a single central point that acts as the test stimulus. Around the central point are a series of numbers arranged in a certain sequence. The patient views each of the numbers in sequence and responds to whether the central point can be seen for each.

Because the patient's fixation shifts, this is also known as autokinetic campimetry. The size and contrast of the central test stimulus can be varied on some models. Clinical studies of the Demato campimeter have given generally positive results.

Student exercise

Fill in the blanks

1. ________________ *is called absolute scotoma*
2. *Traquair's definition of visual field is* ___________
3. *In visual field testing if the fixation point is not seen, it is called* ______ *scotoma*
4. *Optic disc corresponds to* __________ *of the visual field*
5. *The field defect close to but not involving fixation is called* ___________

Match the following

1. *Central fields*	-	*Blind spot*
2. *Retinitis pigmentosa*	-	*Central scotoma*
3. *Amsler's grid*	-	*Bitemporal heminanopsia*
4. *Optic disc*	-	*Humphrey Field Analyser*
5. *Chiasmal defect*	-	*Tubular field*
6. *Automated perimetry*	-	*Bjerrum's screen*

Short answers

1. *Define visual field*
2. *Discuss visual field parameters*
3. *Explain -blind spot*
4. *Explain about central and peripheral field of vision*
5. *Define scotoma and its types*
6. *Explain kinetic and static perimetry with examples*
7. *What do you mean by depression of visual field?*

Short notes

1. *Discuss Traquair's concept of visual field*
2. *Draw the structure of visual pathway and explain*
3. *Discuss the field defects in glaucoma*
4. *Discuss the types of visual field testing methods*
5. *Tangent screen and testing procedures*

CHAPTER 10 ULTRASONOGRAPHY

CONTENTS

GOAL

To enable the ophthalmic assistant to measure the various parameters of the eye and calculate its IOL power.

OBJECTIVES

The OA will be able to

- Discuss principles and methods of ultrasonography
- Demonstrate performing keratometry
- Demonstrate performing A-scan ultrasonography

CHAPTER 10

Ultrasonography

Ophthalmic ultrasonography uses the reflection or echoes of high frequency sound waves to define the outlines of ocular and orbital structures.

Ultrasonography also aids the physician in detecting the presence of abnormalities such as tumours and determining their size, composition and position with in the eye.

Ultra sound procedures are divided into two types:

- A-Scan ultrasonography
- B-Scan ultrasonography

A-Scan: Time amplitude display

It is a one dimensional display, where echoes are depicted as vertical deflections from a baseline. The strength of an echo is indicated by the amplitude (height) of the spike.

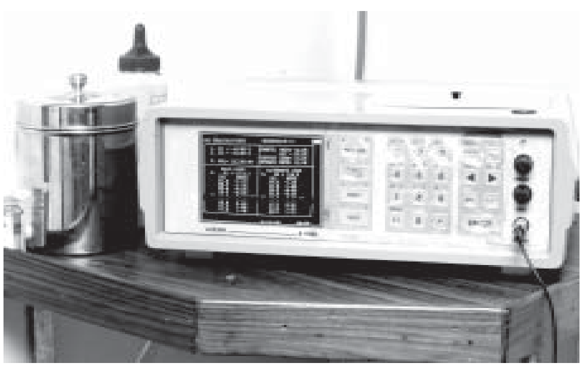

Fig. 10.1

Introduction

A-scan biometry is also called axial length measurement, or simply "A-scan" or "A's". This measurement is combined with keratometry ("A's and K's") in a formula to determine the power of the intraocular lens that replaces the natural lens removed from the eye during cataract surgery.

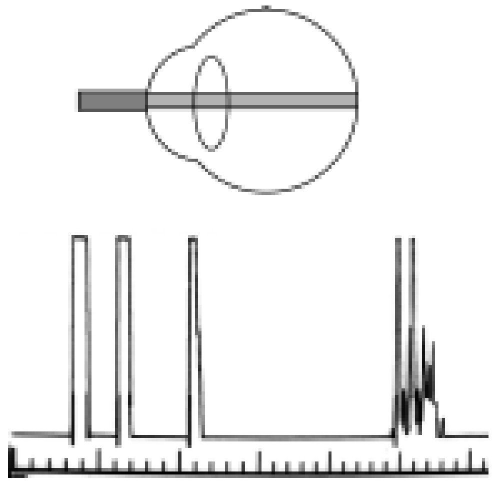

Fig. 10.2

Reflectivity

The A-scan probe projects a thin sound beam that travels through liquid or tissue. When the A-scan beam is projected into the phakic (natural lens) eye it travels through the aqueous humor and encounters a dissimilar substance in the anterior lens surface causing a spike.

Strong reflections also occur as the sound beam encounters the posterior lens surface and the retina. Spikes representing these reflections appear at their corresponding positions along the baseline. The first spike represents the probe tip as it comes into contact with the cornea.

Optical axis

The optical axis of the eye is the distance from the corneal apex to the fovea. This is also the longest cornea-to-retina distance in the normal eye.

Corneal compression

The A-scan probe must come into contact with the cornea, either directly or through a liquid. If a corneal-contact method is used, there is a danger of

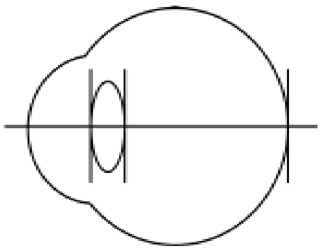

Fig. 10.3

the probe putting too much pressure on the cornea, causing the cornea to compress, which results in an artificial shortening of the axial eye length.

This is a potential source of significant error. A .4mm compression error can result in a 1 diopter error in the calculated IOL power.

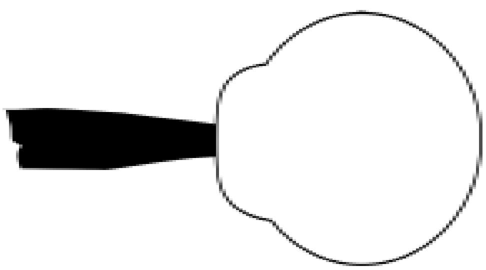

Fig. 10.4

Velocity of sound

Ultrasound travels at different speeds through materials of different densities. Ultrasound travel at high speeds through water and materials containing high water content.

The following are the speeds of ultrasound through the structures of the eye:

Cornea	-	1640 m/s (meters per second)
Aqueous	-	1532 m/s
Normal lens	-	1640 m/s
Cataractous lens	-	1629 m/s
Vitreous	-	1532 m/s

Spike height

In A-scan biometry, one thin and parallel sound beam is emitted from the probe tip at a given frequency of approximately 10 MHz. An echo bounces back into the probe tip as the sound beam strikes each interface. An interface is the junction between any two media of different densities and velocities, which, in the eye, include the anterior corneal surface, the aqueous/ anterior lens surface, the posterior lens capsule/anterior vitreous, the posterior vitreous/retinal surface, and the choroid/anterior scleral surface.

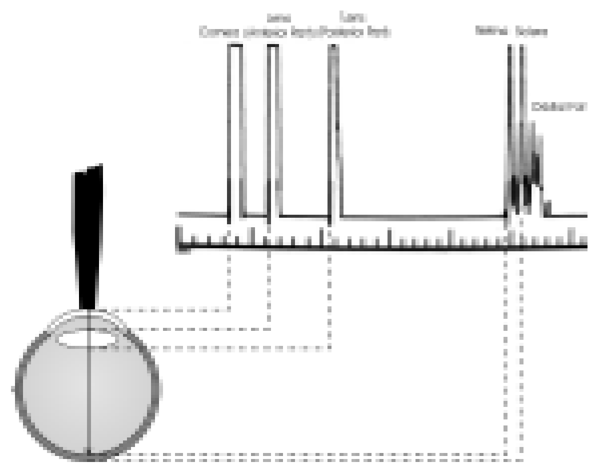

Fig. 10.5

IOL Power with biometry

Biometry essentially consists of a keratometric reading (K) together with an ultra sonic measurement of axial length (AL) of the eye, perhaps with anterior chamber depth (ACD). Biometric information is fed into the variety of formula to calculate the IOL power. Formulae can be broadly divided into two groups.

- Theoretical formulae
- Regression formulae

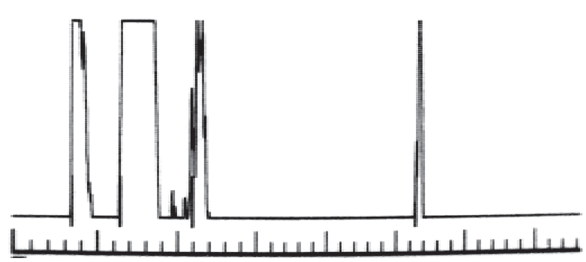

Fig. 10.6

Theoretical formula

Various theoretical formulae derived from the geometric optics as applied to the schematic eyes using theoretical constants have been developed to calculate the power of IOL required for post operative emmetropia. These formulae are based on 3 variables

- The axial length of eye ball (AL)
- Keratometric reading (K)
- The estimated post operative AC depth (ACD)

Binkhorst formula

P = 1336(4r-d) / (a-d) (4r – d)

P = IOL power in diopters

r = corneal radius in mm

a = axial length in mm

d = assumed post operative anterior chamber depth + corneal thickness

Regression formula

These formulae are based on regression analysis of the post operative results of implant power using variables of corneal power and axial length. A number of regression formulas are available. The commonly used are the SRK formula and its modification.

SRK I formula

P = A – (2.5 L – 0.9 K)

P = IOL power

A = Constant specific for each lens

L = Axial length

K = Average keratometry in diopters

It was introduced by Sanders, Retzlaff and Kraft based on the regression analysis taking into account the retrospective computer analysis of a large number of post operative refractions.

SRK II formula

P = A –(2.5 L – 0.9 K)

But A is modified on the basis of the axial length

If L is <20mm: A +3.0

If L is 20 – 20.99: A+2.0

If L is 21 – 21.99 = A + 1

If L is 22 – 24.5 = A

If L is > 24.5 = A – 0.50

SRK/ T formula

- It is a regression formula empirically optimized for post operative anterior chamber depth, retinal thickness, and corneal refractive index
- This combines the advantages of both the theoretical and empirical analysis. This formula seems to be significantly more accurate for extremely long eyes

Keratometry (or) ophthalmometer

Keratometry is the measurement of a patient's central corneal curvature. It provides an objective, quantitative measurement of corneal astigmatism, measuring the curvature. Keratometry is also helpful in determining the appropriate fitting of contact lens. The measurement of the curvature of the anterior corneal surface is done by using the first Purkinje image.

Kerotometry determines corneal curvature by measuring the size of a reflected "mire". Doubling of image avoids problems from eye movements. Radius scale is determined and diopter scale is derived from the radius using the formula for surface power D= (n-l)/r,where n=1.3375, the "standardized" refractive index for the cornea. Keratometer measures only the central 3mm of the corneal diameter.

Principle of keratometry

It measures the size of image reflected from corneal surface, because cornea acts as convex mirror. When an object is in front of the cornea a virtual image is seen inside the convex mirror (cornea). The size of the image depends on,

1. The distance of the object and
2. The curvature of the cornea

For a fixed distance of the object the size of the image depends on the curvature of the cornea. Similarly for a given size of the image distance of the object is different depending on the curvature of the cornea.

The object used is an illuminated circle with plus and minus images as shown in figure (fig 10.1 and 10.2). The two prisms inside the instrument give two additional images one displaced horizontally and another displaced vertically. Three images are seen as in figure while taking the reading the pluses and minuses coincide.

Keratometer set-up

1. Focus the eye piece
   - Set the adjustable eye piece so that it extends as for as possible.
   - Place a white paper in front of the instrument objective to retro
   - illuminates the reticle.
   - Adjust the eye piece until the reticle is first seen in sharp focus
2. Ask the patient to remove his glasses
3. Adjust height of chair and instrument to a comfortable position for both patients and examiner
4. Unlock instrument controls (B& L. Keratometry)
5. Instruct patient to palace his chin in the chin rest and forehead against the forehead rest
6. Raise or lower the chin rest until the patient's outer canthus is aligned with the hash mark on upright support or the pointer on the side of the instrument

Step- by-step procedure

1. From outside the instrument, roughly align the telescope with the patient's eye.
2. Instruct the patient to look at the image of his eye in the keratometer.
3. Look into the keratometer and align it by moving it from side to side or up and down until you can see the image of the mires (circle with plus and minus) on the patient's cornea.
4. Focus the mires and align them with the reticle in the lower right and head circle.
5. Lock the instrument (B&L Keratometer only).
6. Adjust horizontal and vertical power wheels until mires are in close apposition.
7. Rotate the telescope to align spurs (plus and minus signs) on the mires to 2 major meridians of the patient's cornea.
8. Adjust the horizontal power wheel until the vertical mires are co-incident.
9. Adjust the vertical power wheel until the horizontal mires are co- incident.
10. Readjust focus and / re-center reticle as needed.
11. When mires are not clear lubricating drops can be used aand Keratometry can be performed again.

Recording

1. Recording for each eye separately
2. Record the power and meridian for horizontal meridian first (the primary meridan)
3. Write a slash mark after the primary meridian and record the power and meridian for the vertical meridian (the secondary meridian)
4. Record the amount of corneal astigmatism in diopters
5. Record the type of astigmatism:

   WR-With the rule

   AR-Against the rule

   OBL-Oblique
6. Record the conditions of the mires e.g.MCAR-Mires Clear And Regular MIAD- Mires Irregular And Distorted

Example:

OD 42.50 at 180/ 43.50 at 90; 1.0D WR,MCAR

OS 47.37 at 180/ 41.37 at 90; 6.0D AR, Mires distorted

OD 41.75 at 180 / 43.75 at 70; 2.0D irregular astig; mires distorted

OS 43.12 at 135 / 41.87 at 45; 1.25D OBI; MCAR

OD 42.00/43.00 at 90; 1.0D WR MCAR

OS 42.00/42.00 at 90; sphere MCAR

(Meridian are expected to be 90 degree apart; therefore if only the meridian is recording the position of the other can be assumed to be 90 degrees away)

To obtain proper focus, rotate the focus knob until the bottom-right circles converge to form a fused image.(fig 10.7)

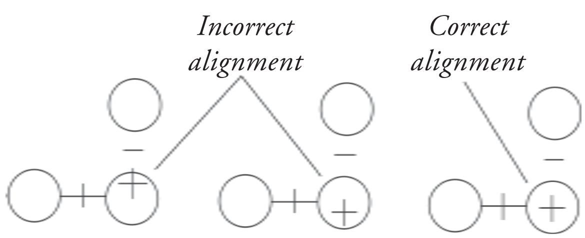

Fig. 10.7

To locate the proper axis, rotate the keratometer until the pluses between the two bottom circles are in the same plane.(fig 10.8)

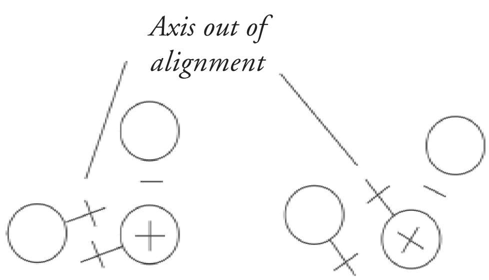

Fig. 10.8

Student exercise

I. Fill in the blanks

1. *Velocity of sound in cataractoues lens is -------------*
2. *SRK II formula is ----------------*
3. *Optical axis of the eye distance from -------------- to -------------.*
4. *An ultra sound beam will not through in ---------*
5. *Corneal compression caused by excessive pressure from the probe will cause ----- axial length.*

II. Choose the best answer

1. *When performing Ascan biometry a one diopter IOL power error could result from an axial length of*
   - *a. 0.33mm*
   - *b. 0.03mm*
   - *c. 33cm*
   - *d. 3cm*
2. *The speed of ultra sound through vitreous is*
   - *a. 153.2m/s*
   - *b. 15.30m/s*
   - *c. 1532m/s*
   - *d. 15.30cm/c*
3. *A pseudophakia scan measure an eye that*
   - *a. Does not have a lens*
   - *b. Has an IOL place*
   - *c. Has a coneal transplained*
   - *d. Has a dense cataract*

III True or false

1. *SRK/T formula is considered to bemost accurate for the eyes between 24.00mm to 28mm long.*
2. *The image formed by the keretometer on the cornea are based on the principle of purkings Samson image.*
3. *Regression formula of IOL calculation is based upon the patient's old glasses prescription.*
4. *Normal axial length 25.33mm.*

IV Abbreviation

AR

WR

MCAR

MIAD

'A' scan A is ----

CHAPTER 11 CONTACT LENS

OUTLINE

History
Types and materials
Fitting procedures
Handling methods
Care and maintenance

GOAL

To equip the ophthalmic assistant (OA) with knowledge about the principles and the management of contact lens

OBJECTIVES

The OA will be able to

- Discuss the optics and principles of contact lens
- List the different types of contact lens
- Prescribe the appropriate contact lens
- Instruct the patients in correct handling procedures

CHAPTER 11

Contact Lens

Contact lenses are the smallest, least visible, the finest of all devices for correcting refractive errors of the eye. Prescribing and fitting contact lenses have become an integral part of today's comprehensive ophthalmology practice. A majority of people use contact lenses for cosmetic purposes. Other reasons for wearing contact lenses include occupational preferences, sports and therapeutic uses. The growing importance of contact lenses makes it appropriate to inquire into the origin and development of these valuable ophthalmic resources.

History

The idea of contact lens was first conceived by Leonardo Da Vinci in 1508. He placed a glass cup containing water over the eye, eliminating the cornea as a refractive surface. After so many attempts made by different scientists, in 1920, Zeiss produced a fitting set used to correct keratoconus. This was the first set of trial contact lens. In 1929 Heine described a method of fitting contact lens by means of a trial set consisting of a large number of contact lenses.

Later, in 1937 there was a break through. William Feinbloom, an American, used plastic in the construction of contact lens. A year earlier in 1936 the Rohm and Hass company introduced transparent methyl methacrylate. The first plastic corneal contact lens was introduced in 1947 by Kevin Touhy. Then in 1960, Wichetrle developed the soft contact lens which is made up of hydrophilic material.

Advantages of contact lenses

There are several advantages of contact lenses and they are:

- Fewer magnification effects
- Decreased peripheral and chromatic aberrations
- Increase in the size of visual fields
- Marked decrease in aniseikonia and anisometropia
- Good cosmetic appearance
- Permits better correction for refractive errors that occur with keratoconus and irregular astigmatism
- Safer for athletes and other sportspeople

Indications

a. Optical: myopia, hypermetropia, astigmatism, presbyopia, aphakia, post keratoplasty, keratoconus
b. Orthoptic uses: anisekonia, anisometropia, amblyopia (occlusion)
c. Special uses: albinism, aniridia, nystagmus with refractive error, coloboma, symblepharon
d. Therapeutic uses: bullous keratopathy, corneal ulcers
e. Prosthetic uses: pthisical eye, corneal opacity, leukoma and corneal scars
f. Surgical uses: corneal protection after surgery

There are several contraindications:

- Dry eyes, lid problems such as active blepharitis, stye, chalazion, entropion.
- Acute and chronic conjunctivitis, corneal abrasions, hyphema, Vth cranial nerve paralysis, hypopyon uveitis and iritis
- Allergies, uncontrolled diabetes, pregnancy period and pterygium

Types and materials

The modern system classifies contact lens into three major types :

- Soft hydrogels
- Gas permeable lenses (semi soft)
- Hard contact lens

Soft contact lens

Soft contact lens are flexible contact lenses that are composed of either hydrogel or silicon material. These soft contact lenses are made up of different polymers but basically hydroxy ethyl metha acrylate (HEMA) which is a stable, clear, nontoxic, non allergic and optically desired material. These lenses are usually larger in size than the cornea for optimum centering and stability. They are more comfortable than rigid lens because of their soft qualities and their ability to flex on blinking. Their larger size produces a fit with its edge lying under the upper and lower eye lids.

Advantages

- More comfortable because the lens fits under the eyelid margins, flexes with each blink and the softness permits more oxygen to reach the cornea
- Spectacle blur is uncommon.
- Less chances of loss of lens, because of larger size and minimal movement.
- Minimal over wear reaction, because of its soft nature and ability to stimulate the oxygen tear pump mechanism by flexing with each blink.
- Less glare and photophobia.
- Ideal for children because of comfort and less chances of losing the lens

Semi-soft contact lens

Semi-soft contact lens are gas permeable lenses which are made up of a unique plastic that has the ability to permit oxygen to diffuse into and carbondioxide to diffuse out of the lens.

Materials

- CAB (cellulose acetyl butyrate) lenses.
- Silicon acrylate
- Butylstyrene

Advantages

- Increased comfort
- Longer wearing time
- Reduced corneal edema, spectacle blur and over wear syndrome.
- Rapid adaptation
- Permeability of more oxygen than other lenses
- Larger optic zone offers increased visual field and fewer glares.
- Gas permeable lenses in a spheric form can correct up to five diopters of astigmatism.

Hard contact lens

Hard contact lens is made up of PMMA (poly methyl metha acrylate) which is a stable, clear, non toxic, non allergic, easily worked and optically desired material. It can be molded or lathed and the stability of PMMA is more than rigid gas permeable (RGP) lenses. The oxygen permeability of hard contact lens is almost nil. It provides oxygen only by means of the tear pump.

Fitting procedures

For soft contact lenses

Soft contact lenses are usually fitted larger than the corneal diameter to maintain good centration and stability.

Fitting steps include

- Record the keratometry values
- Measure the corneal diameter in mm
- Diameter: The initial lens diameter selected should be 1.0-2.0 mm larger than the corneal diameter
- Power: Determine the spherical power first, convert the refraction prescription into minus cylinder and use the spherical equivalent method. Add to the sphere to determine the lens power and compensate for the vertex distance
- Base curve: Select the base curve which is 0.4-0.6 mm flatter than the flattest ‘K’ for smaller lenses and 0.6-1.0 mm flatter for larger lenses

- Fit the contact lens to the respective eye and have the patient wait for 15-20 minutes to settle the lens well

For gas permeable and hard

- Record the keratometry readings
- Select the initial lens based on base curve
- The base curve of the initial lens should be slightly steeper than the flattest meridian
- Diameter selection is directly related to base curve. The flatter the cornea the larger the lens.
- The following table describes the selection of diameter:

Base curve Power	Diameter
40.0 - 43.0 D	9.4 mm
43.25 - 45.0 D	9.2 mm
Greater than 45.25 D	9.0 mm

- While fitting the trial lenses , leave the patient for 20-30 minutes to attain good centration and settlement of the lens
- For best results fit the lens according to its best position and comfort

Handling methods

Insertion and Removal for soft contact lenses

1. Wash hands thoroughly with oil free soap and dry with lint - free towel
2. Take the lens out of the case , clean and rinse it well
3. Place the lens on the tip of the index finger
4. Look up, and retract the lower lid with the middle finger and gently apply the lens to the lower part of the eye
5. Remove the finger and then slowly release the lid
6. Close the eye and gently massage the lids
7. Cover the other eye and focus it to make the correct centration
8. Repeat the same procedure for the other eye
9. For removal, look upward and retract the lower lid with middle finger and place the index finger tip on the lower edge of the lens
10. Slide the lens down to the white portion of the eye
11. Compress the lens between the thumb and the index finger, so that the air breaks the suction under the lens
12. Remove the lens for cleaning and sterilizing

Insertion for hard and RGP

1. Wash your hands thoroughly with oil free soap
2. Take out the lens from the container
3. Keep in your palm, clean it well with the prescribed solution
4. Depress the lower lid with the middle finger while the index finger carrying the lens is gently applied on the cornea
5. Slowly release the lids to avoid accident ejection of the lens. Release the lower lid first and then the upper

Removal for hard and RGP

1. Look downward, open the lids wide so that the edge of the lid will engage the edge of the lens
2. Draw the lid tight by a lateral pull of the index finger and blink
3. The lid should dislodge the lens
4. Cup the other hand under the eye to catch the lens

Scissors technique

Hold the upper lid by the index finger and the lower lid by the middle finger. Apply lateral traction to the lids and squeeze the lens off with a scissors motion.

Contact lens care and maintenance

Contact lens care and maintenance are the most crucial aspects of contact lens wear. It can influence the success of contact lens wear and patient's satisfaction.

The lens care and maintenance procedures have 4 steps (cleaning, rinsing, disinfecting, and storing the lenses).

They can prevent potentially sight destroying infections.

Cleaning

The cleaning agents usually contain surfactants and are used to remove most loosely bound foreign bodies on the lens which includes cell debris, mucus, lipid, protein and micro organisms. The mechanical action of rubbing reduces the amount of loose debris and also enhances the efficacy of the solutions surfactant properties.

Rinsing

After cleaning, the lenses should be rinsed. The rinsing procedure helps to remove the loosened deposits and some micro organisms.

Disinfecting and storage

The process of disinfecting helps to kill or deactivate the microorganisms. There are two types of disinfecting systems.

Thermal disinfection

The lenses should be placed in the case with saline solution and heated to 70 - 80 degree c for 10-20 minutes.

Chemical disinfecting

Hydrogen peroxide based solutions are used for chemical disinfection. This is reasonably effective within 10-15 minutes.

These disinfecting solutions are also used for storage. They function as a hydrating medium which helps to maintain the stability of contact lens parameters and physical parameters.

Multi purpose solutions

The modern lens care systems use one solution to perform the functions of a number of components. For ease of use and patients convenience, multipurpose solutions are formulated to allow cleaning, rinsing soaking and disinfecting functions to be combined.

To avoid lens contaminations, the lens case should be rinsed after every use and the lenses should be stored in fresh solution. For better lens care, change the lens case monthly.

Complications

The complications of contact lens wear include:

- Hypoxic related problems such as corneal edema, superficial punctuate keratitis, decreased sensation, superficial and deep infiltrates, vascularisation, superior limbal kerato conjunctivitis, epithelial microcysts.
- Allergic related problems include hyperemia, sterile infiltrates and giant papillary conjunctivitis.

Care and maintenance

- Wash your hands with oil free soap before handling the contact lenses
- Before wearing the lens it should be cleaned thoroughly in cleaning solution and rinsed well
- Place the lens which should look like a bowl on the tip of the index finger
- After removing, the lens should be placed properly in the lens case with solution
- The lens should be placed in the center of the lens case; it should not be placed at the side because of chances of tearing
- Solution should be changed daily. If the lens is not used daily; solution should be changed once in two days
- The lens should not be kept without solution because it will get dried and the lens will be ruined
- While wearing the lens avoid sitting under the fan or in windy places
- While traveling plain glass or sun glass should be worn
- The lens case should be washed weekly and should be changed once in three months
- Don't change the solution brand without the advice of the practitioner
- Proper care and follow up is must

- Lens should be changed according to the recommendations of the manufacturer
- If any complaints persist in the eye the lens should be removed and consult medical practitioner immediately
- Alternative use of spectacles is advisable if any discomfort develops.

Summary

Contact lenses are the ideal choice for refractive errors. They give better vision correction without any distortions. Proper lens care and regular follow up are very essential to maintain a good ocular health.

Student exercise

Answer the following

1. *What is a contact lens?*
2. *What are the advantages of contact lens?*
3. *List the types of contact lens.*
4. *What are the indications and contraindications of contact lens?*
5. *What is the fitting procedure for soft RGP lens?*
6. *Write short notes on care and maintenance of contact lens.*

CHAPTER 12 LOW VISION AIDS (LVA)

OUTLINE

Introduction
Definition and classification of LVA
Optics of LVA
Optical and non-optical aids
Low vision evaluation
Low vision management
Special techniques for problems with low vision

GOAL

To equip the OA with the knowledge about the low vision aids.

OBJECTIVES

The OA will be able to

- List the different low vision aids
- Suggest appropriate aids for the patients
- Manage the problems faced by the low vision patients

CHAPTER 12

Low Vision Aids (LVA)

For a patient with low vision, the ophthalmologist's positive attitude towards rehabilitation assures the patients that problems presented by sight loss can be managed. They encourage patients to use the remaining vision they have to enhance the quality of their lives. It is a time-consuming process, but to watch a person move from hopelessness and dependence to self-respect and independence is inspiring.

Low vision

Gerald Fonda coined the term low vision in the year 1953.

Definition

A person with low vision is one who has impairment of visual functioning even after treatment, surgery or standard refractive correction and has a visual acuity of less than 6/18, –or a field of less than 10 degrees from the point of fixation in the better eye.

Ocular conditions causing low vision.

- Albinism
- High myopia
- Diabetic retinopathy
- Macular degeneration
- Micro ophthalmus.
- Early stage of retinitis pigmentosa
- Aniridia
- Corneal degeneration

Conditions where there is not much benefit from low vision devices are patients who have a visual acuity of less than 2/60 or a field of less than 10 degrees.

Advanced retinitis pigmentosa with tubular fields

Advanced glaucoma

Conditions with irreversible blindness

Optics of LVA

The image formed using hand magnifier is at infinity and the emerging rays passing through a hand magnifier is parallel and makes a point source in retina. So a patient using a hand magnifier can use it without a bifocal addition glass.

Stand magnifier: In a stand magnifier the image formed is before infinity and the rays are diverging. So a bifocal addition is necessary.

Low vision optical devices

The low vision optical devices provide a magnified view of objects. They consist of the following:

Telescopes

They are prescribed for viewing distant objects at optical infinity (Fig. 12.1). They are available as hand held or spectacle mounted, monocular or binocular. They can be manually adjusted or auto focus.

Fig. 12.1 - Telescopes

Hand magnifier

There is a large variety of hand held magnifiers available with different features such as aspheric surfaces, illumination, multiple lenses that can be combined to alter the total power, and a protective shield to house the lens when not in use (Fig. 12.2).

It is a conventional familiar aid, which can be used along with the distance glasses or without glasses. The lens can be held against a spectacle lens with one hand. They are very cost effective, portable and useful for short term reading tasks.

Those who have limited dexterity or hand tremors cannot use it, and it is also difficult to use for prolonged period.

Fig. 12.2 Hand magnifier

Stand magnifier

There are a large variety of stand magnifiers with different features including a clear housing, illumination and aspheric surface (Fig. 12.3). Most stand magnifiers are designed for use with a standard bifocal or reading glass. They have a fixed focus.

Fig. 12.3 - Stand magnifier

Stand magnifiers have constant magnification. They are helpful for children or patients with reduced coordination and hand tremors. But they are inconvenient to carry and may result in bad posture after prolonged use.

High-plus addition

There are large varieties of high plus spectacles available like convex sphere, aspheric sphere, aspheric lenticular, aspheric doublet, bifocal, clip-on loupes, prism sphere (Fig. 12.4a and Fig. 12.4b).

Fig. 12.4a - Prismo sphere

Fig. 12.4b - High plus

They facilitate hand work, and provide the widest field of view, greater reading speed and cosmetic acceptability.

The closer working distance can obstruct illumination. When the power is too high it makes writing difficult.

Closed circuit television

A closed circuit television (CCTV) reading system is a television camera that relays a magnified image to a monitor screen (Fig. 12.5).

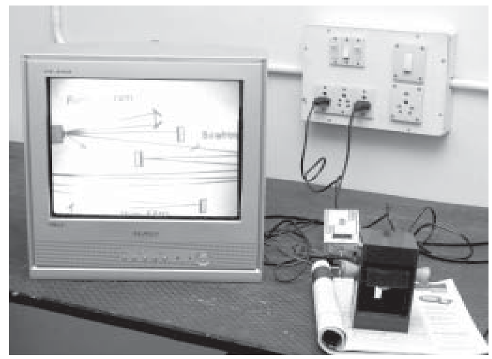

Fig. 12.5 - Closed circuit television

They are devices that allow binocularity at high levels of magnification, at a relatively normal working distance. They allow sufficient reading speed. Magnification can be adjusted for different print sizes.

Non-optical devices

The function of a non-optical device is to enhance the use of vision with or without optical aids (Fig. 12.6). They vary in purpose and are individualized according to the patients needs. It facilitates an environment for efficient functioning.

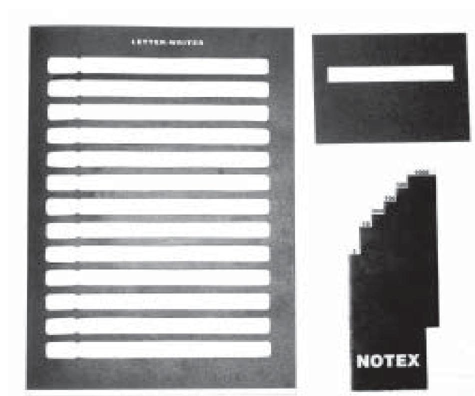

Fig. 12.6 - Non-optical devices

There are seven categories of devices. They are:

1. Relative size or larger assistive devices.
2. Glare, contrast and lighting control devices.
3. Posture and comfort maintenance devices.
4. Written communication devices.
5. Medical management devices.
6. Orientation and mobility management devices.
7. Sensory substitution devices.

Low vision evaluation

Evaluation of the remaining visual function is a key component of low vision rehabilitation. It reveals how patients are using their vision and gives insights into adaptations they are already making use of.

Estimates of visual loss are measured by visual acuity for distance, near, contrast sensitivity, photophobia, color vision, visual fields, etc

Assessment provides for the needs of the patients for education, vocation, daily activities, mobility, social interaction, and psychological reaction, reading and writing performance.

Formulas used in deriving predicted add

Kestenbaum formula

If the patient's best acuity is 6/60 then its reciprocal will be 60/6=1OD.

Required near vision addition will be +1O D.

The lighthouse method

The near vision acuity card is used at 40 cm distance and the patient is given a +2.5D add. Depending on the test distance up to 10cm the add can be increased. The letter size is found on the left side and dioptric add on the right side of the acuity card.

Adjustment training

The philosophy of rehabilitation is that if patients focus on their capabilities rather than on their disabilities, they can begin the process of adapting to the environment and becoming a viable part of it. The program of rehabilitation starts with the evaluation of the patient's abilities and analysis of skills required to meet the activities of daily living.

The process begins with dependence and sense of helplessness and ends with independence and sense of self-achievement. The training instills in the patients with disability a sense of empowerment, that they have control over their lives and can make decisions for themselves.

Generally three approaches are taken in the treatment process:

- Manipulating the environment to make it user friendly
- Increasing the effective use of remaining vision.
- Teaching patients to compensate with other sensory system

Counselling and guidance

Counselling and guidance play an important part in patients' understanding. The information to be delivered through counselling:

- The name of the disease or condition, the part of the eye or brain that is affected.
- The functional implication of the condition, visual acuity contrast sensitivity, visual fields, and any other clinical evaluation.
- The refractive error and why the former prescription is no longer helpful.
- The recommended device and how it assists in completing desired activities of daily living.
- Illumination needs, preferences and problems, both indoors and out doors.
- Instruction without devices to help maximize visual abilities: Fixation, eccentric viewing, scotoma awareness, scanning, spotting etc.
- Instruction with devices.
- The psychosocial implication of visual loss.

A lot of "home work" or practice increases the visually challenged patients' ability to reach their goals.

Student exercise

Answer the following

1. *Define low vision*
2. *What are the causes of low vision?*
3. *What are the types of devices given for low vision patients?*
4. *Explain about the stand magnifier.*
5. *How do you counsel a low vision patient?*
6. *Write the formula for predicting "the add".*

CHAPTER 13 DISPENSING OPTICS

OUTLINE

Introduction
Materials used in spectacle lens
Types of corrective lenses
Lens forms and transpositions
Multifocal lens (designs and features) and progressive addition lens
Tinted lens and Photochromic lens
Special coated lens
Safety lenses
Lens power measuring and methods
Spectacle frame
- Parts of a frame
- Frame materials

Face and frame measurements
- Frame measurements
- Back vertex distance and calculations
- Pupillary distance measurements and methods

Trouble shooting techniques in problematic spectacle

GOAL

To impart knowledge to the Ophthalmic Assistant (OA) to understand and guide about various lenses, frames, technical measurements and problem solving when the patients are not happy about the glasses

OBJECTIVES

The OA will be able know
- The different parts of a frame
- The different types of frame and lens materials
- Comparing different types of frames and lenses
- PD measurement
- The frame PD and lens decentration effects
- The vertex distance and lens effectivity
- Know the Lens power measurement procedures
- Identification of problems when patient is not comfortable with glasses

CHAPTER 13
Dispensing Optics

Introduction

Optical dispensing is a specialised area of eye care that includes the making of corrective lenses from refractive prescriptions and the fitting of the lenses in the spectacle frames for proper visual correction. OAs often are required to perform certain tasks related to opticianry.

OAs may be called upon to answer patients' questions or solve problems concerning the proper fitting or correction of their eyeglasses, serving as an intermediary between the doctor and the optician who dispensed glasses for the prescription. This chapter provides information about types of corrective lenses and materials used in lens manufacture. It introduces you to special optical measurements and techniques used to determine the proper fitting and correction of eyeglasses. Frame design, eye- glass care, and adjustments are also discussed.

Materials used in spectacle lens

Spectacle lenses are made from three different sources of materials. They are natural resources, glass and plastic materials. In Natural media, quartz (or) rock crystal, semi-precious stones (i.e. Topaz, Ruby, etc) were widely used for making lenses in early years.

Glass materials

Now-a-days spectacle lenses are made from either plastic or a high quality glass material. Although many types of glass materials are used in optical industry, crown glass (1.523) material is extensively used for making single vision ophthalmic lenses. Flint glass, material (1.620) is used in the making of bifocal or achromatic lens. This material is used for making the bifocal segment. Flint glass material was replaced by barium crown material, which has no chromatic aberration. It increases the refractive index of the glass. Now-a days almost all high quality bifocal lenses are made only from Barium-crown glass material. The high-index glass named Hidex (1.806), is used for making high refractive power lenses, which are remarkably thin.

Plastic materials

Plastic lenses are generally made from two different materials. They are:

1. Original plastic lens made of (PMMA) Polymethylmethocrylate
2. Modern hard resin lens from allyl diglycol carbonate (CR 39) is harder and more resistant to scratches than other plastic lens materials. Plastic lenses are made from a very high quality material as glass.

Plastic lenses are about half the weight of glass and are highly impact-resistant, but get scratches more easily and do not protect the eye from UV rays unless properly tinted. Glass lenses unlike plastic must be treated to resist breakage. They can be hardened by chemical or heat processes.

Corrected lens

A corrected lens is a form to avoid or minimize the distortions through the edges of lens. In theory the base curve should have same curvature, which coincides with the corneal curvature of the rotating eyeball, so as to maintain the proper vertex distance between cornea and the spectacles in all gazes and avoids distortions. In optical lab each manufacturer has an individualized series of base curves for toric meniscus lenses. Corrected lenses are in different designs but mainly in meniscus lens form which usually are ground on 6.00D Base curve.

A toric lens is curved like a meniscus lens but also contains a cylinder that formerly has been ground on a convex surface in single vision lenses and on a concave surface in bifocal lens.

Types of corrective lenses

Two principal types of eyeglass lenses are manufactured to correct vision: single-vision lenses, which provide correction for only one distance (that is, far or near); and multifocal lenses (bi-focals, trifocals, and progressive-addition lens), which combine two or more corrections in a single lens to provide sharp vision at more than one distance. As part of the process of refraction, the doctor decides which type of lens would most benefit a particular patient.

Lens forms

This section discusses the different lens forms or the possible contours of the lens surface. Almost all spectacle lenses are meniscus lenses having both convex and concave surfaces. Different lens forms have different benefits. For instance, curved lenses are often made flatter to improve the cosmetic appearance.

Single vision lenses have the same power throughout the lens area. Single vision lens forms can be divided into the following basic categories.

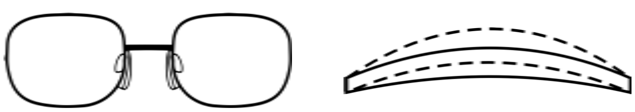

Fig. 13.1

- **Flat:** If the lens form is flatter, the lens is thinner. Thus the best form of the lens to make it as thin as possible without making the centre too thin (for minus powers) is chosen (Fig. 13.1).
- **Lenticular:** This lens form is used for high powers - usually for positive powers more than +10DSph. This form reduces the thickness and weight of high-powered lenses, making them easier to fit. Having only a small central area with the actual power does this and the periphery of the lens is plano or of a lower power called carrier lens. Here the high power lens is cemented onto a base lens. This is the only way that very high-powered lenses can be made. These are used for low vision patients or aphakics. Blended lenticular lenses have the optical power zone blended with the periphery. This gives a better cosmetic appearance than simple cemented lenticular lenses.

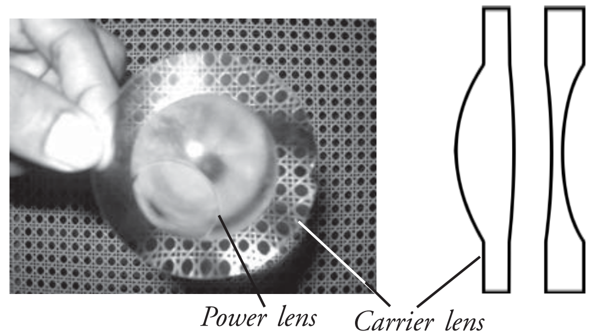

Fig. 13.2 - Lenticular lens

- **Aspheric**: An Aspheric lens is particularly designed to eliminate the peripheral distortions. It has a complex front surface that gradually changes the lens curvature from the center to periphery. In plus lenses, the front curvature of the lens flattens toward the edge of the lens. In minus lenses, the curve becomes steeper toward the lens edge. A conventional pattern lens may be optically correct through its center but causes increased effect of the lens power as the patients vision moves away from the center to the edges of the lens.

Fig. 13.3

Transposition

It is a technical formula to change the lens form from one type to another. There are two types of transpositions, Simple and toric transposition.

Simple transpositions are used to convert one form to another, usually "+" to "-". Toric transposition is used to for meniscus and cylindrical lens manufacture.

Rules of simple transposition

1. Algebric sum of sphere and cylinder is a new sphere.

2. Cylindrical power is the same but
3. Sign of the cylinder is reversed and axis of cylinder is changed by 900

Examples

2.5 D Sph / +3.0 D cyl x 1500

Answer

New sphere	=	+ 5.5 D Sph
New Cylinder	=	3.0 D cyl
Cylinder power & axis	=	-Cyl & (150-90) 600
Final Rx	=	+ 5.5D Sph / - 3.0D Cyl x 60^0

Another example

- 5.5 D Sph / + 4.0D Cyl x 15^0.

Answer

New sphere	=	- 1.5 D Sph
New Cylinder	=	4.0 D Cyl
Cylinder power and axis	=	-Cyl & (15+90) 105^0
Final Rx	=	-1.5D Sph / -4 D Cyl x 105^0

Why we do the simple transposition?

Usually we change the lens '+' form into '-' to reduce the central thickness of lens. It also minimizes the peripheral aberration, reduces weight and gives easy adaptation.

Toric transposition

Toric transposition is an application for selecting the proper form (eg. Meniscus) of cylindrical lens so that it is easy to make a good correcting lenses.

Rules

1. Choose the proper Base curve first
2. Do simple transposition if sign of base curve and cylinder are not same
3. Find out the spherical surface power; subtract the base curve from sphere
4. Find out the cylindrical surface power,
   a. Fix the base curve as a cylinder at right angle to the axis of cylinder.
   b. Add the base curve and cylinder – this is the second cylinder
5. Both spherical (numerator) cylindrical surface (denominator) determines the cylindrical lens power

Example

+ 1.0 D Sph / + 2.0 D Cyl x 165* (-6.0 Base curve)

Base curve	=	-6.0

Simple transposition (base curve and cylindrical power are not same)

	=	+ 3.0 D Sph / - 2.0D Cyl x 75*
Spherical surface power	=	+ 3.0 – (-6.0) = + 9.0 D Sph.
Cylindrical surface power	=	- 6.0D Cyl x 165*
		-2.0 + (-6.0) = - 8.0D Cyl x 75*

Final Rx =
$$\frac{+9.0D\ Sph}{-6.0D\ Cyl \times 165^* / -8.0D\ Cyl \times 75^*}$$

Another example

+1.0D Sph / +2.0D Cyl x 180* (+6 Base)

Base curve	=	+6.0
Simple transposition	=	not required
Spherical surface power	=	+1-(+6) = -5
Cylindrical surface power	=	+6 x90^0
		+2+(+6) =+8

Final Rx =
$$\frac{-5.0D\ Sph}{+6.0D\ Cyl \times 90^* / +8.0D\ Cyl \times 180^*}$$

Key points to remember

Transposition is applied only in optical surfacing lab.

- *To choose the correct tool in lens surfacing.*
- *To bring the lens into proper curvature and thickness.*

Multifocal lenses and design

For Presbyopes there are many lens forms that can cater to different functions and bring different benefits:

Bifocals: The lens has two distinct zones: for distant vision and for near vision. The near vision power is provided by adding or fusing a plus power lens to the distant vision power base lens. This reading segment can be designed in many ways, but it is always found at the bottom of the lens, converging towards the nasal side of the lens. In all bifocals the wearer experiences a "jump effect" when the eye travels from the distant vision zone to the near vision segment because of the difference in powers. Always warn first time bifocal wearers that they will have to adapt to the lens as there are two zones.

- **Kryptok bifocal:** Here the reading segment is a small circle. The eye of the user has to travel to the centre of the segment to get the maximum reading area (Fig.13.4)

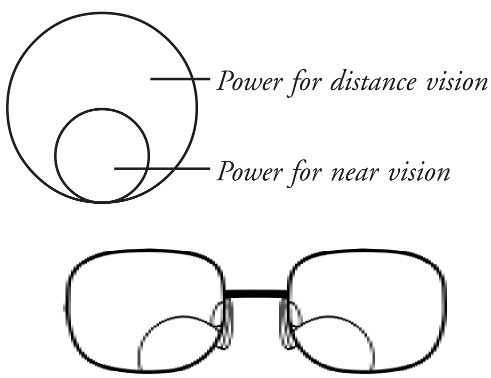

Fig. 13.4

- **D-bifocal:** The reading segment is shaped like the letter D (Fig.13.5). This is only available in plastic lenses as it is very expensive to make it with glass. The advantage of a D segment over a kryptok segment is that the maximum reading area is reached at the top of the segment itself, which makes it more comfortable. In this lens, the "jump effect" is also reduced. These are the best form of bifocals that you can recommend.

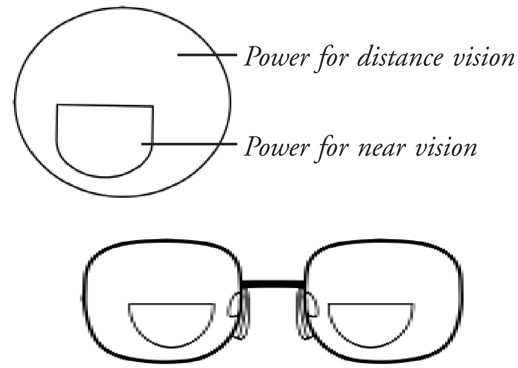

Fig. 13.5

- **Executive bifocal:** These bifocals have the entire bottom of the lens as the reading zone (Fig.13.6). This gives a larger reading area but the jump effect is very pronounced. This is usually recommended for those who do a lot of reading and writing. However, if a patient has been using executive lenses it is very difficult for him to adapt to other types of bifocals. Thus, these are not highly recommended.

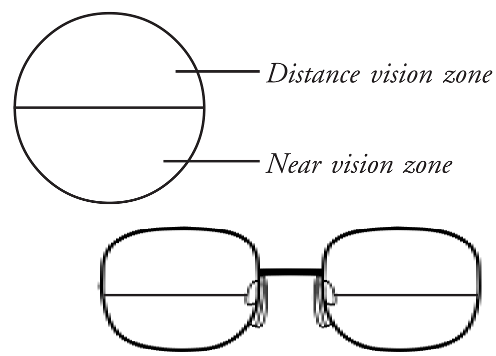

Fig. 13.6

Trifocals: These lenses have three distinct power zones: distant, intermediate and near vision zones. This is not in use nowadays (Fig.13.7).

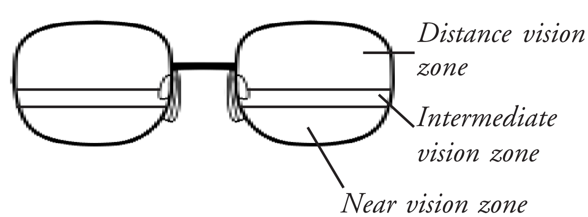

Fig. 13.7

Varifocal lenses: These lenses are designed to give the closest resemblance to vision with a normal eye, as these are not distinctly divided into zones. Instead, they have the power increasing gradually from the distant vision zone to the near vision zone. There is absolutely no jump effect. The lens is more comfortable as powers are available for vision at any distance; and not only for fixed distances like > 6m and < 30cm as in bifocals. But the zone of vision is restricted and the surrounding areas are distorted. So, this lens also needs some adaptation time, as the wearer needs to adjust to viewing only along the viewing zone. Advise the patient to learn to tilt his head at different angles, to focus on objects at different distances. This lens is more comfortable and cosmetically more appealing as there is no distinct segment. These lenses are also called progressive addition lenses (PAL) (Fig. 13.8). Over 150 designs were introduced and only 70 among them are currently available.

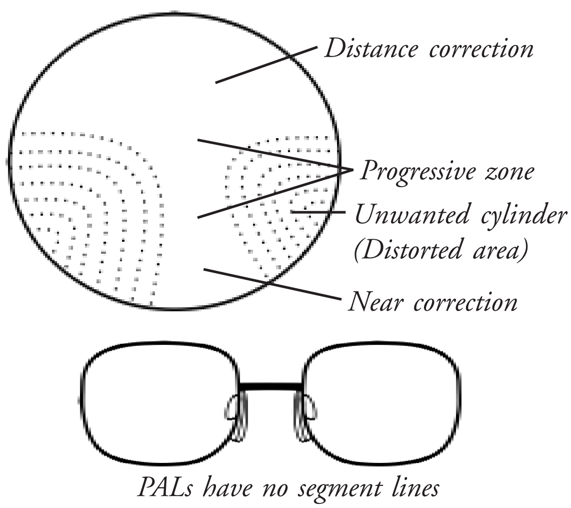

Fig. 13.8

Progressive lenses have been developed over the years to increase adaptability, comfort and its flexibility to suit any frame. These lenses are broadly classified into the following types based on their design:

- **Hard design PAL:** Hard lenses had large distortion areas with little reading area.
- **Soft design PAL:** Hard designs have been improved to reduce the distorted area and increase the reading area. These are called soft PALs and are much more comfortable and easier to adapt to.
- **Short corridor PAL:** These lenses have a short intermediate corridor enabling the lens to be fitted into smaller frames.

While dispensing PAL lenses demonstrate the clarity of different viewing zones by having the patient focus on objects at different distances. Also, remind the patient that he will take a while to adapt to the lenses; and that he must learn to view only along the progression zone and not the distorted area – in order to view objects on the side he must turn his head instead of moving his eye alone.

Tinted lenses and photochromic lens

By using the appropriate chemical dying agents, a white lens is dyed in variety of colours or mirrored evenly (Fig.13.9). Tinting generally is being done eiher with lens itself or lens surface. The popular tints are available as green, neutral gray, pink, brown and transparent one-way mirror surfaces. Tinted ophthalmic lenses give an even colouring across the whole surface of the lens whether it is a strong plus or a strong minus lens. The coating, whether it is anti reflection mirror or colour may be removed chemically in about 10 seconds, should this be necessary.

Fig. 13.9

Almost all sunglasses are white lenses coated with colour. However, coloured-glass lenses are still available that are perfectly satisfactory for plane and weak power prescriptions. In high-powered lenses, such tinted lenses are not suitable. The tinted lens usually reduces the actual illumination level in the eye so that such lenses are not suitable for high power lens and Bifocals. Neutral gray tint has been the most popular tint for sunglasses. Because of its neutral absorption of all colours of the visible spectrum, light intensity is reduced without colour distortion or imbalance- a very important factor when proper colour perception is concerned. Such a gray lens can be recommended for one who wants protection from "intense light" or glare without loss of colour patterns. A green tint lens will absorb most of UV and IR light and transmission peaks roughly at the same point as the luminous curve of the eye. Green lenses are recommended for situations with high amount of reflected (UV) light. In industry green lenses of various densities are used for welding and other high light and heat situations. They also have the psychological effect of "coolness" during hot weather and thus provide comfort to the wearer. For many years, brown tints were very popular. Brown lenses absorb almost all of the UV light and have a very even progressive curve throughout the visible spectrum. This type lenses are most useful for moderate-to-cold-climate with the added benefit of creating a "warm" visual environment. Yellow tint lenses by absorbing UV, violet, and blue areas of the light spectrum will enhance contrast in the rest of the visible spectrum. A yellow lens therefore is preferred to increase contrast in marginal light conditions, such as twilight and foggy condition, but should not be worn to protect against excessive light.

Other tints, such as pink, purple and mauve are deviants of the aforementioned tints and are used mainly as fashion accents.

Photochromic lenses

Photochromic lenses have the ability to change their shade from light to dark and back again when exposed to different sunlight intensities. The silver halide microcrystals in the glass, which give this ability never wears out. The halide becomes darken when exposed to UV light or blue end of the spectrum. The clear photo-chronic lens darkens only to the point where 15% of the light is filtered out and is not really dark enough when compared with standard sunglasses. It is available in three different colours; grey, pink and brown.

In dispensing tinted lenses it is important to know about light conditions and environment the lenses are going to be used in. In dark areas, tinted lens will dilate the pupil and reduces the visual acuity. Generally the tinted glasses are not advisable for high refractive error glass wearers and presbyopes. It reduces the actual illumination and disturbs the functional vision. Tinted lenses also make difficult to identify the colours and ultimately cause poor cosmetic appearance especially in high refractive lenses because they give uneven colouring across the lens.

Special coated lens

Mirrored sunglasses

In mirrored sunglasses a one-way mirror surface is placed on a white or coloured lens to convert it in to a sunglass for special purpose. Mirrored sunglass gives a good cosmetic appearance to patients with facial disfigurements' and at the same time they can see clearly through the mirrored lenses.

Anti-reflection coating (AR)

Artificial powerful lights (i.e.) halogen lights in cars and trucks, and computer monitors can cause reflections in untreated glass. When light passes through spectacles some light rays are reflected by front and back surface of the lens producing ghost images. AR coated lens prevent these images and only one image is seen. The coating material is very tough and usually lasts through out the life of the lens. It will be seen on the surface of the lens. These coated lenses should be cleaned with proper special cleaning solutions. AR coated lenses are readily available in market and it can be coated separately too.

Ultraviolet and blue-blocking lenses

Tinted lenses that filter out over 98% of blue and UV light are available. They are made of CR-39 plastic which is coloured amber to red. For the normal individual these lenses provide comfort from glare, reduce haziness and create sharper vision. The light-coloured lenses may help persons with developing cataracts to see well. The darker red lenses may improve the functional visual acuity in conditions like Retinitis Pigmentosa albinism, aniridia and intense photophobia.

Safety lens

The risk of damage to the eye is minimised by the use of safety glass. It is for those engaged in industrial works and sports to use it.

Hard-resin lenses

These are safety lenses with no additional treatment. A shattered hard-resin lens does not have the sharp splinters typical for broken glass. Hard resin lenses are superior to hardened glass for welding, if not metal may splatter on the lens. Another type of safety lens is the laminated lens in which a sheet of plastic is sandwiched between two pieces of glasses. If the lens is shattered, the glass particles adhere to the plastic.

Poly carbonate lens

First introduced as safety goggles in industry, polycarbonate lenses are the most impact resistant lenses now available in the market. They out perform plastic and glass heat-treated or chemically treated lenses. Polycarbonate is now being moulded into ophthalmic Rx lenses that are coated to reduce their tendency to scratch.

Heat-treated impact-resistant lens

The polished lens is heated on an oven almost to its melting or softening point, removed and then rapidly cooled by blasts of cold air on both surfaces simultaneously. The surfaces cool and contract quicker than the interior of the lens compressing the interior of the lens. Eventually the interior portion of the lenses cools and contracts and the lens becomes hard.

Safety lenses are recommended mainly for children, and by those who engaged in contact sports and industrial works.

Lens power measuring

In optics, an ophthalmic lens is constructed so that its refractive power is constant at center of the lens rather than the edge of the lens. Lens power is usually measured by either a conventional method called hand neutralisation or the use of a lensometer.

Hand neutralisation by trial lens method

It is very simple and conventional procedure to neutralise the power of a lens with trial lenses. This method is being qualitatively followed by many practitioners.

Procedure

1. First checking of a lens often involves simply identifying if it is a sphere or cylinder in '+' or '-' form lens
2. Hand neutralisation is usually done by viewing a distant cross target through the lines whose limbs extend beyond the lens edge
3. The lens is moved up and down, and left and right to ascertain the presence of a 'with' or and 'against' movement
4. A 'with' movement is seen with minus powered lenses and an 'against' movement is seen with plus powered lens
5. Movement is neutralised using an opposite power trial lenses. That is, a 'with' movement occur in concave lens is neutralised by placing the '+' power trial lens in contact with the unknown power lens
6. The power of the trial lens is increased until no movement of the cross hairs is seen
7. If the unknown lens is spherical, the movement and speed will be the same in both principal meridians

How to find out the cylindrical power

If the lens is cylindrical or sphero-cylindrical then every meridian need to be neutralised one by one.

1. To find the principal meridians hold the lens against the cross-hairs.
2. Rotate the lens about its optical axis.
3. At some positions, the appearance of cross-hairs through the lens will not be continuous with those outside the lens and will not be at right angles to each other.
4. Rotate the lens such that the lines within the view of the lens are continuous with those outside the lens. This will constitute the principal meridians; these can be marked and individually neutralised. This will constitute the principal meridians; these can be marked and individually neutralised.

Lensometer and procedures

The lensometer is also known as Focimeter or a vertometer (Fig.13.10). The main use of the lensometer is to measure the back or front vertex power of a spectacle lens. The optical centre of the lens is located in order to position the lens correctly, relative to the visual axes and the centre of rotation. When the optical centre is positioned correctly in the lensometer, the sphere, cylinder and its axis and prism power can be measured. The power of the lens is measured by placing on the lens stop.

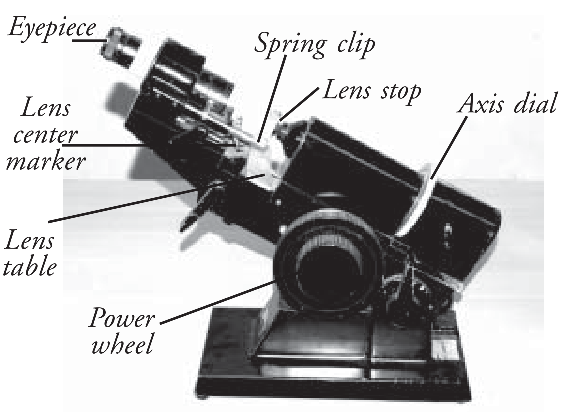

Fig. 13.10 - Lensometer

Procedure

Focusing the eyepiece

The eyepiece should be focused at each use as the setting will vary between individuals. Rotate the eyepiece until fully extended from the instrument (usually by rotating the eyepiece as far as possible in an anticlockwise direction). The graticule visible through the eyepiece will now appear blurred. The eyepiece should then be rotated in a clockwise direction until the target crosshairs and the graticule just come into focus. Continued rotation of the eyepiece will force the observer to accommodate in order to keep the graticule in focus. Accommodating whilst viewing the target can cause variability in the power measurement. With the power wheel at the zero position, the cross hairs and the target should be in clear focus. Failure to focus the eyepiece will result in incorrect readings of lens power.

Determining the lens power (Spherical lenses)

If all the lines or dots of the target are in focus at a given setting of the power wheel, the lens is spherical.

Marking the optical centre

1. Check that the centre of the lens coincides with the centre of the target.
2. When this is so, the lens is correctly positioned and the optical centre could be marked.
3. While there is no centre dot, the whole set of dots can be 'framed' within the lines of the graticule to locate the centre.
4. Repeat the same procedure for the other lens.

Determining the lens power (Sphero-cyl lenses)

- Step 1 (finding the sphere power) Rotate the power wheel until one set of lines (stretched dots) becomes clear. Start with the higher positive power (or lower negative power). The axis drum will need to be rotated to ensure that the lines are unbroken. Note the power on the power wheel.

- Step 2 (finding the cyl power) Rotate the power wheel until the second set of lines (stretched dots) becomes clear. The second power reading minus the first reading will give the power of the cyl (and its correct sign).
- Step 3 (finding the axis) Note the direction of the lines (stretched dots) at the second reading. This is the axis. The rotatable line in the graticule is used to line up with the stretched dots to determine the axis.

Examples:

- Step 1 (finding the sphere power) Rotate the power wheel until one set of target (lines or dots) becomes clear. Start with the higher plus power (or lower minus power). The axis drum will need to be rotated to ensure that the target is unbroken. Note the power on the power wheel. In this case the power reading is +2.00D.
- Step 2 (finding the cyl power) Rotate the power wheel until the second set of targets becomes clear. The second power reading minus the first reading will give the power of the cyl (and its correct sign). In this case the second reading is – 1.00D. So the cylinder power is: -1.00 and + 2.00 becomes -3.00D.
- Step 3 (finding the axis) Note the direction of the lines at the second reading. This is the axis. The lines are lying at 90 degrees.

So the lens power prescription is +1.00/-2.00 X 90 degrees.

Determination of prism power with lensometer

The lens is correctly positioned with the optical centre on the lens stop. If the target is displaced either vertically or horizontally, then the prism is present in the lens.The direction of the displacement of the focimeter target indicates the base direction of the prism. Thus, if the target is displaced upwards from the centre of the crosshair, base up prism is present in the lens. The value of the prism is measured from the centre of the target to the centre of the eyepiece scale.

Conclusion

Accurate measurement of lens power and the location of the optical centres is an important part of the successful prescribing and dispensing of ophthalmic lenses.

Spectacle frame

The part of the spectacles that holds the lens is called the frame. This usually rests on the bridge of the nose and the ears. Frames are available in a variety of shapes, structures, materials and colors. The frame that one chooses can affect the comfort, vision and looks of the spectacles and its wearer. Thus it is important to help the customer to choose one most appropriate to his physical features and his habits. This section deals in depth with the parts of a frame and types of frames – differentiated based on design and material. It also discusses what features are desirable for a spectacle frame.

Parts of a frame

The basic parts of a spectacle frame are (Fig.13.11)

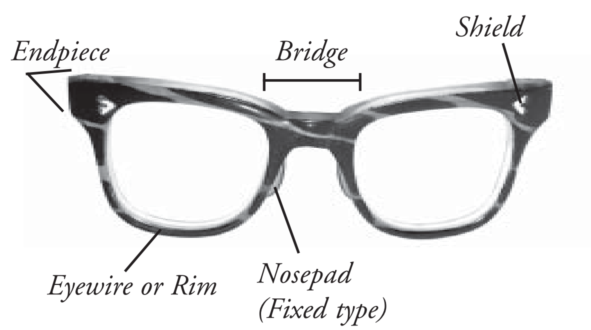

Fig. 13.11 - Frame front of a plastic frame

- **Eye wire:** Eye wire is the rim that holds the lenses. The eye wire has a groove running along its inner surface wherein the lenses are held.
- **End-piece:** The extended outer portions of the frame front, on both the sides, are the end pieces.
- **Front:** The portion of the spectacle housing the lens - including the eye wire, end-pieces and bridge, forms the front of the frame
- **Temple:** The temples are the sides of the spectacles, connecting the frame-front and resting

over the ears (Fig.13.12). Usually the front and the temple are made of the same material. The types of temples include:

Fig. 13.12 - Frame temple of a plastic frame

- **Skull temple:** This is the most common type of temple. The skull temple is most comfortable for those people who wear their eyeglasses for long periods of time. It fits easily on the ear, and bends slightly to fit the skull and lightly hug the head.
- **Library temple:** The temple is a straight line with rarely a slight bend at the very tip. It is suitable for those who need to remove their spectacles many times a day as in reading glasses.
- **Riding/Cable bow temple:** This temple has a curved earpiece and fits around the ear. It hugs the ear, and is more difficult to remove. This type of temple would be particularly helpful for those people whose jobs are very active, or for children.

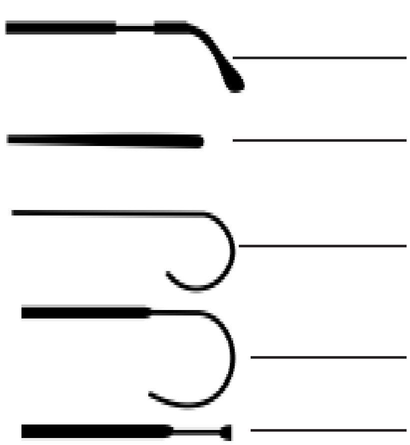

Fig. 13.13

- **Convertible temple:** This looks like a straight line without bend. It can be converted from one shape to another. It can be bent to any shape for comfort (Fig.13.13).
- **Hinge:** The hinge connects the temple to the front. This is usually made of metal. It is made of two leaves, one attached to the front and the other to the temple, which when aligned form a barrel with a hole called the dowel. The two parts are fixed together by a pin running through the dowel hole. Each leaf of the hinge has many loops which are in one of these ratios: 1:2, 3:2, 3:4, and 4:5. Usually, as the number of loops increases, the thickness of each loop is reduced and so the strength of the hinge is also less. These are traditional hinges. Today, many fancy designs are available. When the temple is made of memory metals which are flexible, there is no hinge at all. Spring hinges use a spring tension to press the temples of the frame closer to the sides of the head. This allows for a closer, snugger fit. As a result, models with spring hinges are usually more expensive.

Frame materials

Desirable qualities in a spectacle frame are:

- Durability - the frame must be able to withstand wear and tear
- Light-weight – if the frame is too heavy it is uncomfortable for prolonged use and can also cause marks on the wearer's face
- Flexible - the frame must be flexible enough to be easily adjusted, to insert the lens and to withstand different everyday conditions and handling
- Maintain the original shape
- Fast Color - The coloring on the frame must not fade, peel or wash off
- Inert to body fluids – frame material must not react to common body secretions like sweat and sebum. It should not cause any skin allergy.
- Inexpensive

Types of spectacle frame structure

Types (Construction)	Plastic	Metal	Combine(Metal Chasis & plastic top)
Parts	Front & Temple	Front & Temple	Front & Temple
Basic Material used	Cellulose Nitrate Cellulose Acetate Polymethylmethacrylate Nylon Optyl	Gold Silver Stainless Steel Aluminium Nickel	All the materials at required proportion
Weight	Light weight Standard Semi Library Library/Heavy Weight	Light weight Standard Semi Library Library/Heavy Weight	Light weight Standard Semi Library Library/Heavy Weight
Colour	One colour Bi-colour Multi colour	One colour Bi-Colour Multi Colour	One colour Bi-colour Multi colour

Interpupillary distance (IPD)

Interpupillary distance, the distance between the centre of the pupils, is measured in millimeters. This measurement should be obtained both at distance and near for each patient. Both a binocular measurement (a single recording of the total distance from pupil to pupil) and a monocular measurement (the individual distance from the center of the bridge of the nose to the center of each pupil) should be recorded.

In orthophoric (normal) patients, the eyes look straight ahead when they focus on an object directly in front of them. Eyes that are straight in the primary gaze (straight ahead) will have virtually parallel axes when they fixate on a distant object. However, when the same pair of eyes focus on a near object, the eyes converge (turn in slightly) to allow both foveas to fixate on the object. Because of this convergence, the near IPD will be lesser than the distance IPD.

The distance IPD measurement is required to fit the power spectacles both single-vision and multifocal. The near IPD measurement is required when single-vision or multifocal eyeglasses are prescribed for reading or other specified near tasks. The accurate measurement of both distance and near IPD ensures the appropriate placement of the optical centers of the eyeglass lenses. If the distance between optical centers (DBOC) does not correspond to the patient's IPD, the patient can experience double vision.

Therefore, the MLOP should verify the correct IPD and DBOC for all eyeglasses, whether they are new prescriptions or eyeglasses brought in by patients with vision complaints.

Several methods exist for measuring distance or near IPD. In addition, either binocular or monocular measurement may be chosen. Monocular measurement of IPD is considered more accurate than binocular measurement because the monocular recording takes into consideration any facial asymmetry that might be present (Fig. 13.14).

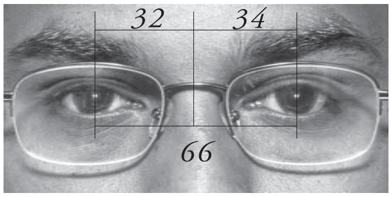

Fig. 13.14 - PD measurements

A binocular distance IPD requires just one pupil-to-pupil measurement made with a millimeter ruler. For a monocular distance IPD measurement, the distances between each pupil and the bridge of the nose are measured separately and the results are added together to yield a single measurement. Simple and accurate monocular IPD measurements may be made with a specially calibrated ruler and a penlight.

Both binocular and monocular near IPD may be measured or calculated. Measuring the binocular or monocular near IPD requires both the millimeter ruler and the penlight.

Measuring monocular distance PD

1. Position yourself 40cm in front of the patient. Make sure your eyes are level with the patient's eyes. Hold the IPD ruler lightly over the bridge of the patient's nose.
2. Hold a penlight under your left eye, aiming the light at the patient's eye. Note the position of the spot light reflection called the corneal reflex on the patient's right eye (Fig. 13.15), and record the number on the ruler just below the reflex. This represents the number of millimeters from the patient's right corneal reflex to the center of the bridge of the nose.

Fig. 13.15 - PD marking

3. Hold the penlight under your right eye, aiming the light at the patient's eye. Observe the corneal reflex on the patient's left eye. Record the number of millimeters from the left corneal reflex to the center of the bridge of the nose.
4. Add the two numbers together and record the sum on the patients chart or form as appropriate.

Face measurements

An Inaccurate size frames greatly affect the overall cosmetic appearance and comfortness of the wearer. In order to fit the spectacles correctly, some technical measurements need to be taken.

Face measurements are taken to choose the appropriate size frame and to hold the spectacle in place. An Optician's ruler is a device used for it (Fig.13.16).

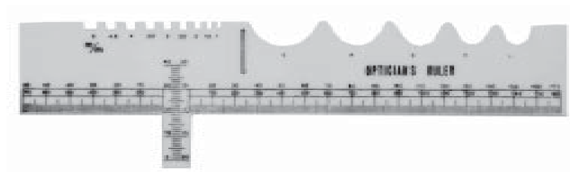

Fig. 13.16 - Optician's ruler

The measurements are:

- **Bridge size**: This is the width of the bridge of the nose
- **Intra temporal distance**: This is the distance between the temples
- **Temple length**: This is the distance between the temple and the top of the ear
- **Pantoscopic tilt**: This is the angle between the normal to the temple and the frame front
- **Vertex distance**: This is the distance between the front of the cornea and the back of the lens
- **Segment height**: The reading segment should not be placed more than2 mm below the lower eyelid and the frame should be large enough to accommodate at least three-fourths of the segment area to enable comfortable near vision.

Progressive lenses need to be fitted with an additional care as the patient will be sensitive to even slight changes.

Back vertex distance and lenseffectivity calculations

The Back vertex distance is usually measured between the front surface of the cornea and back surface of the lens. The normal vertex distance of spectacle lens is about 12mm.

When the convex lens moves away from the cornea, its effective power increases and towards the cornea its effective power decreases (Fig.13.17). Similarly a concave lens moved away from the cornea its effective power decreases. When it moves towards the cornea its effective power decreases. When a patient is tested at 12mm vertex distance and found

Fig. 13.17 - An increased effect of the convex lens

to have 12.0D Sph error and vision is 6/6 by moving the lens the vision is reduced. This is because the effective power is changed. Vertex distance at the time of testing must be equal to the vertex distance after wearing the spectacle. The vertex distance measurement is very essential for all high refractive errors. The distance is measured by means of an instrument called as, 'Distometer'. It must be available both at the time of writing the prescription as well as choosing the frame in the optical shop.

Lens optical effect may vary with vertex distance that causes poor visual performances i.e decrease of vision. If moves away from eye, the effectivity of the '+' lens becomes stronger and becomes weaker in '--' lens.

Example

If the vertex distance are not the same, appropriate correction in the power is required as given below

1. *A patient is refracted at 15 mm and prefers to wear a -10.0 D of his glass at 10 mm. What is the effective power in the position?*

$$Fe = \frac{f'v}{1- df'v} = \frac{-10}{1-(-0.05)(-10)} = \frac{-10}{1- .050} = 10.57D$$

2. *A patient found to have a +8.0 D at 15 mm and now the patients wants spectacle at 11 mm what power should be ordered?*

$$F = \frac{+8}{1-(.004)(+8)} = +8.25D \text{ (d is +ve)}$$

3. *Patient expresses desire for contact lens of -6.5D power tested at 15 mm .What power to be ordered for contact lens?*

$$Fe = \frac{-6.50}{1-(.015)(-6.5)} = -5.9D$$

4. *Refraction of an aphakic eye is performed at a vertex distance of 13mm and shows need for +12.0DSph. If the lens is now dispensed and worn at 17mm from the cornea. What is the effective power of the lens in this new position?*

$$Fe = \frac{+12.0}{1-(.004)(+12)} = +12.605D \text{ (d = +. 004)}$$

Trouble shooting techniques in problematic spectacle

When a patient comes with complaints in his / her new spectacle, the following things must be checked.

1. **Delivery:** Check the delivery slip to find out whether the spectacle has been delivered to the

right person or not. Always refer the patient's medical record number to avoid unnecessary confusions.

2. **Power and Lens design:** Make sure that the lens power and lens design are dispensed as per given prescription. The examiner may make a mistake, the optician and the optical lab technician also are liable to make mistakes.
3. **Wrong prescription:** Ensure the prescription power details that has documented correctly because the examiner might have done a mistake while writing the prescription.
4. **Spectacle alignments:** Fix the spectacle on the patient's face and observe the patient's head posture to check the proper alignments of the frame and segment height of bifocal. Misaligned frames and improper frame size can also cause the following problems:
   - Vertex Distance variations,
   - Frames slide forward
   - Frames fit loosely
   - Frames may be positioned awkwardly to see.
   - Frames temples create pressure on the side of the head or at the ears.
   - Eye lashes or eyebrows touch the lenses.
5. **Poor Centration:** This is the most common defect in dispensing. The lenses may not be centered properly according to the patient's PD that may cause blurring vision. Check the 'Centring' of the spectacle whether it is correct or wrong.
6. **Incorrect frame size:** The frames may be either too big in size or small compared to the patient's face. If so, the patient may experience the new type of distortions which causes adaptative problems to the wearer.
7. **Vertex Problem:** Ensure that the vertex distance is maintained at normal distance. It is important that the spectacle must be positioned at 12mm especially in high power lenses having more than ± 4.0D, The VD should be measured by Distometer to avoid the power variation that could lead to vision difficulties with spectacles.
8. **Unwanted Prism:** Lenses may induce the prism effect due to the surfacing problem that will cause headache and giddiness to the wearer. It occurs occasionally in glass lenses and not in plastic lenses. Check the lens in lensometer for confirming and measuring the prism-induced in the lens.
9. **Base curve:** An incorrect form of lens will cause the discomfort vision and heaviness of the spectacle. Use Geneva lens clock to check the proper thickness and the lens curve. Shadow scope or Polaroid lens can be used to identify the lens defects.
10. **Inaccurate Prescription:** Take the patient to senior refraction staff to confirm whether the prescription is appropriate.
11. **Counselling:** If there is no technical problem found, do the re-counseling gently so that it will be possible to understand the real cause of his /her dissatisfaction with glass. The other reasons cost factor, poor counselling and the behavior of the personnel could also make the patient unhappy.

Summary

The OA learned from this chapter about the different types of lenses, frames and the materials used to manufacture them. It is taught as to how to take measurements effectively and also to rectify the complaints in the spectacle and satisfy the patients.

Key points to remember

- *Ophthalmic lenses are prescribed mainly to correct the vision problems*
- *Induced prismatic effect can cause eye strain, headache and blurred vision*

- *Spectacle frames are made up of either plastic or metal*
- *Technical measurements in dispensing are very important to provide comfortable and clear vision*
- *OA's knowledge and attitude is highly important to ensure the patient satisfaction*

Student exercise

Answer the following

1. *What are the types of corrective lenses?*
2. *Describe the tinted lens.*
3. *Discuss about the PD measurements.*
4. *Explain the back vertex distance with an example.*
5. *Describe the step by step procedure of dealing with the patients who feels unhappy with new glass.*

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