Low Vision and Methods of Rehabilitation: A Comparison between the Past and Present

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Background: The aims of this study were to determine the clinical effectiveness of optical and video low vision aids (LVA) and analyze the characteristics of the visually impaired at the low vision clinic of Chang Gung Memorial Hospital.

Methods: The use of LVA to improve distance and near visual functions was evaluated in 203 new patients from 1998 through 2001 at our clinic. The age, gender, visual status, and primary condition causing low vision of the patients were also compared with data obtained from two different study periods, from 1984 through 1987 and 1991 through 1994.

Results: After careful refraction, spectacles only were able to meet both distance and near visual requirements in 21 patients (10.3%), and among them, 3 patients with hemianopsia were further prescribed Fresnel prisms. Of the 121 patients with distance visual requirements, 84 (69.4%) benefited from using telescopes; however, only one additional patient benefited from the addition of a head-mounted device. Of the 136 patients who could not read the newsprint, 118 (86.8%) succeeded in reading newsprint using optical magnifiers, and up to 125 (91.9%) with using the addition of a closed circuit television. Compared with the previous data, the average age of our patients has steadily increased, and the main cause of ocular pathology has changed accordingly.

Conclusion: Video magnifiers provided suitable rehabilitation for some patients who failed to see clearly using optical magnifiers. However, most of our low vision patients, who have changed during the last decades, can accomplish their desired visual tasks using traditional LVA.

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Key words: **low vision, low vision aids, closed circuit television, head-mounted device.**

Low vision is not a diagnosis but a consequence of irreversible ophthalmologic or neurological disorders that result in reduced visual function bilaterally. It is most commonly described in terms of remaining visual acuity (VA) and visual field (VF). The World Health Organization (WHO) has divided low vision into three categories: 1) moderate visual impairment: best corrected visual acuity (BCVA) of less than 20/60, 2) severe visual impairment: BCVA of less than 20/160 or VF diameter is 20° or less, and 3) profound visual impairment: BCVA of less than 20/400 or VF diameter is 10° or less.[1] Those with BCVA less than 20/1000 are nearly blind or blind, and they are suggested to receive different rehabilita-

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tion, such as Braille, audio devices, vision substitutions, and orientation and mobility training.[2]

Low vision is a common physical impairment for which the patient needs assistant in activities of daily living. It can occur at any age, but its prevalence increases with age. For people older than 65 years, 7.8% have moderate or more marked visual impairment, and for those 85 years and older, the prevalence reaches 25%.[3] Although some low vision patients may successfully minimize the impact of their vision loss without rehabilitation, most have abandoned reading and relinquished independence in their daily activities and rely on others. They often become socially isolated. Even their health may be compromised when they cannot recognize medications or read labels.[4]

Rehabilitation training teaches patients with low vision how to use residual vision and provides patients with many practical adaptations for activities of daily living. Low vision aids (LVA) that maximize available vision play a major role in low vision rehabilitation.[2] Among them, optical devices are the most widely used. Unfortunately, they are task specific, and the patients may need several different aids to deal with a variety of requirements.[5] Recently, a new breed of technology has been introduced and seemingly offers a number of distinct advantages over conventional LVA.

Complementing the traditional "low vision tool box" of magnifiers, telescopes, and absorptive filters, the new adaptive technology incorporates microcameras, computer chips, virtual reality, and even global positioning systems.[6] For example, the electronic magnification system such as closed circuit televisions (CCTV) can provide high magnification with good contrast at a normal viewing distance using both eyes.[5] Furthermore, a head-mounted devices (HMD) that incorporates video magnification in a virtual reality-type format combines the advantages of the CCTV and the portability of optical magnifiers.[6] With the recent introduction of the Magni-Cam TRIAD (a CCTV system) and Jordy (a HMD system) in our clinic, the first purpose of this study was to evaluate their clinical effectiveness. Secondly, since the inauguration of our low vision clinic, we have noted some temporal differences among the visually impaired patients during the last two decades.[7,8] In this paper, we also analyzed the changes in the characteristics of our low vision patients by comparing with patients from two previous studies at the same clinic.

METHODS

We retrospectively reviewed 203 consecutive, newly referred low vision patients, who had received rehabilitation at our clinic from January 1998 through June 2001. Data obtained from the patient files included age, gender, diagnosis, visual function, and types of LVA prescribed. The data were compared with those obtained from two different periods, from 1984 through 1987 and 1991 through 1994, in two retrospective studies at the same clinic.[7,8] Our recent strategies for low vision examinations, as described in Fig. 1, focused on determining visual

Newly referred patients

↓ **Detailed ophthalmic examination**

1. Careful refraction
   BCVA ≥ 20/50 → ordinary spectacles (including regular bifocals)
2. Contrast sensitivity
   decreased → lighting and contrast enhancement
3. Visual field
   decreased → visual field expander trial

↓ **Low vision aids trial (BCVA < 20/50)**

1. Distance visual requirement
   * telescope trial
   → video HMD trial
   (criteria of success: meet patient's goal or read the equivalent of 20/50)

2A. Near-acuity test
   * approach magnification
   * optical magnifiers trial
   * CCTV trial
   (criteria of success: recognize newspaper print = 10 points*)

2B. Reading speed test: to decide the type of magnifiers

3. Other adaptive and non-optical aids trial

↓ **Training in adaptations for activities of daily living, and counseling.**

Note: Points are a printer's unit. Typically, 1 point line height = 1/72 of an inch, for example, 1 point x-height = approximately 1/144 of an inch.

Fig. 1 Flowchart of our low vision rehabilitation strategy

performance and included measuring BCVA, contrast sensitivity, and VF, as well as testing reading speed. Patients with decreased contrast sensitivity were suggested to use optimal lighting, including magnifiers with built-in light sources, electronic magnifiers, proper selection of written material, photocopied reproductions or bold-print reading media. To get a better comparison between optical and video LVAs, we coordinated the ambient lighting to achieve the maximal efficiency of each LVA for each patient during the following trials. Those with severe visual field defects (hemianopsia or VF $< 10^{o}$) used visual field expander, such as reversed telescopes, mirrors, or Fresnel prisms.

Only patients with distance VA < 20/50 in the best eye, or those unable to read normal newspaper print using ordinary reading glasses were included in this study to assess the efficacy of LVA. For distance visual requirements when someone could benefit from a telescope for general spotting but had no clear goal, we prescribed a telescope with the power (up to 10¡) that would allow him or her to read at approximately 20/50. For those who failed to meet our criteria or those who were unsatisfied with optical telescopes, video HMDs such as the Jordy (Enhanced Vision Systems, USA) with magnifying power of up to 24¡ were tried. For near reading, our criteria of success was being able to read 10-point newspaper articles with or without magnifiers (approach magnification). Three major types of optical magnifiers (maximal magnifying power 22¡), including high-plus spectacles, hand-held magnifiers, and stand magnifiers, were tried and then prescribed according to patients' reading efficiency or their preferences. Similarly, for those who failed to read the newspaper or read slowly with optical magnifiers, CCTV systems with 17" monitors (up to 34¡ magnification): either a stand-alone unit, or Magni-Cam TRIAD (Innovations Inc, USA) were also tried.

Some but not all of the patients who were satisfied with or succeeded in using optical LVA were also tested using video LVA. However, due to the high cost and other reasons mentioned below, some patients hesitated or refused to try video LVA. Therefore, we only analyzed the success rate of video LVA among those who failed to use optical LVAs to examine the clinical effectiveness as "second-line" aids. Other LVAs suggested for activities of daily living also included non-optical and adaptive equipment such as typoscopes, large-print reading material, large-button telephones, and absorptive filters. During our rehabilitation process, upon recognizing the emotional impact of vision loss or the concurrent medical problems, consultations with psychiatrists, occupational therapists, or physical therapists were also suggested. The overall goal of our rehabilitation was to recapture, strengthen, and maintain self-confidence for the safe and independent functioning in activities of daily living.

RESULTS

There were 132 male patients and 71 female patients (M/F ratio: 1.86) in this study (1998-2001). Compared with our previous data,[7,8] the M/F ratios were 1.61 (53/33) and 1.21 (82/68), respectively, from 1984 through 1987 and from 1991 through 1994. It is apparent that our clinic always has more male patients than female patients. The age of the 203 patients varied from 5 years to 89 years with an average of 38.8 years (standard deviation 25.4 years). As shown in Figure 2, the ages of our patients steadily increased, with the percentage of patients over the age of 65 years increased and that under the age of 20 years decreased gradually from the mid-1980s to late-1990s.

In this study, the main causes of visual impairment in decreasing order were age-related macular degeneration (14.3%), degenerative myopia (11.8%), retinitis pigmentosa (8.9%), and diabetic retinopathy (6.4%). Other etiologies included: optic atrophy (5.9%), cataract (5.9%), glaucoma (5.4%), macular dystrophy (4.9%), albinism (3.9%), and others (less than 3%): aniridia, corneal opacity, Stargart disease, microphthalmos, cerebral vascular accident, amblyopia, retinopathy of prematurity, retinal detachment, macular hole, and persistent hyperplasia of primary vitreous. Table 1 shows that the rates of presentation of the major causes of visual impairment during the different study periods at our clinic has changed.

Figure 3 shows the distribution of the distance BCVA of the best eye in this study and in two previous studies. According to the WHO standards, 28 patients (13.8%) had mild visual impairment, 55 patients (27.1%) had moderate visual impairment, 87 patients (42.9%) had severe visual impairment, 21

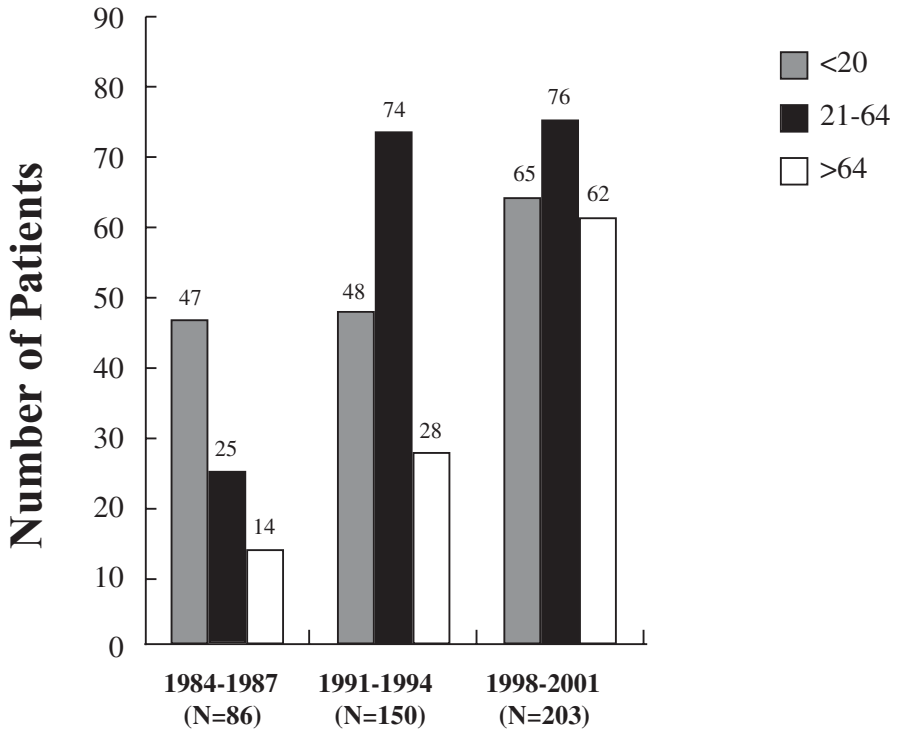

Fig. 2 Age distribution of low vision patients

Table 1. Main Causes of Visual Impairment of the Low Vision Patients

	1984-1987 (N = 86)		1991-1994 (N = 150)		1998-2001 (N = 203)	
1.	RP	(12.8%)	RP	(16.0%)	ARMD	(14.3%)
2.	Macular Dystrophy	(10.5%)	Degenerative Myopia	(14.0%)	Degenerative Myopia	(11.8%)
3.	Degenerative Myopia	(10.5%)	ARMD	(11.3%)	RP	(8.9%)
4.	ARMD	(9.3%)	Diabetic Retinopathy	(7.3%)	Diabetic Retinopathy	(6.4%)

Abbreviations: RP: retinitis pigmentosa; ARMD: age-related macular degeneration

patients (10.3%) had profound visual impairment, and 12 patients (5.9%) were nearly blind in this study. Overall, the conditions of visual acuity in this study were slightly better than those in our two previous studies.

Table 2 shows the major types of LVA prescriptions used. After careful refraction, ordinary spectacles only were able to meet both distance and near visual requirement for 21 patients (10.3%), and among them 3 patients with homonymous hemianopsia were further prescribed the use of Fresnel prisms to enhance their visual fields. Reversed telescopes

Table 2. Overall LVA Prescriptions

Types of LVA	No. of patients (Percentage)
Spectacles only	18 (8.9%)
Fresnel Prism	3 (1.5%)
Telescopes only	27 (13.3%)
Magnifiers only	67 (33.0%)
Distance and Near Aids	58 (28.6%)
Failure	30 (14.8%)

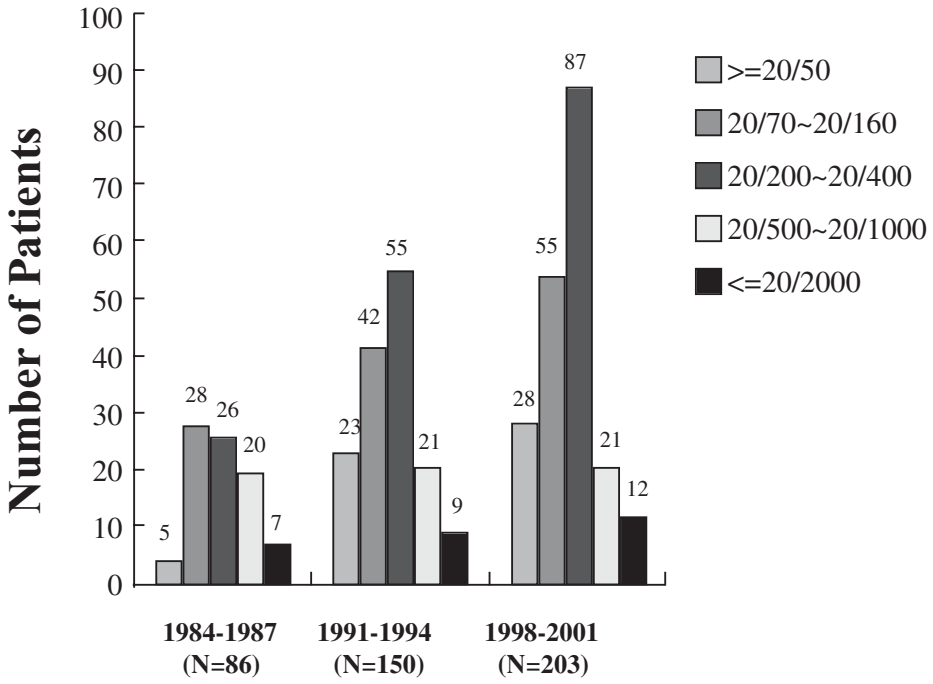

Fig. 3 Best corrected visual acuity distribution of low vision patients

and mirrors were rejected by these three patients due to the inconvenience or obscuring of the remaining VF. Other patients with both VF defects and poor visual acuity were unable to receive VF expanders, which expand VF by further decreasing visual acuity. Of the 121 patients with distance visual requirements, 84 (69.4%) benefited from the use of telescopes (up to 10¡ magnification) for general spotting or reading the equivalent of 20/50 or better. Those who failed in a distance vision test with optical aids were further tested using Jordy with magnification power up to 24¡ . However, only one additional patient benefited and was able to see smaller targets. During testing using Jordy, some patients complained about the weight of the headset, the appearance, the complexity of operation, and the problems with motion sickness and claustrophobia. Of the 136 patients who could not read the newsprint even when approaching to the text, 118 (86.8%) succeeded in reading it with optical magnifiers, and up to 125 (91.9%) with the addition of CCTV. The remaining 30 patients who failed to benefit from the use of either telescopes or magnifiers were due to hand tremors or head instability (43.3%), severe VF defects (33.3%), or lack of motivation (23.3%).

Those who could read the newspaper using near aids received further testing of their reading speed using different types of magnifiers to determine the best ones. Some patients were prescribed more than one type of magnifier (including CCTV); however, the major types of optical magnifiers prescribed in order were: high-plus spectacles (39.8%), stand magnifiers (31.4%), and hand-held magnifiers (28.8%), respectively.

DISCUSSION

In this study, we collected the demographic data of our low vision patients from 1998 through 2001, and analyzed their temporal changes when compared with the patients of the two previous studies[7,8] at our clinic. These results clearly demonstrated the changing face of our low vision patients over the last two decades. Of particular importance was that both the

average age of our low vision patients and the proportion of those aged above 65 years steadily increased. This trend was similar to that in western countries,[9,10] except that the majority of our patients were still under the age of 65 years. The female predominance found in low vision populations of industrialized nations was noted and was explained by the fact that women live longer.[9-11] While our low vision population was male predominant, as in other developing countries,[12,13] which probably reflects the need of visual aids in young low vision males, or the fact that more suffering of visual impairment in young males.[10,14] Actually, even in the industrialized countries, it is also interesting to note a male predominance in the young low vision population (age <60 years).[9,10]

The primary causes of visual impairment in the industrialized countries in decreasing order were ARMD, glaucoma, diabetic retinopathy, and cataract.[10,11] There was a similar trend of increasing the proportion of age-related degenerative diseases in the primary ocular pathologies among our low vision patients, which was compatible with the gradual increase in age of these patients. Nevertheless, it is important to note that degenerative myopia constituted a substantial proportion of the etiologies of the visually impaired in our clinic. This fact also reflects a serious problem of myopia in Taiwan.[15] It is well known that the prevalence of myopia in Asian countries especially in Taiwan has increased every year. The prevalence of high myopia at the age of 18 years was as high as 20% in girls and 12% in boys,[15] and some of them will become low vision population and need rehabilitation. Further study is needed to see whether the present strategy to prevent myopia progression is effective in preventing this problem.[16]

For more than 15 years, Chang Gung Memorial Hospital has been the only medical center in Taiwan that has provided low vision rehabilitation with a large variety of optical LVA.[7,8] We have shown that 85% of the low vision patients can benefit from our LVA prescriptions.[8] However, some patients discontinue use of LVA because of the ergonomics of the devices, frustration with the optical limitations, or in some cases users obtain another device or solution to the problem.[17] Research has shown that a patient's age and the visual acuity achieved are not predictive of their continued use.[5,17] Therefore, in this study, we also adopted reading speed test, which simulates use in the real-world of the low vision.[18] Successful reading with magnifiers requires coordination of eye, hand, and head movements.[19] It is reasonable that the main reason for failure of LVA prescription in this study was hand tremors or head instability. In addition, even with the more strict definition of success we obtained a high success rate on traditional LVA prescription when compared with the results of our previous studies. This is probably related with our increasing experience, or the overall better visual status in our present low vision patients.

Low vision devices have traditionally relied on optics to maximize available vision.[2] These conventional aids are popular because they are usually inexpensive, portable, and provide adequate magnification for many people with mild or moderate vision loss.[2,5] However, optical magnifiers also have drawbacks, such as restricted power of magnification, lack of contrast reversal, and ergonomic problem in keeping appropriate distance and alignment.[5] Video magnifiers including CCTV and HMD were designed to overcome the limitations of optical magnifiers.[5,6] Although HMDs are potentially useful aids for the visually impaired, there has been very little research on their effectiveness.[20,21] In a preliminary study of low vision students living in a residential school, HMDs improved acuity and contrast sensitivity, prevented glare, and enhanced performance of near, intermediate, and distant tasks, including mobility.[20] However, there were no comparisons with optical aids in that study. Another study suggested that the restricted range of magnification may limit the usefulness of HMDs in reading for patients with very low acuity.[21] In our study, we were surprised at the similar effects of the maximal magnification power of Jordy and of an optical telescope. The discrepancy between the expected (24¡) and the observed (10¡) improvement in a distance vision test was probably related with the poor spatial resolution of the camera, or the floor effect, under which the maximal resolution of its display is approximately 20/100, thus, people with acuity better than 20/100 might not benefit from using HMDs.[21]

Unlike HMDs using new adaptive technology, CCTV has been used to aid low vision persons since 1970s.[6] However, just as the early console-model televisions ultimately gave way to portable and even

Walkman televisions, new CCTV low vision devices are making early models seem primitive. Today at least four different types of CCTV systems are available including the stand-alone units, typically with 14" to 20" monitors and camera held over a viewing table, portable hand-held micro-cameras, about the size of a computer "mouse", which can be linked to the patient's regular television or a portable flat screen, spectacle CCTV systems, such as HMDs, and computer-interface CCTV.[6]

Due to the drawbacks of HMDs mentioned above, during our near-reading tests, we did not include the head-mounted displays, which can be used for both distance and near tasks. In this study, a 17" TV monitor, either in a stand-alone unit or connected with a portable hand-held micro-camera (Magni-Cam TRIAD), was used in our CCTV system to compare with optical magnifiers. It was not surprising that CCTV helped more low vision patients than optical magnifiers did, because it provided a large range of magnification levels, wide field of view, good illumination, freedom to vary head position, and control of contrast polarity.[21] In addition, it could be used for writing. The major limitation of CCTV is that most of them are not portable. An additional limitation of HMDs and CCTV is their cost. Therefore, optical LVA are still the primary consideration of the present low vision rehabilitation in our clinic. We also found that most our patients especially the older ones preferred simple rather than complex LVA. It was estimated that 82% of low vision patients used optical aids as their preferred magnifiers. Other factors which may influence the choice towards simple aids were availability, less training required, and ease of prescribing.[22] Therefore, the current video magnification systems, especially HMD, are likely to be suitable for only a minority of patients with low vision.

Conclusions

Because the life expectancy is steadily increasing worldwide, there is an increasing need for eye-care personnel to undertake primary low vision care. Our study showed that with appropriate rehabilitation, most of the visually impaired could lead to successful independent lives with the help of optical LVA and CCTV.

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低視能及復健方法：過去與現在之比較

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背 景： 探討長庚醫院低視能病人的特性，及各種低視能輔具的臨床價值。

方 法： 我們收集自西元1998至2001年期間，共203位低視能初診病人的資料，評估其使用低視能輔具的成功率。並分別與1984至1987年及1991至1994年兩個不同時期的報告比較，分析他們在年齡、性別、視力及造成低視能病因的異同。

結 果： 經過謹慎的驗光之後，有21位 (10.3%) 配戴一般眼鏡即可滿足看遠及看近視力的需求；其中3位偏盲患者，可接受高偏折稜鏡。在121位有看遠需求者中，84位(69.4%)可成功使用望遠鏡，如加用頭戴式輔具，則僅多1位成功者。在136位無法閱讀報紙者中，有118位 (86.8%) 可成功使用放大鏡，再加用擴視機，則可達125位(91.9%)。與過去的資料比較，目前低視能病人的平均年齡有逐漸增高的趨勢，其病因也有相對變化的現象。

結 論： 擴視機可以幫助某些無法使用光學放大鏡滿足看近需求的病人。然而目前我們的多數患者仍以使用傳統光學輔具爲主。

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關鍵字： 低視能，低視能輔具，擴視機，頭戴式輔具。

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fl`¤œ' ƒLæ»‡B¡GS1« ¿‡´ fıV¡A“‡' < ' ´ | †·< ¡Cfı ¶Ø¿/ 333 t/s¶m·_¿‡ 5 „Œ Tel.: (03)3281200 ´ 8666; Fax: (03) 3287798; E-mail: Leejsh@adm.cgmh.org.tw