Article • Portable Video Magnification Solutions for the Low Vision Prescriber

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ABSTRACT

Background: Video magnification (VM) is a useful tool often employed in low vision rehabilitation (LVR), particularly when conventional magnification options are unable to fulfill a patient's reading goals. VM offers an alternative solution to overcoming the limitations of traditional low vision (LV) aids. Portability is an important feature that can extend the use of these devices into multiple settings and tasks. As with any LV aid, every portable VM device will have pros and cons that should be considered when prescribing.

Case Reports: Five cases are discussed illustrating the application of a systematic approach to prescribing portable VM devices for LV patients with various levels of visual impairment. Standard measures of visual function, including visual acuity (VA), visual fields (VF), and contrast sensitivity, were reduced to different extents in each case. All patients communicated a chief complaint of decreased reading performance. Primary goals covered included spot reading, recreational volume reading, and vocational reading. These goals were all successfully met by carefully matching each patient's reading goals with a specific type and model of a portable VM device.

Conclusion: Handheld VM devices offer a portable and adaptable solution for addressing a LV patient's reading needs, thereby making these devices appealing to both the LV provider and the patient. However, with such a large array of portable electronic magnifiers available on the market, the task of prescribing the most appropriate device for the LV patient can be challenging. A systematic LVR approach assessing all of the factors that may influence a patient's success with a portable VM device can ease the selection process. This paper will provide an overview of the vast number of options of portable VM devices available, review the patient and device selection criteria utilized for determining the most appropriate one, and demonstrate practical application of these devices in LVR through case presentation.

Keywords: low vision, low vision rehabilitation, portable video magnification, video magnification

Introduction

Various treatment options are used in LVR to address the reading goals of the visually impaired. In general, these treatment modalities can be broadly divided into the following categories: optical aids, non-optical aids, and electronic assistive technology. Traditional optical aids include high-plus reading spectacles, handheld magnifiers, stand magnifiers, and telemicroscopes. Non-optical aids include tints, lighting, and typoscopes. In many cases, reading goals can be met by improving visual efficiency with the development of LVR compensatory strategies such as eccentric view (EV) training and prescribing conventional optical and non-optical devices. Furthermore, these traditional devices are often an ideal treatment choice for reading given their ease of use, portability, and lower cost. Nevertheless, there will be cases when conventional LV aids are not able to meet the LV patient's reading goals adequately. In such situations, electronic assistive technology can be a viable alternative solution.[1]

Electronic assistive technology includes computer magnification software, audiobooks or electronic books, wearable technology, and video magnification (VM), among others.[2] VM is one subcategory of electronic assistive technology employed in LVR to overcome some of the limitations of conventional LV aids. This digital solution uses a camera with an attached task light to project an image onto a screen or TV monitor.[1,3] The image on the screen can be enlarged and the contrast enhanced to facilitate reading. VM devices are available in both desktop and portable versions, depending on the needs of the patient. Desktop VM devices are meant to be used in one fixed location and often come with a stand-mounted camera. Such devices often integrate a reading X-Y table to move the document, so the desired text is displayed on the screen. However, they are typically large, bulky, and consume a lot of space, restricting their use to one place. On the other hand, portable VM devices offer a compact and lightweight option to meet reading needs both at home and on-the-go. For this reason, these transportable devices afford the opportunity to extend the use and benefits of VM into various settings, making them an ideal treatment choice for a particular subset of LV patients.[4]

There are several studies focused on the success of VM with respect to reading.[3,5] Many of them use reading speed as a primary outcome. Jackson et al. found that patients of similar age, VA, and contrast sensitivity exhibited faster reading speeds for both spot and continuous reading, on a desktop VM device versus traditional aids.[3] Additionally, a systematic review by Virgili et al. demonstrated with moderate-certainty evidence that reading stamina was longer when using a VM in comparison to conventional optical devices.[5] Although there is some proof to back the use of VM generally in LVR, there are fewer studies specifically focused on the portable subcategory. Much of the available research has been limited to older models of portable VM devices. On the other hand, the majority of the current research has been concentrated on tablet-based VM, especially using the Apple iPad.[6-9] While faster reading speeds have been observed using the iPad compared to traditional optical aids, Morrice et al. and Wittich et al. found no statistically significant difference in reading speeds with an iPad versus portable and desktop VM devices.[8,9] Even though there remains a lack of studies covering the extensive VM devices available on the market, the benefits of all types of VM cannot be overlooked.

Reading material comes in all different font sizes and contrasts often not visually accessible to the LV patient. However, VM can transform the small, poorly contrasting text into a visually discernible, high-contrast, enlarged image. VM also allows the LV patient to read at a more comfortable working distance while providing variable magnifications. This is especially beneficial when the level of magnification required to meet the demands of a reading task necessitates a very close and uncomfortable working distance with traditional aids. Furthermore, VM devices are typically more user-friendly and easier to learn than other types of electronic assistive technology. Nevertheless, they will still require more training and skills to operate them proficiently compared to conventional LV aids.[10]

Portable VM devices offer a transportable, ergonomic, and versatile solution for overcoming the limitations of conventional devices. As with any LV aid, there is a specific patient population best suited for these portable electronic devices. Matching a patient's reading goal with the best VM device model can be a challenging task for the LV provider, especially when a large array of portable VM devices is available. Careful consideration of the patient's goals, visual capabilities, and physical limitations in relation to the task requirements is necessary to ensure that the most ideal portable VM device has been prescribed. Furthermore, new portable VM devices are continuously entering the market as novel advancements in technology occur. Consequently, it is important that LV practitioners remain knowledgeable and up to date about current VM technology, as this will guarantee that their LV patients are being prescribed the most suitable and latest VM devices.

This paper presents an overview of the many options of portable VM devices available to prescribe and gives case-based guidance on when one device may prevail over another. The tables contained within the scope of this review provide a comprehensive but not all-inclusive list of portable VM options. Ultimately, this paper serves to provide the LV optometrist with guidelines to improve their confidence and increase patient satisfaction when prescribing portable VM devices.

Discussion

The purpose of LVR is to equip the visually impaired with the tools and strategies necessary to preserve independence. One skill area often negatively impacted by vision loss is reading. Reading is crucial for performing everyday educational, vocational,

recreational, and daily-living tasks. In fact, reading is the most sought-out activity of daily living (ADL) with which visually impaired patients request assistance from the LV provider.[1,5,11] Moreover, considerable evidence exists to support the benefit that LVR has on improving reading ability.[12]

A wide variety of LV aids is available, and these are often employed in LVR to assist the visually impaired with reading. Typically, reading goals are assessed with conventional optical and non-optical aids during a LV near evaluation. In many cases, these devices will be appropriate and meet the patient's reading needs. However, despite the employment of conventional aids, the patient may continue to experience difficulty. With a greater degree of functional vision loss, many of the traditional optical systems will require a very close and inflexible working distance, which may also reduce the reading field of view (FOV).[4] These systems are usually not ideal for patients with poor hand control or for those who are unable to maintain or adapt to a very close working distance. Similarly, while the application of conventional non-optical aids, such as lighting, anti-reflective coatings, and tints, may improve access to print for some, these interventions will likely not be adequate for LV patients with severe loss of contrast sensitivity.[1,13] In situations where conventional optics are unable to compensate adequately for the limitations of functional vision, VM offers a viable alternative solution.

VM devices provide several advantages compared to traditional aids. They offer a wide range of magnification levels that can be varied to accommodate specific task(s).[4] VM devices afford more flexible working distances and provide enhanced contrast by including multiple contrast and color options.[1] These devices also provide a larger FOV when compared to most optical aids of equivalent magnification.[1] Moreover, the advantages of VM go beyond improving accessibility of print, reading speed, or stamina to include the availability of special ancillary and advanced functions. Some of these helpful supplementary features include saving a photo for later reference, distance viewing with magnification, or text-to-speech, to name just a few.[1] Despite the many pros of VM, there are cons to these devices, the most significant of which is cost. Many also require a battery to operate and will therefore need time to charge. Additionally, even compact portable VM devices will still be larger and heavier than a traditional pair of reading spectacles. Furthermore, some patients may even experience nausea from the motion of the print on the screen.[1]

Before considering VM as an alternative option for reading, it is important to determine whether the patient is an appropriate candidate for this mode of treatment. The LV provider must be able to identify and to recognize ideal candidates, as this ensures that the patient will receive the most functional benefit and have continued success. Patients who are unable to meet their reading goals with traditional aids but who are motivated and have intact cognition are likely to be good candidates. VM devices require training, from the simplest device to the most complex. The patient must be willing and able to learn the skills necessary to operate the various features and functions and to care for the device properly, as well as demonstrate proficiency while using it. VM devices are not recommended for patients with cognitive impairment and/or poor memory. However, in cases of mild cognitive decline, with a motivated patient, choosing a simpler device with fewer buttons and settings may be still suitable. In addition, prior experience with technology, while not a prerequisite for VM device use, may be correlated with the complexity of the device prescribed and may suggest the amount of training that will be needed.

Selecting and prescribing the most appropriate VM device will largely depend on the task requirements dictated by the patient's specific reading goal(s) and the patient's level of visual function. The hallmark of all the devices included in this review is portability, which is perhaps the first task requirement to consider when deciding on the type of VM to prescribe. Desktop VM devices are large, bulky, and can only be used in a fixed location. Such devices would not be practical for patients wanting to read in multiple settings. Instead, these patients would be better served with a portable VM device. To complicate matters, the level and ease of transportability varies among the large array of portable VM devices available. The patient's goals should direct the LV provider as to the level of portability necessary. For example, if a patient needs a portable device to keep in their pocket for reading price tags and ingredient labels at the grocery store, then a small, lightweight portable VM device is indicated. On the contrary, if a patient is trying to read longer bodies of text or is planning to use the device in a school or vocational setting, then a larger VM device is more appropriate. In cases where larger portable VM devices are indicated, physical limitations to carrying these heavy portable VM devices should

be considered. Some companies may offer a rolling case for the devices to ease the transporting process.

Reading rate, or fluency, is a very important task requirement that plays a key role in the device-selection process. Every reading task has a defined rate of words per minute (wpm) that must be met to achieve fluency and success. Spot reading tasks, such as reading a price tag, menu, or medication bottle, can be accomplished comfortably and fluently with a minimal reading rate of about 40 wpm.[1,14] However, volume reading goals typically require a reading rate of at least 80-100 wpm, which is the equivalent of a 2nd grade reading rate.[1,14] Nevertheless, even when some LV patients achieve the required fluency for volume reading, they may still not be satisfied, especially if they are an avid reader or have vocational demands. This is likely due to the fact that more complex and long-term reading tasks typically necessitate a higher fluency defined by 160 wpm, which is the equivalent of a 6th grade reading rate.[1,14] This rate becomes even higher for vocational reading goals, and a rate of 250 wpm may be warranted.[1] With vision loss, it is quite common for LV patients to experience reduced reading rates.[15] Although it has been concluded that reading rates do not affect comprehension, LV patients will typically avoid reading if it is too tedious and slow due to frustration.[1,14,15]

There are several factors that can influence reading rates. The LV provider must be cognizant of these factors, as they influence reading performance and are adversely affected with impaired visual function. Visual span is the area around fixation within which characters can be recognized.[16] It has been shown that low contrast sensitivity reduces the visual span size and increases the fixation time required to recognize those characters; this in turn yields a slower reading rate.[13] Portable VM devices offer high-contrast reading modes, which create a contrast reserve positively impacting reading rate. The central 15-20 degrees of fixation is the most important area for reading.[1] Central VF loss has been shown to have a direct impact on reading fluency. Larger central scotomas typically result in the patient using a preferred retinal locus with greater degrees of eccentricity, thus yielding increasingly slower reading rates.[1,14,17] Likewise, peripheral VF loss encroaching on the central area of vision can also impact reading rates.[18] Despite the employment of LV aids with high-contrast settings and appropriate magnification, many LV patients will not obtain a level of fluency equivalent to that prior to their vision loss.[13] However, in many cases, LV aids can still help the visually impaired patient achieve an acceptable level of fluency with regard to their reading goals.

Special ancillary and unique features offered by the different types of portable VM devices are another important factor to consider when selecting a particular device. All portable VM devices offer standard CCTV functions; however, a few stand out because of distinctive features. If a certain function could be useful to a patient given their goals, then this step may help narrow the selection. Some of these features include line masking, OCR capability, and access to the internet. Although the primary use of portable VM devices is typically at near, some devices also offer a range of working distances. This affords the advantage of prescribing one device to assist with multiple tasks that would otherwise require the prescription of more than one LV aid. For example, a self-viewing mode provided by a certain portable VM device would allow the patient to meet not only their reading goals but also their self-care goals. Similarly, a student in a classroom setting will likely have a range of reading demands, which includes reading at their desk as well as reading the whiteboard. In such cases, a single portable VM device could satisfy multiple goals and simplify the LVR process.

Ultimately, the most appropriate portable VM device will need to compensate for the patient's visual limitations and address task requirements while complementing the patient's lifestyle. A balance must be struck between the size of the patient's functional VF, their preferred working distance, the screen size, the required reading rate, and the level of magnification required by the patient's VA. If the portable VM cannot adequately balance these factors to achieve the reading goal(s), the LV provider will need to consider other adaptations or alternative solutions. Lastly, cost may be a major barrier for prescribing and selecting a particular portable VM device. Portable VM devices can be an expensive rehabilitative therapy. Costs are drastically different among the devices, ranging from $300 to $4000 depending on the sophistication of the technology and the size of the device.[19] Financial assistance may be available through state-funded agencies, non-profit organizations, or the American Veterans Affairs Hospitals for US veterans.

The number of VM devices assessed during the evaluation should be limited to a few specific types and models best matching the patient's reading goal(s) and specific task requirements. This will ensure that the most appropriate VM device is prescribed, promote success, and prevent overwhelming the

Table 1. Handheld Video Magnifiers (parameters and specifications obtained from manufacturers' and vendors' websites)[20-55] (touchscreen)**

Company	Device	Screen Size (inches)	Magnification	Weight (ounces)	Battery (hours)	No. of Contrast Options	Save Pictures	Distance View	Self-View	Line Masking
Bierley	Maggie	5	3.5-7x	4.9	6.0	3				
Enhanced Vision	Pebble mini	3	3.1-10x	4.0	2.0	10+	+			
	Pebble HD	4	1.2-20x	7.2	2.5	10+	+			
	Amigo HD	7	1.4-25x	20.8	3.0	10+	+	+		
	UltraMag 5	5	2.0-30x	8.5	3.0	9	+	+		
Eschenbach	Mobilux Digital Touch HD *stand	4	Without base: 4.0-15x	8.0	3.0	5	+			+
	Smartlux Digital	5	1.7-12x	7.7	2.5	5	+			
	Visolux Digital HD	7	2.0-22x	16.0	3.5	10+	+			+
	Visolux Digital XL FHD	11	2.0-22x	37.0	2.5	10+	+			+
Freedom Scientific	Ruby	4	2.0-14x	7.7	2.0	5	+			
	Ruby HD	4	2.0-13x	8.0	2.0	10+	+			+
	Ruby XL HD	5	2.0-14x	10.5	3.0	10+	+			+
	Ruby 7	7	2.0-24x	18.0	4.0	10+	+	+		+
Humanware	Explore 3	3	2.0-16x	5.2	3.5	8				
	Explore 5	5	2.0-22x	8.0	3.0	10+	+			+
	Explore 8	8**	2.0-30x	20.8	4.5	10+	+			+
Optelec	Compact + HD	4	3.0-10x	8.9	3.0	5	+			
	Compact 6 HD *Speech: OCR	6**	0.5-21x	9.5	3.0	10+	+			+
	Compact 7 HD	7	2.5-30x	22.6	5.0	10+	+			
	Compact 10 HD *Speech: OCR	10**	0.5-22x	32.3	3.5	10+	+			+
Patriot Vision Industries	Patriot 7 FHD *Voice commands	7**	2.3-19x	15.5	5.0	10+	+	+		
	Patriot 10 HD	10	2.5-18x	24.0	4.0	10+	+	+		
Rehan Electronics	Looky	3	3.0-8x	7.0	1.5	3				
	Looky+	3	2.0-20x	7.0	2.5	5				
	Looky 4+	4**	2.0-20x	7.6	2.0	10	+			+
	Looky 5	5**	2.0-20x	10.5	3.0	10	+	+		+
	Looky 10	10	2.2-16x	23.9	3.0	10+	+	+	+	+
Sightcare	Clover 4	5	3.5-16x 2.5-24x	6.3	4.5	10+				
	Clover 5	5	4.0-20x 3.0-30x	7.4	3.0	10+				
	Clover 7s	7	2.2-16x	14.6	3.0	10+	+	+		+
	Clover 10	10	2.5-18x	23.9	3.0	10+	+			+
Zoomax	Snow	4	2.0-16x	7.2	3.5	10				
	Snow 7 HD Plus	7	2.5-19x	18.8	3.5	10+	+	+		+
	M5 HD Plus *OCR	5	2.3-16x	9.3	4.0	10+	+	+		+
	Luna 8	8	2.5-19x	17.6	4.5	10+	+			+
		4	2.0-19x	7.0	3.0	10+				

Table 2. Foldable Desktop Video Magnifiers (parameters and specifications obtained from manufacturers' and vendors' websites)[56-68]

Company	Device	Screen Size (inches)	Magnification	Weight (lbs)	Battery (hours)	No. of Contrast Options	Connect to Wifi	Save Pictures	Distance View	Self-View	Line masking	OCR
Enhanced Vision	Merlin HD mini	15	1.4-20x 2.0-32x 3.5-60x	10.6	5.0	10+		+	+	+	+	
		17	1.4-25x 2.3-35x 3.5-70x	12.0								
	Acrobat HD Mini Ultra (portable via rolling case)	13	1.3-65x	12.2	6.0	10+			+	+	+	
Freedom Scientific	Topaz PHD	12	1.7-24x	9.4	4.0	10+		+		+	+	
		15	2.3-31x	10.4								
	Topaz Ultra	15	1.4-20x 2.0-32x 3.5-60x	10.6	5.0	10+		+	+	+	+	
		17	1.4-25x 2.3-35x 3.5-70x	12.0								
Human-ware	Reveal 16	16	1.0-45x	14.1	5.0	10+		+	+	+	+	
	Reveal 16i			15.2			+					+
Low Vision Interna-tional	MagniLink One	17	1.7-45x	9.5	plug	10+						
	MagniLink Zip Premi-um FHD	13	1.1-35x	8.4	5.0	10+			+	+	+	
		17	1.4-45x	9.5	4.5	10+		+	+	+	+	
Optelec	ClearView GO	15	1.4-20x 2.0-32x 3.5-60x	10.6	5.0	10+		+	+	+	+	
		17	1.4-25x 2.3-35x 3.5-70x	12.0								
	Traveller HD	13	2.4-30x	4.4	4.4	2.0	10+		+			+
Sightcare	Clover Book Pro	12	1.0-60x	5.2	4.0	10+		+	+	+	+	+
Zoomax	Snow 12	12	2.5-19x	2.7	2.5	10+		+	+		+	+

patient. To simplify the comparison process, this review has sorted the most well-known portable VM devices into the following categories: handheld, foldable desktop, camera-only, and tablet-based (Tables 1-4). This is a comprehensive list but not an all-inclusive one.

Handheld VM devices represent category 1 and provide the best portability (Table 1). A smaller screen size allows for easy transport between the home, the store, and the workplace. Some devices in this category are quite simple to use with straightforward functions, while other devices offer more viewing options, such as distance view mode, saving pictures, and line masking. Category 2 consists of foldable desktop VM devices, which generally have the largest screens (Table 2). Larger screens are great for volume-reading goals requiring increased FOV and higher magnification levels. Since they are larger in size, they tend to be heavier and therefore less portable. However, many come with a case designed to be carried. Camera-only VM devices, which is category 3, are designed to be connected to a computer or monitor (Table 3). Many of the devices in this category include OCR with an auditory option. OCR is especially helpful in cases where the patient has high-volume fluency goals for prolonged periods of time and using vision alone would be inefficient and laborious.

Category 4 includes tablet-based VM devices, which offer the widest range of functionality (Table 4). Tablets offer most of the capabilities of a computer, including Wi-Fi and Bluetooth accessibility.

Table 3. Camera-Only Video Magnifiers (parameters and specifications obtained from manufacturers' and vendors' websites)[69-73]

Company	Device	Minimum Operating System Requirements	Magnification	OCR	Weight (lbs)	Save Pictures	Battery (hours)	Distance View	Self-View	Line masking
Enhanced Vision	Transformer HD	Windows 10 Mac Mojave 10.14 Chrome OS V73 Android OS 8.1 iPad OS 12	1.7-30x	+	3.4	+	2	+	+	+
Freedom Scientific	PEARL with Fusion	Windows 7-10	1.0-60x	+	2.0	+	USB			+
Low Vision International	MagniLink S Premium 2	Windows 7 Mac OS X 10.6 Chrome OS 59-85 Simple Monitor	1.1-75x	+	4.2	+	USB	+	+	+
	MagniLink Pro FHD TTS	Windows 7 Apple OS X 10.6 Chrome OS 59-85 Simple Monitor	1.1-70x	+	9.9	+	5	+	+	+
TrySight	ReadDesk	Windows XP	1.0-30x	+	1.5	+	USB			+

Table 4. Tablet-Based Video Magnifiers (parameters and specifications obtained from manufacturers' and vendors' websites)[74-79]

Company	Device	Tablet Included	Screen Size (inches)	Weight (lbs)	Battery (hours)	Magnification	Option of Stand	OCR	Distance View	Self-View
Humanware	Connect 12	Humanware tablet	12	4.3	7	1.0-24x	+	+	+	
Low Vision International	MagniLink TAB	Microsoft Surface Pro	12	6.4	3	0.7-8x	+	+	+	+
Patriot Vision Industries	Patriot VRM 12	Samsung Galaxy Tab A	10	1.3	13	2.0-60x	+	+	+	+
	Patriot Pro	Apple iPad Pro	12	5.9	14	1.0-80x	+	+	+	+
TrySight	Mercury 8	Samsung Galaxy Tab A	8	1.1	4	1.0-22x	+	+	+	
	Mercury 12	Microsoft Surface Pro iOS software	12	6.4	8	1.0-20x	+	+	+	

Unlike the other categories of portable VM devices, tablets are mainstream, and some patients may already own one or know how to use them. While a variety of apps are available for download onto a personal tablet, some LV vendors offer tablet-based systems that are inclusive of a tablet loaded with their proprietary magnification software and a tablet stand for ergonomic viewing comfort. For LV patients already owning a personal tablet, some vendors offer the option to load their software onto a capable personal tablet; however, often the accessory tablet stand will only fit the specific model of tablet included in the full system. These tablet-based systems are a more comprehensive option with robust functions and customizations, such as OCR with the option to follow along visually, contrast options, and voice recording. While downloadable apps can be useful for simple daily tasks, they do not offer the level of functionality of a tablet-based VM system. Therefore, device prescribing is dependent on the task requirement factors for the individual patient's needs. Wittich et al. found no statistically significant difference between reading performance with an Apple iPad Air versus the Optelec Compact 5 HD, which is a handheld VM device.[9] While equal in efficacy to a more traditional portable VM device and more sophisticated functionally, tablet-based VM devices are more recommended for patients who are very motivated and high functioning. If a tablet-based system is appropriate for the goals and cognitive ability of the patient, then training is warranted to facilitate learning of the robust accessibility functions and app(s). Morrice et al. demonstrated tablet-based systems were equal in effectiveness to desktop VM

devices for reading rehabilitation; however, prior use of the tablet, and therefore understanding of the device, proved to be an important factor in success.[8]

Once the LV practitioner has assessed all of the factors influencing device selection and has narrowed the choices, the next step is an in-office demonstration. The hands-on device evaluation entails demonstrating two or three appropriate devices and involves the patient choosing the final device. Often, patients may prefer one device over another similar device based on their subjective review of the optical quality, screen dimensions, ergonomics, ease of device manipulation, and unique functions. The patient may also feel more strongly about a particular device because of similarities to previous devices with which they have prior experience. A LV prescriber may not have a device in office that best fits the patient's needs. In these cases, the LV prescriber should use their best judgement to determine whether another device on the market would be more appropriate and, if so, would warrant a visit or loaner from a vendor for demonstration.

Due to the multitude of devices available on the market, the LV prescriber will not possess the entire possible inventory of portable VM devices in office. In general, it is helpful to have at least one device from each of the main categories (Table 1-4) of portable VM devices to meet a variety of patient goals. If the LV prescriber can stock further devices, then it is recommended to consider the patient population served at the clinic in question. For example, the population of LV patients at the West Haven VAMC are overwhelmingly geriatric patients having less experience with technology and in many cases less-demanding reading goals. To serve this population's reading needs better, the clinic has more handheld or foldable desktop VM demonstration devices in office rather than camera-only or tablet-based VM devices. If a specific device is not in stock, the LV prescriber can contact the local vendor affiliated with the VA to loan the device for a device demonstration. It is beneficial to develop relationships with vendors ahead of time for easier and quicker accessibility to the devices.

Portable VM devices are a unique and useful tool for LV providers. They can offer patients with reading goals a solution when they are unable to achieve those goals with traditional optical LV aids. Consideration of patient factors, visual limiting factors, and task requirement factors in a systematic sequence can help streamline the device selection process and improve outcomes for the LV provider and patients.

Case-Based Application

The following case presentations serve to demonstrate the application of a systematic LVR approach for addressing reading goals with the prescription of portable VM devices. Emphasis will be placed on both patient-centric factors and task-related factors, influencing the selection of a particular portable VM model. Keep in mind that although the portable VM devices discussed provide a representative model from the portable VM categories (Tables1-4), they are still only a subset of what is available to patients.

Case 1

An 89-year-old white male presented to the outpatient LV clinic at the West Haven VAMC seeking assistance with reading. His established ocular history was significant for non-exudative age-related macular degeneration (ARMD) category 3 OU, vitreomacular traction OS, and cataracts OU. The patient's pertinent medical history included Parkinson's disease with resting tremors; however, cognitive function was intact. Of note, the patient had undergone a comprehensive LV evaluation one year prior and was prescribed a 70% transmission gray-tinted single-vision reading spectacle with a 3x/12D ClearImage (CI) over OD and OS occluded.

At his LV exam, the patient complained of difficulty reading fluently with his current LV reading glasses. He also stated that when using his reading spectacles, he had to hold the material very close, and this was uncomfortable, as well as extremely difficult to maintain with his tremors. His primary goal was to be able to read various types of texts fluently, including the newspaper, engineering books, data sheets, and history books, both at home and on-the-go. The patient also communicated difficulties cutting his own fingernails and seeing his bingo cards when playing at the local community center. Additionally, he noted that when reading outside his home, ambient lighting could be too dim or too bright, making it more difficult to see.

Best-corrected VA (BCVA) in primary gaze, measured with the Feinbloom Acuity Chart, was 10/80 OD and 10/140 OS. With EV training, the patient achieved a BCVA of $10/40^{-2}$ with a 4 o'clock EV OD and $10/60^{-3}$ with a 7 o'clock EV OS. Contrast sensitivity was severely reduced to 0.9 log OD and OS, as measured using the Pelli-Robson contrast sensitivity chart. After a thorough tint evaluation, the patient preferred a 70% transmission gray tint, with which he was able to appreciate an additional letter

on repeat contrast sensitivity testing. He also noted subjective improvement in visual comfort with the tint.

Due to the patient not meeting his portable reading goals with conventional spectacles, VM devices were considered as a viable alternative treatment option. Patient-centric factors and visual-limiting factors, as well as reading-task-requirement factors, were carefully assessed and taken into consideration when selecting a device for this patient (Table 5). Although the patient had some experience with computer use, it was very basic and limited. Additionally, the patient had resting tremors and some dexterity concerns, but he had intact cognition and was very motivated. The patient was an avid reader prior to his vision loss, and his current reading goals required a high reading rate and fluency to be successful. A portable VM device with a larger screen that could accommodate more words at one time and OCR capability would ensure that the patient's lower and higher fluency demands would be met. However, the device could not be too large, inhibiting safe and easy transportation. Lastly, his secondary goals of cutting his fingernails and playing bingo cards could also be satisfied if the selected portable VM device provided enough space to fit his hand under the camera.

Within the sample of devices carried by the West Haven VAMC, the Snow 12 by Zoomax best fit the needs of this patient (Table 5). Most of the stocked devices within the handheld category (Table 1) do not provide OCR capability, except for the Optelec Compact 6 HD, which has a smaller screen size common to the handheld category and was not ideal for his fluency needs. Since this patient did not have much experience with technology and preferred to learn a device requiring minimal technological skills, a camera-only device (Table 3) and a tablet-based VM (Table 4) were not likely good options for this patient. However, several devices within the foldable desktop category (Table 2) provide both OCR and the larger screen that he needed to achieve all of his reading goals. The Snow 12 was demonstrated to the patient and ultimately prescribed with success.

Case 2

A 75-year-old white male presented to the outpatient LV clinic at the West Haven VAMC seeking assistance with reading. His established ocular history was significant for non-exudative ARMD category 4 OU and retinitis pigmentosa OU. The patient's pertinent medical history was significant for Guillain-Barré syndrome with mild tremors and diabetic peripheral neuropathy. At a previous comprehensive LV exam 4 years prior, the patient was given a reading spectacle with a +4.00 add and 75% transmission orange tint. However, the patient was lost to follow-up for 4 years and presented with a significant decrease in vision.

At this LV exam, the patient complained of difficulty reading fine print. He reported losing his prior reading glasses and presented to his exam using no current LV aids for reading. Due to the drastic change in his vision since his last LV exam, the previous reading glasses prescribed were no longer appropriate. A comprehensive LV exam was performed to establish his new baseline. The patient's primary goals included spot reading labels at the

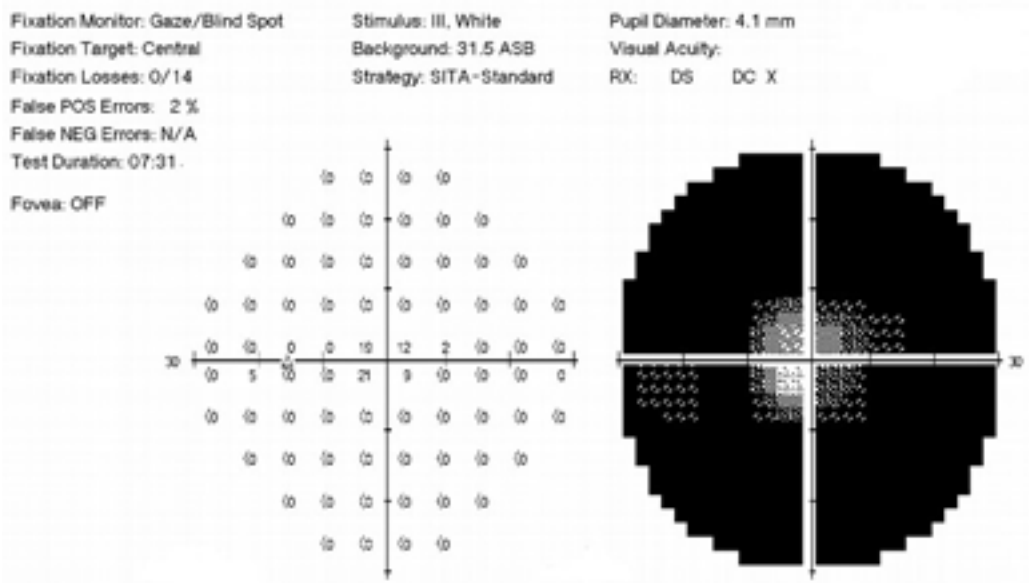

Figure 1. *Visual field for case 2*

Table 5. Factors Influencing Device Selection for Cases 1-5

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Patient Goals	-To read the newspaper, engineering books, data sheets, and history books fluently, both at home and on-the-go -To spot read his bingo card -To cut his own fingernails	-To spot read labels at the grocery store -To read menus at restaurants -To read brief notes from local society meetings he attended -To maintain visual reading status in public rather than use auditory aids	-To increase reading fluency -To see the whiteboard in the classroom -To type her notes in class	-To spot read labels on food items at the grocery store, including items on higher shelves out of reach	-To read the newspaper and magazines
Patient Factors					
Reading goals not met with conventional LV aids	+	+	+	+	+
Motivation	+	+	+	+	+
Intact cognition	+	+	+	+	
Physical limitations	+	+	+		+
Cost					
Limited space availability					+
Prior technology experience		+	+	+	
Visual Limiting Factors					
Visual acuity (VA)	+	+	+	+	+
Peripheral field loss		+	+	+	+
Contrast sensitivity	Severe	Profound	Moderate	Moderate	Moderate
Task Requirement Factors					
Importance of portability	+	+	+	+	+
Spot reading	+	+		+	
Prolonged reading	+		+		+
Reading rate required (different rates for different goals)	40 wpm >160 wpm	40 wpm 8 0-100 wpm	160 wpm >250 wpm	40 wpm	80-100 wpm
Working distance: Near and intermediate				+	
Special function	OCR Able to fit hand under camera to cut fingernails		OCR Distance viewing	Near and intermediate viewing distances	Scrolling
Patient preference:		Device with a handle			

grocery store and menus at restaurants, as well as reading brief notes from local society meetings.

BCVA in primary gaze, measured with the Feinbloom acuity chart, was light perception OD and 10/600 OS. With EV training, the patient achieved a BCVA of 10/80 with a 3 o'clock EV OS. Contrast sensitivity was profoundly reduced to 0.15 log OS, as measured using the Pelli-Robson contrast sensitivity chart. VF in the OS showed 360 degrees of severe constriction, sparing a small central island of vision approximately 6 degrees in extent (Figure 1).

Since the patient was unable to meet his spot-reading goals with conventional reading glasses, VM was considered as a possible option. Patient-centric factors and visual-limiting factors, as well as reading task requirements, were carefully assessed and taken into consideration when selecting a device for this patient (Table 5). Visual-limiting factors for this patient included reduced VA, profoundly reduced contrast, constricted VFs, and monocular status. The patient was very motivated to read visually, rather than auditorily, especially in public settings. He was willing and cognitively able to learn. Additionally, he was technologically savvy, having experience using an iPad for both recreational and prolonged volume-reading goals. However, the patient required a smaller and more compact portable device with

a pop-up stand and/or handle option for easier use while on the go.

Within the sample of devices carried by the West Haven VAMC, the Explore 5 by HumanWare and the Ruby XL by Freedom Scientific best fit the spot-reading needs of this patient (Table 6). Due to the importance of size and portability for him, the most appropriate device would need to be a compact and lightweight handheld VM, represented in Table 1. Although the patient was technologically savvy, he was already using an iPad visually and auditorily for his prolonged reading demands and needed a smaller handheld device to use on-the-go. Of note, the patient had mild hand tremors, but this did not interfere with his ability to stabilize a handheld device. After device demonstration, the patient preferred the optics, screen size, and pop-out handle of the Ruby XL, and this device was prescribed successfully.

Case 3

A 35-year-old white female was admitted to the Eastern Blind Rehabilitation Center (EBRC) for the inpatient comprehensive LVR program. She was interested in attending school to pursue a career. Her established ocular history was significant for autosomal dominant optic atrophy OU. The patient's pertinent medical history was significant for back pain and De Quervain's tenosynovitis of the wrist.

At this LV exam, she reported that she was able to read with her current reading spectacles, consisting of a +5.00 add with a total of 1.5 prism diopters (pd) base-in prism OU and an 80% transmission orange tint. However, she would require optimal fluency to accomplish the reading demands of collegiate-level courses. Of note, the patient was technologically savvy with her smart phone and was interested in using advanced technology to assist with her classroom needs. Additionally, she reported that her vision and comfort were greatly affected by ambient lighting, as well as the various contrasts and finishes of the different reading materials. Glossy finishes tended to increase glare and were extremely problematic for her when reading. The patient's primary goals for school were to increase her reading fluency and to ensure her ability to see the whiteboard and type her notes efficiently during class.

BCVA in primary gaze measured with the Feinbloom acuity chart was 10/350 OD and 10/400 OS. With EV training, the patient achieved a BCVA of $10/30^{-2}$ with a 4 o'clock EV OD and $10/80^{+2}$ with an 11 o'clock EV OS. Contrast was moderately reduced to 1.2 log OD and OS as measured by the Pelli-Robson contrast sensitivity chart. The patient was cognitively able and very motivated to learn LV strategies to allow her to return to school and enter the work force again.

Since the patient would not meet her optimum fluency reading goals with conventional reading glasses, VM devices were considered as a viable additional treatment option. Patient-centric factors and visual-limiting factors, as well as reading-task-requirement factors, were carefully assessed and taken into consideration when selecting a device for this patient (Table 5). Collegiate-level classes require an optimum level of fluency, which is typically >250 wpm, to meet the reading demands. Since this patient was planning to use VM in a collegiate classroom setting, a tablet-based device was recommended (Table 4). With a tablet-based VM device, she would be able to access the internet, type her notes via a Bluetooth keyboard connection, and download any additional apps for learning or recreation. A tablet-based system would allow her to accomplish a variety of visual tasks while still offering easy portability between the classroom, library, and home settings. OCR functionality would also be necessary for this patient to assist with the extensive high-volume reading demands for prolonged periods of time.

This patient presented to the EBRC with a unique situation and goals requiring sophisticated technology. The local vendor affiliated with the VA was contacted for an in-office device demonstration. The following portable VM devices were deemed most appropriate for the patient's goals: Patriot Pro by Patriot Vision Industries, Reveal 16 by HumanWare, Connect 12 by HumanWare, and Magnilink TAB by Low Vision International. After demonstration, the Patriot Pro was lacking functionality for distance goals, and the Reveal 16 was deemed to be too heavy for the patient's smaller stature and physical limitations. Of note, the patient took public transportation to her classes and needed to carry this device, along with her backpack, throughout the day. The patient appreciated both the Connect 12 and Magnilink TAB, but the latter device gave the patient the ability to record lectures. The Magnilink TAB was prescribed, and the patient was fully trained on the device to use it efficiently and successfully in school.

Case 4

An 81-year-old white male was admitted to the EBRC for the inpatient comprehensive LVR program. His established ocular history was significant for exudative ARMD OU. The patient had no incoming

pertinent medical history for cognitive or physical limitations.

At the initial LV assessment, he reported difficulty reading with his current amber-tinted +3.00 add reading spectacles prescribed by an outside VA. The patient admitted that he did not read often, but the small font on food packaging, medicine bottles, and price tags was difficult to discern even with his illuminated handheld magnifier 10X/38D. He further explained that food items on higher shelves were not within reach, and he would like to see these labels as well.

BCVA in primary gaze, measured with the Feinbloom acuity chart, was 10/200^{+} OD and 10/225 OS. With EV training, the patient achieved a BCVA of 10/80^{+} with a 12 o'clock EV OD and 10/100^{+} with a 12 o'clock EV OS. Contrast was moderately reduced to 1.35 log OD and OS as measured by the Pelli-Robson contrast sensitivity chart. A tint evaluation was completed, and the patient preferred an 80% transmission amber tint, which subjectively improved contrast.

Due to the patient not meeting his portable spot-reading goals with conventional glasses or a handheld magnifier, VM devices were considered as a viable alternative treatment option. Patient-centric factors and visual-limiting factors, as well as reading-task-requirement factors, were carefully assessed and taken into consideration when selecting a device for this patient (Table 5). The patient was motivated and able to learn a new device; however, he had no prior experience with technology such as smartphones or computers. Due to his portable near and intermediate spot-reading goals, a VM device providing greater flexibility in working distances would best address his needs. Additionally, the device needed to be compact and lightweight to increase portability so that this patient could comfortably carry it around the grocery store. Based on BCVA, the patient should require higher levels of magnification that may be better served with a larger screen/larger FOV. However, since his main goals are mostly for spot-reading tasks, which require a minimal reading rate, a smaller screen size should be sufficient to achieve his spotting goals and provide increased portability.

A device from the handheld category was most appropriate for this patient based on portability, size, and simplicity (Table 1). When looking at the handheld VM devices, intermediate distance viewing is not a feature included on every device. Viewing prices and items on shelves at the grocery store would require a 2- to 5-foot intermediate viewing range. Among the devices fitting the needs of this patient, the Amigo HD by Enhanced Vision and the Ruby 7 by Freedom Scientific were demonstrated to the patient. The patient preferred the Amigo HD device, and the device was trained and dispensed.

Case 5

An 89-year-old white male presented to the outpatient LV clinic at the West Haven VAMC seeking assistance with reading. His established ocular history was significant for severe POAG OU and branch retinal vein occlusion (BRVO) OS with persistent macular edema. The patient's medical history was significant for mild Alzheimer's disease with hand tremors. The patient was accompanied to this exam by his wife, who would provide limited help to the patient for ADLs. One year prior to this exam, the patient was given a non-tinted binocular reading spectacle with a +2.50 add from his primary eye care doctor.

At this LV exam, the patient reported blurry vision with his current reading glasses. The patient shared that his primary goals were to read the newspaper and magazines comfortably. A near evaluation for plus reading spectacles showed limited improvement because the patient was unable to maintain the proper working distance due to his hand tremors. In addition, he noticed that lighting affected his ability to read, and he noted a variety of lighting levels in both his home and on-the-go. Of note, the patient and his wife expressed concern for the size of additional reading devices due to limited space availability in their home and preferred a more compact device to address his goals.

BCVA measured on the Feinbloom acuity chart was 10/25^{+} in primary gaze OD and 10/30^{-} in primary gaze OS. VFs were constricted 360 OU, with 6 degrees of remaining FOV temporal to fixation OD and 2 more peripheral islands of vision temporally and nasally (Figure 2). A 24-degree FOV temporal to fixation OS with an arcuate island of vision superior temporal peripherally was remaining. Contrast sensitivity was moderately reduced to 1.05 log OD and OS, as measured by the Pelli-Robson contrast sensitivity chart. The patient noted subjective improvement with a gray 70% transmission tint.

Due to the patient not meeting his reading goals with conventional reading glasses or other LV aids, VM devices were considered as a viable alternative treatment option. Patient-centric factors and visual-limiting factors, as well as reading-task-requirement factors, were carefully assessed and taken into consideration when selecting a device for this patient

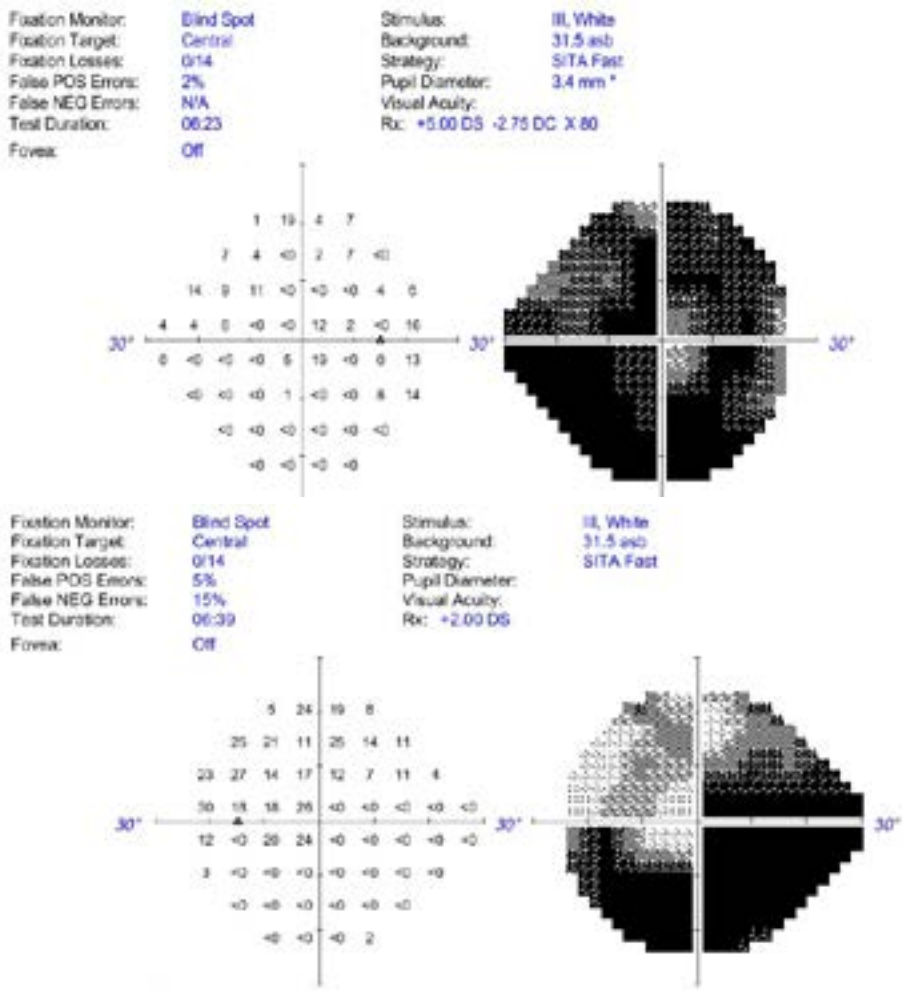

Figure 2. *Visual field for case 5; OD (top)/OS(bottom)*

(Table 5). Although this patient presented with mild cognitive impairment, he was a relatively high-functioning patient with a strong support system. While the patient had some experience with computer use, his use of technology was limited. Additionally, the patient had hand tremors, with accompanying concern for holding a device or moving a device smoothly across a page, but he was motivated to read. Due to the limited space in the patient's home, along with the patient's reduced functional VFs, a smaller device was warranted. Since portability and size were a priority, a device from the handheld category was deemed most appropriate (Table 1). Furthermore, the patient was interested in reading longer paragraphs of continuous text fluently, which demands a larger screen size from a handheld VM device.

Out of the available devices at the West Haven VAMC, the Visolux XL FHD by Eschenbach and the Explore 8 by Humanware fit the needs of the patient best. The patient preferred the larger screen size of the Visolux XL FHD, as well as the scrolling feature, allowing him to maneuver the device on the page less frequently. In addition, the patient had experience with the pinch-to-zoom function of an iPad and appreciated this function on the Visolux XL FHD as well. The Visolux XL FHD was prescribed, and both the patient and his wife were trained on the device in the event that he was physically or cognitively unable to set up the device independently.

Conclusion

Portable VM can be life-changing for those living with visual impairment, and it starts with appropriate prescribing by the LV optometrist. A comprehensive assessment of patient factors, visual-limiting factors, and task-requirement factors can increase success using VM. When the LV provider encounters a patient who is unable to meet their defined reading goals with conventional LV aids, VM can be considered as an alternative treatment given that the patient is a good candidate. An ideal candidate will be motivated and able to learn a new device. The LV provider can then consider visual-limiting factors such as VA, VF, and contrast sensitivity. The patient's goals will also present task requirements to consider when choosing the final devices to trial, such as desired fluency, the

importance of portability, and the required working distance. While portable VM devices can provide improved contrast, variable magnification, and a more comfortable working distance, these devices can also be more expensive and will require time to charge before use. VM is a useful and worthwhile treatment option for a subset of the LV population, making it an essential management tool for the LV provider to understand.

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