LOW VISION DEVICES - OPTICAL

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INTRODUCTION

This chapter includes a review of:

- What are low vision devices
- Definitions of various low vision devices
- Different types of optical low vision devices and their uses, advantages and disadvantages

WHAT ARE LOW VISION DEVICES?

Optical devices, sometimes referred to as Low Vision Devices (LVD), consist of one or more lenses placed between the eye and object to be viewed, which increase the size of the object on the retina.

Non-Optical devices are supplementary devices that do not use optical lenses, while optical LVD incorporate lenses resulting in optical magnification

There are basically two types of optical devices

- Distance:
  - Telescopic devices (sometimes intermediate distances)
- Near:
  - Spectacle magnifiers
  - Hand held magnifiers
  - Stand magnifiers

MAGNIFIERS

1. HAND HELD MAGNIFIER

- The hand held magnifier produces an enlarged virtual image behind the magnifier (Fig. 5-1)
- Material held at focal point of lens
- Distance correction should be used because the image is formed at optical infinity when the reading material is held at the focal length of the magnifying lens

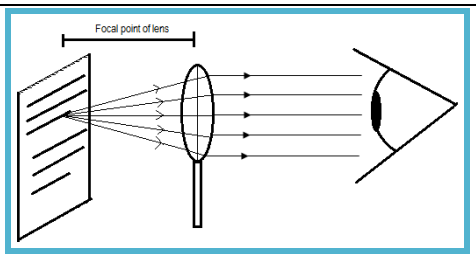

Figure 5-1: *Basic optics of hand held magnifier*

Figure 5-2 (a): *Non-illuminated hand-held magnifiers*

Figure 5-2 (b): *Illuminated hand held magnifiers*

Introduction and Use:

- Used for near viewing e.g. reading or any near activity
- The individual can move it around the print or object and will be able to see an enlarged image of the target
- One hand is in use
- Available in different magnifications and sizes (Fig. 5-2a)
- Can be used with distance and near glasses for providing extra magnification

Advantages:

- Variable eye to lens distance
- Normal reading distance
- Convenient for short term tasks
- It is readily available and fairly inexpensive
- Useful in diseases with constricted field
- The variable eye to lens distance allows the patient to use eccentric viewing when required
- The device may have its own light source, thereby also improving contrast (Fig. 5-2b)
- Portable

Disadvantages:

- Tremors in older patients can result in a problem with maintaining focus
- The lens always has to be held at the correct focal distance in order to obtain the maximum power
- Tricky and steady handling is required
- Decreased field of view
- One hand is occupied

MAGNIFIERS (CONT.)

2. STAND MAGNIFIER

- The stand magnifier produces an enlarged virtual image in front of the eye (Fig. 5-3) and therefore patients require their near prescription to view the resultant image
- The material is placed within the focal length of the lens

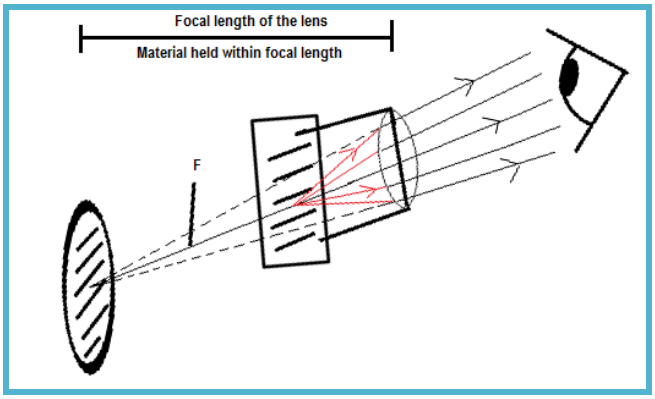

Figure 5-3: *Basic optics of a stand magnifier*

Figure 5-4: *Various types of stand magnifiers (illuminated on left and non-illuminated on right) Photo courtesy of LV Prasad Eye Institute (LVPEI)*

Introduction and Use:

- An optical low vision device used for near
- Helpful for school aged children
- Can be used in high magnification
- Image is always in sharp focus (sometimes referred to as a predictable focus) because of the rigid lens mounting
- Person moves it around the print and can see enlarged image of the print or any object
- Available in different magnification and sizes
- Can be used with distance and near glasses for providing extra magnification

Advantages:

- Device of choice for tremors, arthritis, constricted fields
- May have its own light source (Fig. 5-4 left)
- Portable

MAGNIFYERS (CONT.)

2. STAND MAGNIFIER (CONT.)

Disadvantages:

- Image Distortion
- Reduced field of view
- Needs constant head down for reading.
- This poor posture is maintained unless a reading stand is used (Fig 5.5a)
- Poor illumination in the case of non-illuminated stand magnifiers with an opaque
- lens mounting
- Requires a flat surface to place reading material
- Requires the use of accommodation or a near prescription

Figure 5-5 (a): *Non-illuminated stand magnifier used with reading stand*

Figure 5-5 (b): *Illuminated stand magnifier*

TELESCOPES

TELESCOPES	Distance magnification normally requires a telescopic lens system. Telescopic devices are of 2 types, Galilean or Keplerian. Telescopes consist of two elements: one objective lens (always a positive lens) and one eyepiece lens (either a positive or a negative lens).
A. GALILEAN TELESCOPE	A Galilean telescope is one which comprises of a convergent objective lens and a divergent eyepiece lens (Fig. 5-6). Parallel rays of light strike the convergent objective lens and an image is formed at the second focal point of the lens. The eyepiece is positioned in such way that its primary focal point is coincident with the image formed by the objective lens. Finally an upright virtual magnified image is formed.

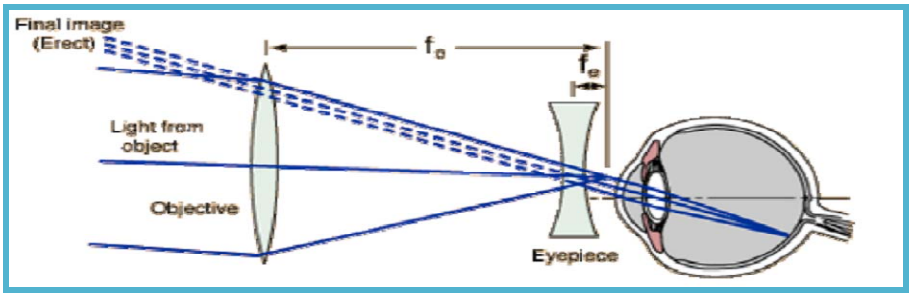

Figure 5-6: *Optical system of a Galilean Telescope*
[Graphic courtesy of LV Prasad Eye Institute (LVPEI)]

The most commonly used telescope in low vision assessment work is the Galilean telescope because of its upright image, simple design, smaller size and easier handling. It comprises of a negative eye piece lens and a positive objective lens separated by difference of their focal lengths:

The relationship between the size of the objective and the eye piece determines the image brightness of a given telescope. The best situation is when the diameters are in the following ratio:

$$\text{Magnification of a Galilean telescope} = \frac{\text{F Eye piece}}{\text{F Objective}}$$

It is therefore possible to get some magnification with different sets of lenses, bearing in mind the length of the unit.

Advantages:

- Small compact light unit
- Easy to produce
- Upright image

Disadvantages:

- Low magnification 2x - 3x
- Restricted field of view

TELESCOPES (CONT.)

B. KEPLERIAN (ASTRONOMICAL) TELESCOPE

A Keplerian telescope is one that comprises of convergent objective and eyepiece lenses (Fig. 5-7). Parallel rays of light strike the convergent objective lens and an image is formed at the second focal point of the lens. The eyepiece is positioned in such a way that its primary focal point is coincident with the image formed by the objective lens. Finally an inverted real magnified image is formed.

Since the image formed is inverted and reversed it is necessary to incorporate a third lens or prism system into this telescope to re-invert and re-reverse the image. This makes this type of telescopic design more difficult to produce and is certainly more expensive. In addition, the incorporation of the prism results in the telescope being heavier.

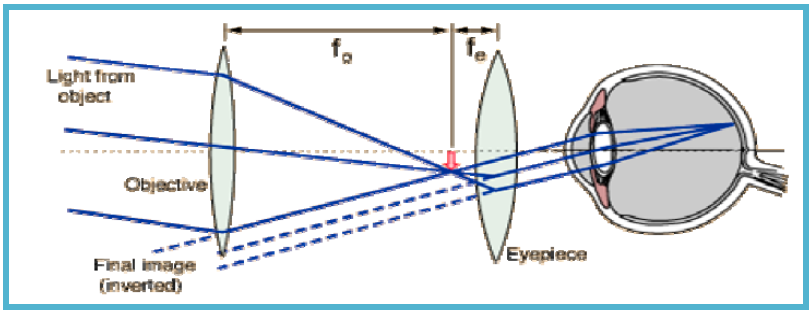

Figure 5-7: *Optical system of a Keplerian/Astronomical Telescope*
[Graphic courtesy of: LV Prasad Eye Institute (LVPEI)]

Advantages:

- Larger field of vision
- High magnification 6x - 8x

Disadvantages:

- Inverted image
- Heavy
- Complicated
- Difficult to use

CRITERIA FOR TELESCOPIC USE IN LOW VISION

Some of the criteria used when looking at a telescopic use in low vision work are:

1. Magnification extent
2. Ability of telescope to transmit light
3. Field of view

IMAGE BRIGHTNESS

The relationship between the size of the objective and the eye piece determines the image brightness of a given telescope. The best situation is when the diameters are in the following ratio:

$$\frac{\text{Diameter of Objective Lens}}{\text{Diameter of Eye-piece Lens}} = \frac{f_o}{f_e} = \text{Magnification of the unit}$$

Providing the ratio is more than 1, the larger the diameter of the lens the greater will be the amount of light transmitted.

FIELD OF VIEW

The greater the amount of magnification, the smaller will be the field of view. So when considering a telescope unit for a visually impaired person, the smallest possible magnification with which the patient can view the desired target will be the ideal choice.

Here one must remember that everybody wants maximum magnification with greater image brightness and unlimited field of view, but we know that it is not practically possible to incorporate all of the above in one unit.

SELECTING A TELESCOPE

SELECTING A TELESCOPE

When selecting a telescopic unit, one should be have the following consideration:

1. To establish the patient's need and advice on unit that is available
2. To explain, compare & contrast different units
3. Manual dexterity
4. Cost
5. To make it clear to the patient what is possible and what is optically impossible
6. Train the patient in using the particular units
7. Motivation of the patient

To better understand the optical aspects of the field of view in a telescopic system, and to calculate the field of view, one should bear in mind that field of view is in proportion to the diameter of the objective lens and that this is determined using the exit pupil of a lens.

Size of the field of view = Diameter of exit pupil

Where the diameter of the exit pupil is given by:

$$\text{Diameter of exit pupil} = \frac{\text{Diameter of Objective Lens}}{\text{Magnification of Unit}}$$

Figure 5-8: *A child with low vision using a telescope to perform board work in a classroom [Photo courtesy of: LV Prasad Eye Institute (LVPEI)]*

CLOSED CIRCUIT TELEVISION (CCTV)

CLOSED CIRCUIT TELEVISION (CCTV)

- CCTV system is an electronic LVD used for near work. The system consists of a camera (Fig. 5-9a) that focuses on reading material and projects it onto a TV Screen (Fig. 5-9b). The object can be enlarged in excess of 40 times. It is considered an optical device as it uses lenses to magnify.
- It provides a reasonable field of view
- It is a good option for near tasks when the patient has severe visual impairment
- Patient can enjoy a comfortable working distance and unlike other near optical devices there is no need for closer viewing distance
- Reading material is moved across the screen and patient does not view eccentrically
- Can also be found in the form of portable devices (Fig. 5-9c)

Figure 5-9 (a): *Mouse model CCTV*

Figure 5-9 (b): *CCTV with X-Y table*

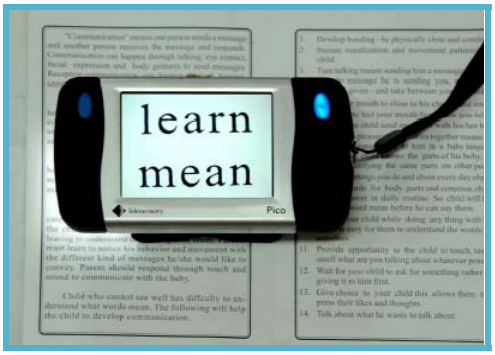

Figure 5-9: *Portable CCTV*
[Photos courtesy of: LV Prasad Eye Institute (LVPEI)]

Disadvantages:

- Typically not portable
- Expensive
- Takes time to learn and handle, but very useful if adapted properly.

DEFINITIONS OF VARIOUS LOW VISION DEVICES

HAND HELD MAGNIFIER	A magnifying aid held in the hand in front of the eye for viewing small objects at close range. It is good for spot viewing or reading, with usual powers of 2x to 5x.
ILLUMINATED HAND HELD MAGNIFIER	A magnifying aid with internal illumination held in the hand in front of the eye for viewing small objects at close range. It is good for spot viewing or reading, with usual powers of 2x to 5x.
FOLDABLE MAGNIFIER	A magnifying aid which is compact and can be folded, and is held in the hand in front of the eye for viewing small objects at close range. It is good for spot viewing or reading, with usual powers of 2x to 5x.
STAND MAGNIFIER	A magnifying aid fitted in a casing and held on the object to be viewed at close range. It is good for extended reading and is usually used in conjunction with a reading stand. Its usual powers range from 2x to 15x.
ILLUMINATED STAND MAGNIFIER	A magnifying aid fitted in a casing with internal illumination and held on the object to be viewed at close range. It is good for extended reading and is usually used in conjunction with a reading stand. Its usual powers range from 2x to 15x.
DOME OR BAR MAGNIFIER	A type of stand magnifier that is a transparent magnifying aid held on the reading material. It provides good contrast and is usually available in 1.5x to 2.5x.
TELESCOPES	A combination of lenses fitted in a tubular form to view objects from far distances to get a magnified view. Their powers range from 2x to 10x.
EXTRA-SHORT FOCUS	Telescope which can be used to view objects at close ranges i.e. 25cm to infinity.
NEAR CLIP-ON MONOCULAR	Telescope to view near objects with a clip to attach on the spectacle frame. It is good for intermediate tasks, with powers from 2x to 4x.
DISTANCE CLIP-ON MONOCULAR	Telescope to view far objects with a clip to attach on the spectacle frame. It is good for intermediate tasks, with powers from 2x to 4x.
NEAR TELESCOPES FITTED INTO A SPECTACLE FRAME	Telescope to view near objects fitted in a spectacle frame. They are good for extended reading and near vision tasks, with powers from 2x to 4x.
DISTANCE TELESCOPES FITTED INTO A SPECTACLE FRAME	Telescope to view far objects fitted in a spectacle frame. They are good for watching TV, sports, etc., with powers from 2x to 4x.
NEAR TELESCOPES FITTED INTO A SPECTACLE FRAME ANGLED TO FOCUS FROM 25CM TO 35CM	Binocular telescope for near viewing which gives a single view at near and provides depth of focus.
LED STAND MAGNIFIER	A magnifying aid fitted in a casing with internal Light Emitting Diode (LED) illumination (white, shadow free light and long battery life) and held on the object to be viewed at close range. It is good for extended reading and is usually used in conjunction with a reading stand. Its powers range from 2x to 15x.
LED HAND HELD MAGNIFIER	A magnifying aid with internal LED illumination held in the hand in front of the eye for viewing at near. It is good for spot reading, with usual powers between 2x to 5x.
CCTV	A closed circuit television (CCTV) is an electronic magnifier consisting of a camera with zoom lens and a monitor for reading. It provides excellent contrast and high magnification, but it is bulky and relatively expensive.

DEFINITIONS OF VARIOUS LOW VISION DEVICES (CONT.)

MAX BLACK & WHITE HAND-HELD	A CCTV fitted in a mouse-type casing that is scrolled over the text and attached to a television monitor for viewing. It provides a black & white image, has adjustable magnification and reverse polarity (black on white and white on black), and provides excellent contrast and high magnification. It is bulky and relatively expensive.
MAX COLOUR HAND-HELD	A CCTV fitted in a mouse-type casing that is scrolled over the text and attached to a television monitor for viewing. It provides a coloured image, has adjustable magnification, provides excellent contrast and high magnification, but is bulky and relatively expensive.
HALF-FRAME SPECTACLES MAGNIFIER	A high power plus spectacle lens fitted in a half eye spectacle frame for providing a magnified image at very close distance from the eye. It is usually monocular but could also be binocular with base in prisms.
FULL-FRAME SPECTACLES MAGNIFIER	A high power plus spectacle lens fitted in a full aperture spectacle frame for providing a magnified image at very close distance from the eye. It is usually monocular but could also be binocular with base in prisms.
FILTERS	Worn over the user's spectacles to shield light from all sides, block UV & luminous transmission of 40%. Many eye conditions and diseases make eyes particularly sensitive to light or to certain wave-length. Filter lenses are used to cut off glare and undesirable frequencies of the visible spectrum of light.

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