

## Current Perspectives in Low Vision and its Management

**Dewang A\*, Rebika D, Sneha A, Rohit S and Radhika T**

Dr R P Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi, India

**\*Corresponding author:** Dewang Angmo, Dr R P Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, Ansari Nagar, New Delhi, India, Tel: +91-1126594127; E-mail: dewang45@gmail.com

**Review Article**

Volume 2 Issue 3

**Received Date:** August 29, 2017

**Published Date:** September 20, 2017

### Abstract

Visual impairment is a growing public health challenge worldwide. Low vision has a huge impact on the patient's physical and mental capabilities. In children, visual impairment has a significant impact on their education, environmental learning, growth and hence, their career. Low vision rehabilitation (LVR) aims to enhance the individual's functional ability and independence by maximizing the use of the residual vision. With the wide availability of internet, devices like smart phones and tablets are increasingly being used as low visual aids. Despite these ongoing advances in the field of LVR, lack of awareness about low vision services amongst the eye care practitioners as well as the patients remain a major barrier in the uptake of these services. Hence, in this review we outline the principles and details of various low vision aids with stress on the modern low vision rehabilitation services.

**Keywords:** Low vision aid; Low vision rehabilitation; Low vision; Blindness; Peripheral visual

### Introduction

As per the International Statistical Classification of Diseases and Related Health problems (ICD-10) published by World Health Organization (WHO), visual disturbance and blindness is classified as H53-54.9 [1]. Low Vision (Visual impairment Categories 1 & 2) is defined as "A person who has impairment of visual functioning even after treatment and/or standard refractive correction, and has a visual acuity of less than 6/18 to light perception (in the better eye), or a visual field less than 10 degrees from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task for which vision is essential". Blindness (Visual impairment Categories 3, 4 & 5) is defined as visual acuity of less than 3/60 or a corresponding visual field loss of less than 10 degrees in the better eye with best possible correction. The term visual impairment includes both blindness as well as low vision [2].

Visual impairment is a pressing public health challenge, with blindness being one of the most common disabilities world wide [3]. Globally, the number of people of all ages visually impaired is estimated to be 285 million, of whom 19 million are children [4]. The burden of childhood blindness may not seem to be large in number, but it is the second largest cause of blind-person years worldwide (following cataract).

With a home to an expected more than one-third of global blind cases, South East Asia and especially India shares a large burden of the disease [5]. With the recent revision in the definition of blindness by NPCB (National Program for Control of Blindness), the population of blind people in India will reduce from 1.20 crore (as per National Blindness survey 2007 data) to 80 lakhs [6]. However, demographic trend suggests that the number of blind people is expected to rise worldwide with

increasing life expectancy and therefore more age related visual problems [7].

Low vision has a huge impact on the person's emotional and physical capabilities, as well as the quality of life, depending upon the type and severity of visual disability (Table 1) [8]. Especially in children, low vision is a significant barrier to learning and development. Hence, low vision rehabilitation (LVR) should aim to improve the functionality and independence of a visually

disabled person by optimizing the use of the remaining sight.

Despite the recent technological advances in the field of LVR, lack of awareness among eye care practitioners about low vision management remains a major barrier in the uptake of low vision services [9-11]. Thus, in the wake of the changing trends in the management for low vision, we discuss about the current management options for low vision in this review.

Type of visual loss	Functional Implication	Behavioral Manifestation
Peripheral visual loss	Inability to identify objects (sides) Slow light & dark adaptations Poor vision in dull light	Unusual head movement Disorientation in mobility Unable to locate lost objects
Central Visual Loss	Poor perception of people and objects Poor color discrimination Poor perception for distance and near objects	Head position for mobility and recognition Clumsy reading Uncoordinated activities
Overall blurred vision	Poor vision and clarity affected Reduced contrast and increased sensitivity to light Poor night vision	Difficulty in Activities of Daily living Bumping into objects Poor concentration

Table 1: Functional implications and behavioral manifestations due to poor vision and visual field.

### Low Vision Rehabilitation (LVR)

Low vision negatively impacts the quality of life with increased need or dependency on care givers for activities of daily living, increased rate of depression, risk of multiple falls, and inhibited social interaction. Thus, the purpose of low-vision rehabilitation is to allow the person to resume or to continue to perform daily living tasks by providing appropriate optical/non-optical devices, environmental modifications, special mobility and vocational training in the use of low-vision aids (LVA). Rehabilitation must be tailored to correspond to the type of visual loss and may also be modified by the individual's choice or expectations. Reading has been identified as the most common problem in patients with low vision [12]. Improvement in reading for distance as well as for near has been reported using optical aids in several studies [13].

#### Principle of Low Vision Devices

The basic principle of all optical LVA is magnification. The specified magnifying powers of most of the available aids are computed from the single formula.

$$\text{Magnification (M)} = \frac{\text{Dioptic power (D)}}{4}$$

This formula works on the following assumptions:

- Unaided eye can sustain just enough accommodation to hold the matter at 25cm
- When magnification is used, the reading material is placed at principal focal plane.

Thus, magnification can vary by changing the distance between the object and the lens (eg. spectacles, hand magnifier). This, formula can be written as

$$M = D + \frac{A}{2.5}, \text{ where } A = \text{amplitude of accommodation}$$

If the distance between the eye and lens is appreciable, then magnification is given by the formula

$$M = D + \frac{(A-hAD)}{2.5}, \text{ where } h = \text{eye lens distance in meters}$$

This implies that:

- The eye should be kept close to the lens in order to reduce h and thus to increase magnification.
- Reading matter should be as close to the patient's eye as much as his accommodation allows.

For example, if a 16D lens is to be prescribed, and then magnification (M) and the working distance can be calculated using the following formula:

- Magnification =  $\frac{D}{4}$ ;  $M = \frac{16}{4} = 4x$
- Working distance (inches) =  $\frac{40}{D} = \frac{40}{16} = 2.5$  inches.

There are four different ways to achieve magnification. Low vision devices make use of either ones or a combination of these four types of magnification.

1. Relative Size Magnification- It means enlargement of the size of the object. This does not use an optical system. Example: Large print books.
2. Relative Distance Magnification- It is achieved by moving the object of regard towards a person to

subtend a larger image on the retina. The magnification is inversely proportional to the change in distance. In this an optical system is usually required. Example: the common magnifiers.

3. Angular Magnification- It is the apparent change in size of the object as compared to the true size seen without the device. This type of magnification is generally produced by telescopic systems.
4. Electro-optical Magnification- This is produced by electronic systems that enlarge the objects directly by scanning or are computer generated.

However, there are certain disadvantages of high magnification (Figure 1). It leads to:

- Smaller field of view
- Closer working distance
- Reduced depth of field
- Needs more illumination
- Greater difficulty for the patients to use

The selection of the device will thus depend upon these factors, and not only on the level of magnification.

Legge and associates gave a “5×5” rule for prescribing magnification. According to this rule an optimal reading rate can be attained in patients of low vision by prescribing magnification of atleast five times the threshold size and field of view of atleast five-characters [14]. However, recent studies recommend prescribing sufficiently high magnification that gives atleast three line acuity reserve for the patient [15].

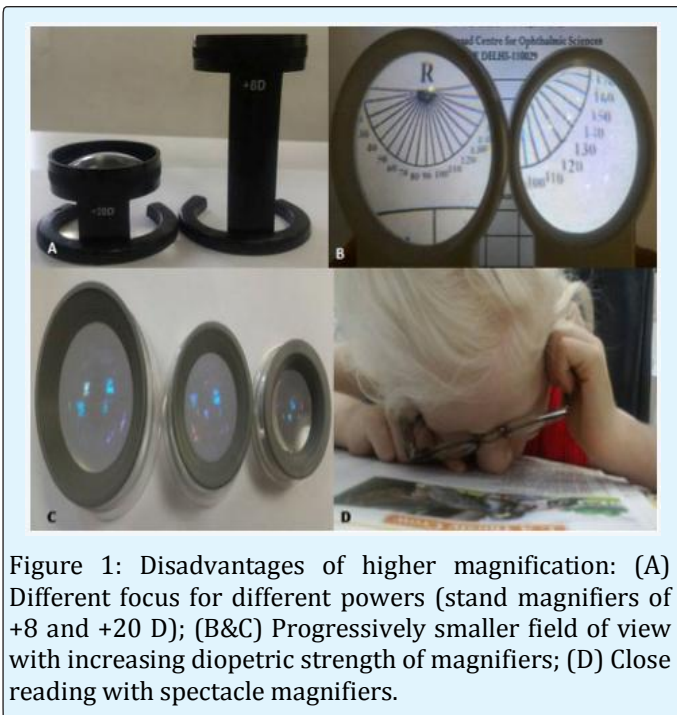


Figure 1: Disadvantages of higher magnification: (A) Different focus for different powers (stand magnifiers of +8 and +20 D); (B&C) Progressively smaller field of view with increasing dioptric strength of magnifiers; (D) Close reading with spectacle magnifiers.

### Prediction of the Add

The calculation of the Dioptric adds for low vision patients can be done by two methods:

#### 1. Kestenbaum's rule: Reciprocal of Snellen's visual acuity:

- Example: If the patients reads 2M print, the Snellen's equivalent is 6/36
- Reciprocal of 6/36 is 36/6, which is equal to 6D

#### 2. Reciprocal of distance:(For Near)

- Example: If the near acuity tested at 40cm is 2M
- Then in order to read 1M print, the patient must hold it at 20cm
- The add required is  $100/20 = 5D$

#### 3. Lovie-Kitchin and Bowman formula<sup>16</sup>

- Required near addition (D) =  $\frac{\text{Print size read}}{\text{Print size required}} \times \text{Present Near addition (D)}$
- Minimum power that enables the patient to just achieve the print size of their desired task is prescribed.

### Types of Low Vision Devices

There can be three types of low vision devices- optical, non-optical and other assistive devices (Figure 2).

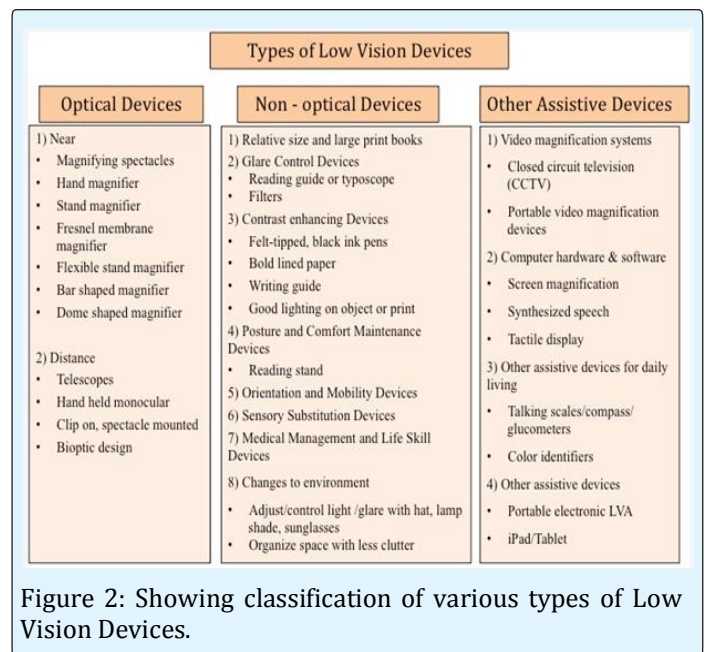


Figure 2: Showing classification of various types of Low Vision Devices.



### Optical Devices (Figure 3 & 4)

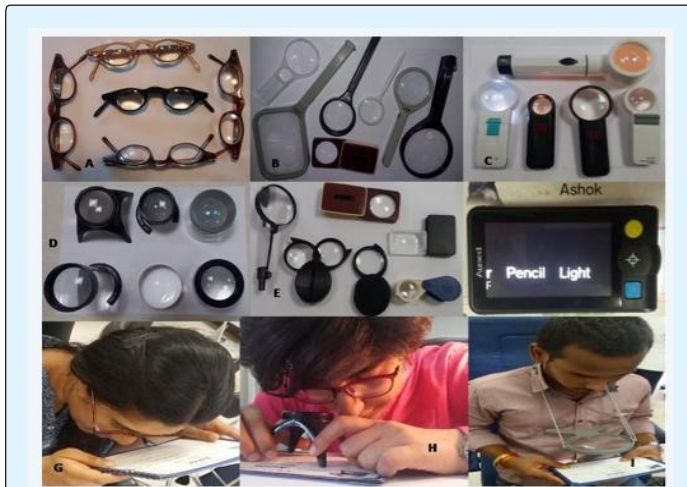


Figure 3: Optical low vision devices for near:(A) Spectacle magnifier; (B) Non-illuminated hand-held magnifier;(C) Self-illuminated hand-held magnifier; (D) Stand and dome magnifiers; (E) Pen magnifier and foldable pocket magnifiers; (F) Portable digital CCTV-type magnifier; (G) Reading with spectacle magnifier; (H) Reading with cut away stand magnifier; (I) Reading with neck magnifier.



Figure 4: Optical low vision devices for distance: (A) See TV magnifier for a distance of 3 meters; (B) Ocutech Bioptics; (C, D) Telescopes - unioocular hand-held and spectacle-mounted; (E) Binoculars: Spectacle Mounted Telescope; (F) Patient reading with SEE TV Glasses; (G) Use of Sight Scope Biopix for Distance; (H) Use of Unioocular Hand Held Telescope.

#### Magnifying Spectacles (High Plus Reading Glasses)

Normally, near addition in glasses can be prescribed upto +3.5Dsphere (S). Add greater than this is called a

high plus add. Higher the addition, closer is the reading distance. The various forms of low vision spectacles are:

- For binocular correction prism spectacles (half or full field) are used. The commonly available powers are +4D, +5D, +8D, +10D, +12.0D, +16D, +20D, +24D. Base in prisms are added to compensate for the convergence angle of the eye and facilitate binocularity (1Δof base-in prism is incorporated for each diopter of reading addition).
- For monocular correction high plus aspheric spectacles are used, with commonly available powers being +4.0D to +10.0D, +12.0D, +14.0D, +16.0D, +20.0D, and +24.0D. The design should preferably be aspheric to prevent peripheral distortions and enhance the field of vision. The better eye is corrected, and the other eye is prescribed a balance or a plano lens.
- Spectacle magnifiers are also available with Fresnel prisms for low powers only.

A study comparing the performance of prism spectacles versus conventional spectacles, reported that prism spectacles were not beneficial in visual impairment due to age-related macular degeneration [17].

The optical quality of the lens used for magnifying spectacles should be as follows:

1. Aspheric design - eliminates peripheral aberration and provide reasonable field
2. Plastic lenses - high index lenses, therefore reduces the thickness and weight as compared to glass
3. Feinblooms doublet design eliminate spherical and chromatic aberrations and provide wider field than aspheric lenses
4. Antireflection coatings help eliminate unwanted reflections from lenses and increase light transmission

Prescription of magnifying spectacles

- Addition is given over the distance correction

$$\text{Reading distance} = \frac{100}{\text{Near Add}}$$

- Example:

- If the distance correction is +1.0Dsph/-2.0Dcyl@90, and the required add = +10.0D

- Then final near correction becomes +11.0Dsph /- 2.0Dcyl@90

- Then, the reading distance =  $\frac{100}{10} = 10\text{cm}$

#### Advantages of magnifying spectacles

- Hands free device
- Greater comfort for prolonged reading
- Greater visual field as compared to telescopes and some stand magnifiers
- Both monocular and binocular forms are available
- Portable
- Most acceptable

**Disadvantages of magnifying spectacles**

- Fixed close reading distance is a major disadvantage.
- Closer reading distance causes fatigue or unacceptable reading posture. Use of reading stands are recommended for better posture.
- Illumination is often obstructed by closer reading distance. Uses of table lamps are advised for better illumination.
- May not be effective in patients with constricted visual field.

**Hand Held Magnifiers**

These are plus lenses that are held in front of the spectacle plane. Hand magnifiers are available in a power range of +4.0D to +68.0D. The field of view depends on the distance of the lens from the eye, the size and magnification of the magnifier. Higher the power, smaller is the size of the magnifying lens, and hence the field of view. It could be illuminated or non-illuminated and are available in spherical, aspheric, bi-aspheric and doublet forms.

**Uses:**

- Reading signs, labels, prices, books
- Identifying money
- Viewing near objects and inspecting objects

**Advantages**

- Eye to lens distance can be varied.
- Patient can maintain normal reading distance, unlike spectacles and stand magnifiers.
- Convenient for short tasks and can be used in any angle or position.
- Easily available from low to high powers.
- Useful in patients with constricted fields.

**Disadvantages**

- Occupies both hands and difficult to hold steady.
- Requires good hand-eye coordination. So, difficult to use in elderly patients with tremor or poor manual dexterity.
- Limited field of view.

**Stand Magnifiers**

These may be technically simpler to use than a hand magnifier, as they are pre-focused and rest on the rigid mount. Illuminated stand magnifiers have an added advantage of non-glare light source. Magnification ranges from 2x to 20x. The patient needs to place a stand magnifier on the reading material and move across the page to read. A reading stand is recommended with this kind of magnifier. They are preferred in children and in patients with constricted visual fields or central visual field loss. An initial reduction in the reading rate has been reported with the use of stand magnifiers as compared with their large print, but it subsequently improves after instruction and practice [18].

**Uses:**

- Reading from a book or a newspaper
- Looking at a picture or a diagram

**Advantages**

- Fixed focus
- Works good for patients with tremors, arthritis and constricted fields
- May be illuminated

**Disadvantages**

- Restricted field of view
- Requires good hand-eye coordination
- Physical discomfort due to close reading posture

**Telescopes**

They magnify the apparent size of distant objects, making them appear closer to the patient. The magnification ranges from 2x to 10x. The patient has to spot the object he wishes to see and then brings the telescope in front of the eye. The optics of the telescopic systems is based on two basic principles- Galilean or Keplerian. It could be hand-held, Clip-on/spectacle-mounted or abioptic design.

**Uses:**

- Finding and recognizing people
- Reading from a blackboard (distance > 2m).
- Finding an entrance to a building.
- Watching games, television.
- Reading traffic signals, street signs, bus numbers.

**Advantages**

- One of the most popular device to enhance distance vision.
- Can be used in classroom for blackboard reading or outdoors

**Disadvantages**

- Major drawback is the restriction in the field of view.
- Focusing requires good hand-eye coordination.

Biopic telescope is a term for a pair of vision-enhancement lenses used to improve distance vision. It can either be a combination of head-mounted eyeglasses (termed the "carrier") and binoculars, or be designed to attach to existing glasses. It has a small mini telescope, magnifying up to six times, which can be embedded into the spectacle glass. It allows the wearers to switch their sight between their regular vision and the magnified vision of the device by just a slight tilt of the head, similar to how one uses bifocal spectacles. Several recent studies have highlighted the effectiveness of bioptics for driving among the visually impaired patients [19,20]. However, the evidence regarding the safety and efficacy of biopic driving is still unclear, and laws surrounding it are ambiguous [21]. Its use is legalised conditionally in some provinces in United States, Canada and The Netherlands [19].

### Non-Optical Devices (Figure 5)



Figure 5: Non-Optical for low vision management: (A) Visor Cap for outdoors to prevent photophobia; (B) Table lamp while studying; (C) Big font telephone numbers; (D) Filters and Tinted lenses for contrast enhancement; (E) Writing guide, Notex (for counting notes), Typoscope and Signature guide; (G) Digital audio thermometer; (H) Increased contrast objects for routine work; (I) Smart cane for mobility

These devices enhance the visibility of the retinal image and optimize the use of optical devices. They can be grouped according to their function:

- 1) Relative size and Larger Assistive Devices- Large print materials are the best examples
- 2) Glare Control Devices- Conditions like glaucoma, albinism, rod-cone monochromatism produce glare. Use of these devices provides great comfort in these situations.
  - Different tinted glasses and filter that cut ultraviolet and infrared light to reduce glare and contrast. They can be fitted over glasses as clip-on or added to regular glasses.
  - Reading guide or Typoscope has a cut- out section to reduce glare and the amount of text visible to read is easily focused.

- Signature guide helps to sign independently in the writing speed.
  - Hats controls glare in natural light.
- 3) Contrast enhancing Devices- Contrast plays an important role in enhancing the functional vision of a person. Some of these devices used are:
    - Felt-tipped, black ink pens
    - Bold lined paper
    - Writing guide
    - Good lighting on object or print
  - 4) Posture and Comfort Maintenance Devices- Most of the optical devices require closer reading distance. A reading stand will allow the person to have a comfortable body posture while reading for prolonged time at a close working distance
  - 5) Orientation and Mobility Devices- Long canes, dog guides and strong portable torches are some examples of these devices. Mobility canes are the most commonly and widely used low-vision device. They are cost effective and easily available.
  - 6) Sensory Substitution Devices- When vision is affected, the loss is compensated using other residual senses. Some of the sensory substitution devices are audio books and Braille.
  - 7) Medical Management and life skill devices- Examples of such devices are
    - Pre-set insulin syringe: the patient feels the pre-set level notes and knows how much to inject even if he is not able to see the markings
    - Notex: scientifically accepted device for currency identification
    - Needle threader: it helps in easy threading
    - Talking clock and watches: these are readily available in the market at low cost. They have raised buttons with speech output option
  - 8) Changes to environment to facilitate and use of residual vision
    - Adjust/control light /glare with hat, lamp shade, sunglasses
    - Organize space with less clutter



## Electronic Devices/ Other Assistive Devices (Figure 6)



Figure 6: Desktop magnifiers: (A) Normal contrast; (B) Zoom settings: Zoom 8; (C) Black and white contrast; (D) Contrast and brightness settings; (E) Green over black and contrast settings; (F) Desktop Magnifier – writing is easy.

### Closed Circuit Television (CCTV)

CCTV consists of a monitor, a camera, a table or a platform where the reading material can be placed. It has controls for brightness, contrast, colour and magnification. Magnification can be varied from 3x to 70x. Current video magnification systems include:

- Desktop CCTV with enhanced features (autofocus, speech commands, flat screens, text manipulations).
- Handheld cameras/portable devices.
- Head mounted systems where camera and LCD displays are combined in a single unit.

#### Advantages

- Higher magnification up to 70x.
- Binocularity.
- Patient can sit at comfortable reading distance.
- Hands are free for writing, etc.

#### Disadvantages

- Expensive.
- Need more training and practice.

A study reported better reading performance with optical than with head-mounted electronic devices. However in two other studies, electronic stand-based (camera and monitor) CCTV and a hand-held CCTV (14-inch monitor at 40 cm) allowed faster reading than optical devices. This difference in results could be explained by the evolving and improving technology for electronic devices [17].

### Computer Education Software

- JAWS screen Reading software: It converts a normal personal computer into a talking computer so that one can learn to operate the computer independently.
- Connect out load internet and e-mail software: Access to internet through speech and braille output.
- MAGic 8.0 screen magnification system with Speech: It has a magnification range of 2x to 16x and it also reads the information aloud.

**Portable Electronic Low-Vision Aids-** Interest is increasing among the patients and the physicians in portable electronic low-vision aids. Some of these devices are Optelec *Compact+*, Optelec *Compact 4HD*, Schweizere *Mag43*, and Eschenbach *Mobilux Digital*, *Aumed –EYE-C*. In a prospective randomized crossover study, portable electronic vision enhancement system (p-EVES) devices were found to be cost-effective for improving near vision visual function [22].

One portable artificial vision device (OrCam) is an optical character recognition device, capable of recognizing text, monetary denominations, faces, and can be programmed to recognize other objects. It consists of a miniature camera and an earpiece that can be mounted on the spectacle frame. When activated OrCam can click pictures and even read aloud any text found on the pictures that can be heard by the user via the earpiece. The Or Cam was recently made commercially available in the United States and its usefulness has been elucidated in a recent study [23].

### Smart Phone/ Tablet/ Electronic Readers

With a widely available internet access, internet-ready devices like smart phones and tablets are being commonly used worldwide and off late are being increasingly used as visual aids. These devices are incorporated with features of image enlargement, high-contrast screens, invert colors and bespoke apps. The textural characteristics like font size, format, word spacing, line spacing, color can also be manipulated. Several recent studies have shown that with proper training these devices can be a valuable tool for low-vision patients especially as a reading aid [24-26]. Another exciting ongoing development is the Google glass technology and research is on way for its use in cases of visually impaired.

Here are some examples of mobile friendly low vision apps:

- Claria Zoom- Easy to see interface for the visually impaired. Such as - big characters and color themes
- Low Vision Clear Sight – Multi-featured application for low vision having options to view enlarged contacts, camera, calculator, clock and GPS with bold color themes

- Eye – D – for visually impaired – it is intelligence based smart phone assistant app. It helps user to be location aware, explore and navigate to nearby places of interest.
- Zoom Plus Video magnifier – it enlarges text and allows changing colors and contrast of the text and background like video magnifier.
- Macular Society, Low Vision keypad free, blind and senior music player etc. are few more which can be used.

### Tele-Rehabilitation

There is an upcoming concept of tele-rehabilitation for patients with low vision. It refers to the delivery of rehabilitation services via information and communication technologies [27]. It has commonly been used in patients of stroke, brain injury, joint replacement, or spinal cord injury. Patients with low vision often are unable to gain access to LVR services due to transportation difficulties and other associated physical co-morbidities. These barriers can be overcome by internet-based consultation. There are studies from Southern part of India that describe tele-ophthalmology as real-time interaction using a videoconferencing system between eye care practitioner and patients undergoing screening for ocular diseases [28,29]. This concept could very well be applied for LVR. However, there is lack of evidence in literature in this regard and future studies are warranted to explore the potential for tele-rehabilitation in LVR [30].

Some important considerations to be kept in mind while prescribing LVAs are the ease of use, frequency of use, patient satisfaction, physical comfort, weight, cosmesis and cost. Success in using an LVA may also be dependent on a person's needs and the training received, as well as other components of a multidisciplinary low-vision rehabilitation approach [31]. Patients with central scotoma can be taught to ignore the scotoma and view eccentrically. Despite the ongoing advances in the field of LVR, there are certain gaps in knowledge and care that need to be addressed.

There is a lack of good quality evidence regarding the use of optical low-vision aids in children and young people [32]. Apart from the known visual factors, there are several non-visual factors like mental state (depression), physical functioning and cognition that have been recently found to be equally important in the management of a low vision patient [33]. There are reports about the neglect in the field of emotional and family support in LVA clinics [34]. Also, there is a need to ensure that both the clinicians and the health practitioners are aware of the type of LVR services available and to develop adequate referral pathways for

the same.

The concept of low vision rehabilitation has changed considerably in the recent decades. It has become a new emerging subspecialty in the wake of the technological advances. A multidisciplinary approach and coordinated efforts are necessary to take advantage of new scientific advances and achieve optimal results for the patient. Accordingly, this paper outlines the principles and details of low vision aids with stress on the modern low vision rehabilitation service.

### References

1. WHO (2009) International Statistical classification of diseases, injuries and causes of death, tenth revision, 1993. ICD – Classification of Diseases, Functioning, and Disability. Atlanta (GA): National Center for Health Statistics.
2. WHO. Priority eye diseases.
3. Pascolini D, Mariotti SP (2012) Global estimate of visual impairment: 2010 Br J Ophthalmol 96(5): 614-618.
4. WHO (2014) Visual Impairment and blindness.
5. South East Asia. International agency for the Prevention of Blindness.
6. The definition of blindness under NPCB.
7. Office for National Statistics. Population: by age, 1961–2021. In: Social trends 29. London: Stationery Office, 1999.
8. Trillo AH, Dickinson AM (2012) The Impact of Visual and Non visual Factors on Quality of Life and Adaptation in Adults with Visual Impairment. Invest Ophthalmol Vis Sci 53(7): 4234-4241.
9. Jose J, Thomas J, Bhakat P, S Krithica (2006) Awareness, knowledge, and barriers to low vision services among eye care practitioners. Oman J Ophthalmol 9(1): 37-43.
10. Khan SA, Shamanna B, Nuthethi R (2005) Perceived barriers to the provision of low vision services among ophthalmologists in India. Indian J Ophthalmol 53(1): 69-75.
11. Pollard TL, Simpson JA, Lamoureux EL, Keeffe JE (2003) Barriers to accessing low vision services. Ophthalmic Physiol Opt 23(4): 321-327.



12. Owsley C, McGwin G, Lee PP, Wasserman N, Searcey K (2009) Characteristics of Low Vision Rehabilitation Services in the United States. *Arch Ophthalmol* 127(5): 681-689.
13. Margrain T (2000) Helping blind and partially sighted people to read: the effectiveness of low vision aids. *Br J Ophthalmol* 84(8): 919-921.
14. Legge GE (1991) Glenn A. Fry award lecture1990: Three perspectives on low visionreading. *Optom Vis Sci* 68(10): 763-769.
15. Lovie-Kitchin J (2011) Reading with low vision: the impact of research on clinical management. *Clin Exp Optom.* 94(2): 121-132.
16. Lovie-Kitchin JE, Bowman KJ (1985) *Senile Macular Degeneration—Management and Rehabilitation*. Boston: Butterworths,
17. Virgili G, Acosta R, Grover LL, Sharon AB, Giovanni G (2013) Reading aids for adults with low vision. *The Cochrane Database Syst Rev* 10: CD003303.
18. Cheong A, Lovie-Kitchin J, Bowers A, Brown B (2005) Short-term reading practice improves reading performance with standmagnifiers for people with AMD. *Optom Vis Sci* 82(2): 114-127.
19. Owsley C, McGwin G, Elgin J, Joanne M Wood (2014) Visually impaired drivers who use bioptic telescopes: self assessed driving skills and agreement with on-road driving evaluation. *Invest Ophthalmol Vis Sci* 55(1): 330-336.
20. Bowers AR, Sheldon SS, DeCarlo DK, Eli Peli (2016) Biopic Telescope Use and Driving Patterns of Drivers with Age-Related Macular Degeneration. *Trans Vis Sci Technol* 5(5).
21. Chun R, Cucuras M, Jay WM (2016) Current Perspectives of Biopic Driving in Low Vision. *Neuroophthalmology* 40(2): 53-58.
22. Bray N, Brand A, Taylor J, Hoare Z, Dickinson C et al. (2017) Portable Electronic Vision Enhancement Systems in Comparison With Optical Magnifiers for Near Vision Activities: An Economic Evaluation alongside a Randomized Crossover Trial. *Acta Ophthalmol* 95(5): e415-e423.
23. Moisseiev E, Mannis MJ (2016) Evaluation of a Portable Artificial Vision Device among Patients with Low Vision. *JAMA Ophthalmol* 134(7): 748-752.
24. Mednick Z, Jaidka A, Nesdole R, Bona M (2017) Assessing the iPad as a tool for low-vision rehabilitation. *Can J Ophthalmol* 52(1): 13-19.
25. Walker R, Bryan L, Harvey H, Afsane Riazi, Stephen J Anderson (2016) The value of tablets as reading aids for individuals with central visual field loss: an evaluation of eccentric reading with static and scrolling text. *Ophthalmic Physiol Opt.* 36(4):459-464.
26. Robinson JL, Braimah Avery V, Chun R, Pusateri G, Jay WM (2017) Usage of Accessibility Options for the iPhone and iPad in a Visually Impaired Population. *Semin Ophthalmol* 32(2): 163-171.
27. Brennan DM, Lum PS, Uswatte G, Taub E, Gilmore BM et al. (2011) A telerehabilitation platform for home-based automated therapy of arm function. *ConfProc IEEE Eng Med Biol Soc* 2011: 1819-1822.
28. Prathiba V, Rema M (2011) Teleophthalmology: a model for eye care delivery in rural and underserved areas of India. *Int J Family Med* 2011: 68326.
29. Murthy KR, Murthy PR, Kapur A, Owens DR (2012) Mobile diabetes eye care: experience in developing countries. *Diabetes Res Clin Pract* 97(3): 343-349.
30. Bittner AK, Wykstra SL, Yoshinaga PD, Li T (2015) Telerehabilitation for people with low vision. *Cochrane Database Syst Rev* 8: CD011019.
31. Langelaan M, van Nispen RMA (2007) Multidisciplinary rehabilitation and monodisciplinary rehabilitation for visually impaired adults. *Cochrane Database Syst Rev.*
32. Barker L, Thomas R, Rubin G, Dahlmann-Noor A (2015) Optical reading aids for children and young people with low vision. *Cochrane Database Syst Rev* 3: CD010987.
33. Goldstein JE, Chun MW, Fletcher DC, Deremeik JT, Massof RW, Low Vision Research Network Study Group (2014) Visual ability of patients seeking outpatient low vision services in the United States. *JAMA Ophthalmol* 132(10): 1169-1177.
34. Gillespie-Gallery H, Conway ML, Subramanian A (2012) Are rehabilitation services for patients in UK eye clinics adequate? A survey of eye care professionals. *Eye (Lond)* 26(10): 1302-1309.