

THE BASIC LOW VISION EXAM

August Colenbrander, MD, San Francisco

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INTRODUCTION

Before we embark on any intervention we should know our starting points. This holds true for Low Vision Rehabilitation as it holds for traditional medical interventions. When patients arrive for a Low Vision evaluation, they often ask why they should have another eye exam. "My doctor just dilated me and took lots of pictures". We explain that their regular ophthalmologist is concerned with the *causes* of their eye condition and with the treatment thereof, our service is aimed at dealing with the *consequences* of the eye condition. A dilated exam and dazzling indirect ophthalmoscopy are essential for determining proper treatment, but they prevent us from assessing the patient's undilated and undazzled reading performance.

Several aspects that represent subtle but important differences between a Low Vision evaluation and a traditional eye examination deserve mention.

In a traditional examination the patient is seated for the examiner's convenience and for easy access to the slitlamp, phoropter and ophthalmoscope. For the Low Vision evaluation the arrangement should be for the patient's viewing and reading convenience. An adjustable hospital bed table placed in front of the exam chair facilitates this. For many patients who have a need to search around their scotomata, an old fashioned trial frame with full diameter wire-rim lenses is more appropriate than a phoropter.

To indicate that macular function is below normal, vague statements such as 'count fingers' may be sufficient. To accurately predict the amount of magnification needed, more accurate measurements are necessary than are possible with a standard projector chart. Since most people do not spend their days in a semi-dark room looking at brightly projected images, visual acuity measurement on a printed chart in a lighted room is a more appropriate predictor of daily performance than is the use of a projector chart. We will discuss the details later in this paper.

In the prevalent model of medical and surgical treatment, the doctor has the active role and generally is the decision maker; the patient is asked for compliance and (informed) consent. In rehabilitation the roles are reversed: the doctor provides guidance and shows the patient options; the patient has the active role and must work at re-learning certain skills (whether that is to walk with crutches or to read with a magnifier) and must decide which of several options is most appropriate for a particular living situation. The doctor cannot select and 'prescribe' low vision aids in the way he/she prescribes glasses or medications; the doctor can only recommend solutions, the patient must choose which one to use. This is one of the reasons why the use of a loaner system is so successful, since it allows the patient to verify that what seemed to work best in the clinician's office is also the best solution at home, at work or at school. Failure to recognize this role reversal from the 'medical model' to the 'rehabilitation model', whether it is on the part of the doctor, the patient or both, may lead to failure of successful rehabilitation. Sometimes the role reversal is more readily accepted if the Low Vision adviser is an associate or consultant, rather than the primary ophthalmologist, since this avoids the need for repetitive role reversals between the medical and the rehabilitative model.

Yet it is important that the primary ophthalmologist presents the referral as a natural extension and completion of the medical and surgical treatment, rather than as an admission of failure.

VISUAL ACUITY MEASUREMENT

Visual acuity notations are used so often that the underlying mathematical meaning is often forgotten. An eye is said to have a visual acuity of one half of normal if that eye can just recognize standard symbols that are twice as large or twice as close as those just recognized by a standard eye. If the symbols need to be ten times larger (or ten times closer), visual acuity is said to be one tenth of normal. Thus, visual acuity provides a direct estimate of the amount of magnification required to perform standard tasks. To determine that a macula is abnormal it does not make much difference whether the visual acuity is measured as 20/200 or 20/400; the latter measurement, however, indicates a need for twice as much magnification as the former. The following pages will describe a simple, systematic approach for the accurate determination of visual acuity in low vision patients using a 1-meter test distance for letter chart acuity and a variable test distance for reading tests.

LETTER CHART TESTING

Distance visual acuity measurement is traditionally carried out at 6 meters (20 feet). For routine eye examinations this measurement is used to answer one of two questions. Is the visual system normal or abnormal, and can the refractive correction be improved? For both purposes the range of normal and near-normal acuity is most important. Our regular charts reflect this. In the 20/15 - 20/20 - 20/25 - 20/30 - 20/40 - 20/50 - 20/60 - 20/80 - 20/100 range three steps equal a change in the visual angle by factor of two. In the low vision range, accuracy on most charts drops significantly. For 20/100 - 20/200 - 20/400 each single step represents a factor of two. The common notations of 'Count Fingers' and 'Hand Movement' are even less accurate.

For low vision, more accurate measurements are critical. The measurement range can be extended by moving the test charts normally used at 20 ft. (6 m) to a closer distance. Many low vision practitioners do this by moving from 20 ft. to 10 ft. (3 m), thus gaining a factor of two. We recommend bringing the chart to **1 meter**, thus gaining a factor of six. We use a **printed chart** with external illumination, since a printed chart in a lighted room is a more appropriate predictor of everyday function, than is a projector chart in a dark or semi-dark room.

Using a 1-meter viewing distance also brings us in line with the metric system and provides for much easier calculations than does the use of feet and inches. Since we use the metric system to measure the viewing distance, we should also use the metric letter size unit. Snellen used the letter 'D' for this unit; Louise Sloan introduced the term 'M-unit' to prevent confusion with the symbol 'D' for diopters. Standard acuity (1.0, 20/20) is defined as the ability to just recognize a standard letter (1M-unit) at a standard distance (1 meter) or a letter with the same visual angle (x M-units at x meters).

Using a letter chart at one meter has significant advantages:

- It extends the measurable range down to 1/50 (20/1000) if a chart with 50M letters (20/200 at 5 m) is used and makes more letters per line available at each level. Table 1 demonstrates how a standard chart at 20 ft. covers mainly the normal and near-normal ranges; bringing the chart to 10 ft. includes the moderate low vision range (The single 'big E' at 20/200 is a memory test rather than a visual acuity test); bringing the chart to 1 meter extends accurate measurement to the ranges of severe and profound low vision. (see Table 1)

- It is easy to maintain the exact testing distance by attaching a one-meter long string to the chart that can be extended to the patient's forehead.
- The chart is within arm's reach of the examiner, who does not have to get up to point to the chart.
- One meter is 1 diopter from optical infinity; thus, a refraction carried out at this distance simply needs 1 diopter subtracted for distance correction; conversely, a 1 diopter trial lens placed over the distance glasses will focus the patient for 1 meter testing. This can be done with a trial lens in a Halberg clip. A convenient alternative is to place a wide pair of +1D drugstore reading glasses over the patient's own correction.
- A simple metric Snellen fraction 1/... results from testing at one meter. The denominator of this fraction represents the theoretical number of diopters of add necessary for reading of 1M print. This is known as Kestenbaum's rule. Multiplying both numerator and denominator of the 1/... Snellen fraction by 20 will give the familiar 20/... notation.

TABLE 1. Expanded Measurement Range with 1m chart.

ICD-9-CM CLASSIFICATION		VISUAL ACUITY VALUES			MEASUREMENT RANGES		
		US notation	1-m chart	Magnif. need	Traditional	ETDRS	1-meter
(Near-) Normal Vision	Range of Normal Vision	20/12	1/0.6	0.6		20/12	
		20/15	1/0.8	0.8		20/16	
	20/20	1/1	1	20/20	20/20	1/1	
	20/25	1/1.25	1.25	20/25	20/25	1/1.25	
	Near-Normal Vision (mild loss)	20/30	1/1.5	1.5	20/30	20/32	1/1.5
		20/40	1/2	2	20/40	20/40	1/2
20/50		1/2.5	2.5	20/50	20/50	1/2.5	
20/60		1/3	3	20/60	20/63	1/3.2	
Low Vision	Moderate Low Vision	20/80	1/4	4	20/80	20/80	1/4
		20/100	1/5	5	20/100	20/100	1/5
		20/120	1/6	6		20/125	1/6.3
		20/150	1/8	8		20/160	1/8
	Severe Low Vision	20/200	1/10	10	20/200	20/200	1/10
		20/250	1/12	12			1/12.5
		20/300	1/15	15			1/16
	Profound Low Vision	20/400	1/20	20			1/20
		20/500	1/25	25			1/25
		20/600	1/30	30			1/32
	20/800	1/40	40			1/40	
	20/1000	1/50	50			1/50	
(Near-) Blindness	Near-Blindness	20/1200	1/60	60			
		20/1500	1/80	80			
		20/2000	1/100	100			
		20/2500	1/125	125			
	Total Blindness	<i>NLP</i>					

PRACTICAL HINTS:

- Do not push the patient too far for marginal performance, nor help by pointing to each individual letter. Determine the level at which patients can perform with reasonable comfort using their own fixation ability.

- For occasional use and portability, a plastic chart with a 1-meter string attached to an occluder is useful. Ask the patient to hold the occluder to one eye and the chart will automatically be at 1 meter. For more frequent use it is helpful to place the chart on a movable easel. Again, use a 1-meter string so that the distance of the easel can be adjusted when the patient leans forward.
- In principle any letter chart can be used. However, charts with a consistent geometric progression of letter sizes and with letter size notation in M-units are preferred. Table 2 provides conversions if a chart without M-unit notation is used. A special chart with a 1 m cord and occluder attached and with an extra wide range of letter sizes from 50 M (20/1000 at 1m) to 1M (20/20 at 1m) is now commercially available [1].

TABLE 2. Conversion to M-Units

A. Letter charts												
20/200	/100	/80	/70	/60	/50	/40	/30	/25	/20	/15	/12	/10
60M	30M	25M	21M	18M	15M	12M	10M	8M	6M	4.5M	3.5M	3M
<p>Older charts and recent charts often carry metric letter size notations. When using a 20 ft. chart without such notations, the above conversions can be used for a chart calibrated for use at 20ft. When in doubt, measure the height of the letters in mm. Remember that 1 M = 1.45 mm or 7 M = 1 cm. For a convenient clinical approximation 1 M = 1/16" may be used.</p>												
B. Reading charts												
Jaeger numbers: <i>(caution, they may vary from card to card)</i>												
# 4-5	# 7-8	# 8	# 10		# 12	# 14	# 16				# 18	
Printer's Points: <i>(caution, may vary for different font styles)</i>												
6 pt	8 pt	10 pt	12 pt	14 pt	16 pt	20 pt	24 pt	28 pt	32 pt	36 pt	40 pt	
Size in mm:												
1.0	1.5	1.7	2.2	2.5	3.0	3.6	4.5	5.1	5.8	6.5	7.25	
M-units: <i>(defined by Snellen, named by Sloan)</i>												
0.75M	1.0M	1.25M	1.6M	1.7M	2M	2.5M	3M	3.5M	4M	4.5M	5.0M	

Jaeger numbers refer to the catalogue numbers in the print shop where Jaeger selected his reading tests in 1854. They have no mathematical meaning and are implemented inconsistently on different cards.

Point sizes are used in printing. Within one type style they are proportional to the letter size. However, actual letter sizes may vary for characters of different styles.

M-units are the units used in Snellen's visual acuity formula. They apply for distance charts and reading cards. Characters with the same M-unit designation have the same recognizability.

READING PERFORMANCE

When the purpose of measurements at different distances is to determine accommodative range and to prescribe for presbyopia, it is proper to distinguish between 'distance' and 'near' vision. For rehabilitation purposes the distinction between 'letter acuity' and 'reading acuity' is more relevant because reading difficulties constitute the most frequent complaint of low vision patients. Letter recognition requires only a very limited visual area; word recognition requires a larger area and fluent reading requires the availability of additional areas to the right of fixation to guide successive saccades. Letter acuity may be measured at far distances (4, 5, 6 m, 20 ft, most useful for patients with normal vision), at an intermediate distance (1 m, most useful for low vision) or at near distances (pocket screener, not recommended); reading acuity can also be measured at far distances (bill boards) or near (continuous text reading card).

Traditionally, reading vision is most often tested at a fixed distance, with some practitioners using 40 cm (16", 2.5D add), some 14" (35 cm, 2.87D add), some 3 D (33.3 cm, 13"). For low vision patients these reading distances may be too far away. An additional problem often is that the patient's current correction is not optimal for the standard test distance. Therefore, a method is needed that allows simple calculations for various short reading distances.

Such a method will be described.

As with distance acuity, two values are needed to calculate visual acuity: *letter size* and *reading distance*. Many practitioners are in the habit of recording just the letter size read (e.g.: 'J7') without specifying the reading distance. This is a bad habit in general, but for Low Vision work such notations are completely meaningless. The ability to read news print at 5" is very different from the ability to do so at 15" or 20".

Another problem is the use of 'Jaeger numbers' to describe letter size. Jaeger numbers refer to the catalogue numbers in the print shop where Jaeger selected his reading tests in 1854. They have no mathematical meaning. Worse, they are inconsistently used as one can easily determine by comparing charts from different manufacturers.

If both distance and letter size are recorded properly, the same visual acuity value should be calculated for all distances. The problem is that the most prevalent measures: inches and J numbers make such calculations impossible. The solution, again, is to adopt metric measurements. Recording the reading distance in cm and the letter size in M-units gives us the information we want and makes calculations possible. A remaining problem, however, is that the traditional notation of the Snellen fraction still leaves us with the need for **division** of two numbers and that the reading distance in meters becomes a fraction-within-a-fraction.

Since most people are better at mental **multiplication** than at mental division, could a multiplication be used instead? Indeed, this can be done. Since many optical formulas require the reciprocal of a distance, Monoyer (1872) suggested using the term 'diopter' to indicate the reciprocal of a distance in meters. We are thoroughly familiar with the use of diopters in connection with lenses (lens power expressed as the reciprocal of the focal distance), but tend to forget that diopters can be used in any formula where the reciprocal of a distance is needed. Changing the measurement units from cm to diopters does not require an additional calculation, since the reading distance in diopters can be measured directly, using a ruler like the one provided with any phoropter. Indeed, it has the additional advantage that the reading distance in diopters relates directly to the reading add (in a presbyope) or to the required accommodation (in a young person).

If: $VA = \frac{\text{test distance}}{\text{letter size}}$ then: $1 / VA = \frac{\text{letter size}}{\text{test distance}} = \text{size} \times \frac{1}{\text{distance}} = \text{size} \times \text{distance in diopters}$

Thus, the procedure is as follows:

Determine the baseline performance with existing glasses:

- ask the patient to hold the reading material at whatever distance is in sharp focus with their existing glasses;
- measure the reading distance in diopters (using a phoropter type ruler);
- record the smallest letter size read (in M-units, 1M = newsprint) as well as the reading distance (in diopters, D).
- Multiply M x D to confirm the consistency of the recorded findings. M x D should equal 1/V (the letter size read at 1 meter).

If the patient cannot read the desired print size, provide more add:

- measure the reading acuity with more add (adds do not stop at +3);
- adjust the reading distance as the add increases;
- check the reading distance vs. the reading add at each distance; the reading distance in diopters should equal the dioptric power of the reading add. If the reading distance is different, encourage the patient to move the print until it is in best focus. At high adds it is impossible to estimate the correctness of the distance without an actual measurement.
- record M and D and check M x D at each distance; continue until 1M (newsprint) is reached. In a perfect case, the patient should have progressed from xM at 1D (1 meter) to 1M at xD. This is known as Kestenbaum's rule: the number of diopters needed is the reciprocal of the visual acuity value. Table 3 gives an example of possible findings with various adds at various distances.
- when newsprint can just be read, try a little more add. This will reduce the reading distance but increase the magnification and may improve reading fluency. Different patients will value this trade-off differently. Remember that while letter chart acuity tends to determine a threshold level, reading must be performed at a comfort level.
- while the patient is reading, note not only the end point, but also the quality of reading (fast, slow, smoothly, stop-and-go, guessing, etc.). This provides valuable information to estimate the quality of the pericentral visual field (*see below*)

Advantages

The advantages of using the 'M-unit and Diopter' (M&D) notation while gradually reducing the reading distance and recording performance at each step, are:

- **Any distance can be used**, no need for a prior refraction to correct the patient for a 'standard' reading distance.

- It provides several checks on the **distance refraction**. If the reading add and reading distance (in diopters) coincide at each distance, the basic refraction (or at least its spherical equivalent) must be correct.
- It provides several checks on the **visual acuity**. Consistent results at each distance reassure us of their reliability. Inconsistencies should not be ignored; they provide additional information which demands an explanation (see below).
- The gradual progression encourages the patient with each paragraph read, even if 1M is not attainable.
- The gradual progression also eases the patient into the eventual short reading distance which might otherwise be resisted if the examiner jumps directly to the highest add, based on Kestenbaum's rule.

Table 3. Reading performance at various distances

1-meter acuity: 1/12 Equivalent to: 5/60, 6/72, 20/240, 0.08

Since the 20/240 line is omitted on most traditional charts, this value would probably have been erroneously reported as 20/400 in many offices. On a chart with a proper logarithmic progression there is a 2-line difference between 20/240 and 20/400. A patient with 20/400 needs 50% more magnification than one with 20/240.

Reading acuity:

Letter size	Distance		Record as: ..M at ..D	check:	Acuity: 1/MxD	Traditional Snellen fraction
	meters	diopters				
12M	1	1D	1-m acuity	$12 \times 1 = 12$	1/12	1 / 12
6M	1/2	2D	6M at 2D	$6 \times 2 = 12$	1/12	0.5 / 6
4M	1/3	3D	4M at 3D	$4 \times 3 = 12$	1/12	0.33 / 4
3M	1/4	4D	3M at 4D	$3 \times 4 = 12$	1/12	0.25 / 3
2M	1/6	6D	2M at 6D	$2 \times 6 = 12$	1/12	0.16 / 2
1M	1/12	12D	1M at 12D	$1 \times 12 = 12$	1/12	0.08 / 1

Note that the M x D calculation is easy. The traditional Snellen fraction requires a calculator.

PRACTICAL HINTS:

Discrepancies in the above measurements provide additional information.

- A **constant difference** between reading distance and reading add indicates an undetected refractive error. This often is an effective way to detect index myopia in elderly low vision patients. When the findings are consistent, it avoids the need for a time consuming subjective refraction.
- Failure of the patient to reduce the reading distance in accordance with the increasing adds may indicate resistance to a close reading distance. If the reading distance is incorrect, the image will not be focused properly and reading will not be optimal. Many patients need to be

continually reminded about this. An incorrect reading distance is probably the most frequent reason why patients may report that stronger reading glasses which were effective in the office 'do not work' at home. A good strategy is to ask the patient to start by bringing the print too close and then moving it away to the point of best focus.

- It is useful to have the patient start to read at a large print size where they can read easily. This is more encouraging than moving directly to their level of failure. If patients can read the (very) large print quickly, it will waste very little time. If they cannot read with fluency at any print size, it provides additional diagnostic and prognostic information. Patients who read large print smoothly, then slow down at smaller sizes, can be expected to respond to magnification with a better reading speed. However, patients who read slowly at all letter sizes will not read small, magnified print any faster than large, unmagnified print, although they may find magnification less strenuous. When older patients have suffered a minor stroke and also have a maculopathy, it is often easier to distinguish between the cognitive handicap of the stroke and the visual handicap of the maculopathy when they are reading larger print.*
- Another reason for M x D inconsistencies may be found in fixation problems. Paradoxical performance, where reading large words and letters is harder than reading smaller ones, may result from the use of a small island of high resolution sandwiched between paracentral scotomata, a condition often seen with drusen and geographic atrophy. Such patients have a narrow range of optimal magnification. They are also likely to report more problems with long words than with short ones, and frequently lose their place when reading; they are often particularly responsive to underlining to facilitate tracking.*

< These conditions are discussed extensively in the papers by Fletcher [2] and Schuchard [3]. >

Selecting a reading card

Selection of a proper reading card is important. In principle any card can be used. However, as with letter charts, a card with a geometric progression of letter sizes and with M-unit notation is preferred because it facilitates calculations. If your reading card does not carry M-unit notation, the conversions in Table 2B may be used.

The low vision letter chart, mentioned earlier [1], also contains reading segments from 10M to 0.8M. Each paragraph has the same number of words and the same layout, so that it is easy to compare reading speeds for unmagnified large print and magnified small print.

For regular use, as in a Low Vision Service, the same texts are available on an 8½ x 11 card, which comes with a diopter ruler, so that the card can be used at any distance,

For screening use of subjects with normal and near-normal vision a smaller card is available with a cord for testing at a fixed 40cm distance.

All cards are available in multiple languages.

Use of magnifiers

The end point of the testing sequence, as outlined above, is a spectacle correction that allows reading of 1M print (newsprint). This represents the simplest method of magnification: magnification by reduction of the working distance. It is a good starting point for the demonstration of magnifiers.

Spectacle correction provides the widest field of view, because the lens is closest to the eye. However, the short reading distance is sometimes experienced as a disadvantage. Magnifiers

provide a means of increasing the working distance. The optical effect may be explained as follows.

A reading lens may be considered to consist of two components: the distance correction and the reading add. The two components can be visualized separately by holding an add-on lens immediately in front of the distance correction. The elements can now be separated: the first element is the eye with its distance correction, which is the equivalent of an emmetropic eye; the second element is the reading add, forming a virtual image of the reading material. If the object is at the focal distance of the lens, the virtual image is at infinity; if the object is closer, the virtual image is at a finite distance.

We can now move the object and add-on lens as a unit (constant lens-to-object distance). The working distance (eye-to-object) is increased by the eye-to-lens distance. When the add-on lens is no longer a part of the glasses it is called a magnifier. We can observe the following:

- As the lens and object are moved away, the virtual image is moved to the same extent. Since the virtual image moves away, the retinal image becomes smaller. Hence, the effective (retinal) magnification of a magnifier (away from the eye) is less than that of the corresponding reading add (close to the eye).
- Since the effective field of view is limited by the rim of the lens, the field of view decreases as the lens is moved away from the eye. Hence, spectacle correction gives the widest field of view and the highest magnification for a given lens power. A magnifier away from the eye allows a greater working distance, but restricts the field of view.

For the practical use of magnifiers and glasses this means that magnifiers are indicated if the task requires a greater working distance (e.g. looking at the text in a typewriter), if the patient has difficulty overcoming the natural resistance to a short reading distance, or if the task is brief (e.g. looking at a price tag or label) and changing glasses is not practical. The same patient may prefer spectacle correction for longer reading tasks (books, newspaper).

< *The use of magnifiers is discussed in more detail in the paper by Evans [4].* >

VISUAL FIELD

< *The importance of visual field changes has been discussed in the paper by Faye [5]. The impact on reading is discussed in the paper by Rubin [6]. Detailed measurements in the pericentral area (micro-perimetry) are discussed in papers by Fletcher [2] and Schuchard [3].* >

Such measurements, however, require a Scanning Laser Ophthalmoscope (SLO), which for most settings is prohibitively expensive. What will follow is a brief discussion of observations that can be made in a routine exam.

The peripheral field

For orientation and mobility, the peripheral field is most important. If formal visual field studies are available, *Goldmann* fields are generally more informative than static fields such as the *Humphrey*. Since orientation is mainly concerned with large objects, a simple *confrontation* field can often provide most of the needed information. It has the additional advantage of being a good demonstration for the patient and for attending family members. The importance of informing family members is often overlooked. In our service we request that a "significant other" attends the entire examination. Especially for conditions such as hemianopia or tunnel vision, it is essential that they understand the patient's problem.

PRACTICAL HINTS:

For demonstration purposes it is useful to have the core of a roll of toilet paper on hand; this restricts the field to about 20°, the field limit for 'legal blindness'.

Patients with moderate tunnel vision may still be able to drive, but they should have additional fender-mounted rearview mirrors and a panoramic internal mirror. Patients with severe tunnel vision should probably not drive. Patients with profound tunnel vision (5° field) may benefit from a reverse Galilean telescope as a field expander, usually the 2.5x pocket model. Patients with wider fields usually find scanning easier than a reverse telescope.

In patients with hemianopia, one should be aware of spatial neglect. Spatial neglect can exist with or without hemianopia and vice versa. Patients with spatial neglect will not scan spontaneously to the non-seeing side; sometimes their performance can be improved with extensive training. Patients with hemianopias should probably not drive. Patients with spatial neglect should definitely not drive.

Patients with panretinal photocoagulation for diabetic retinopathy may still have a fair visual field for hand motions on confrontation testing, but the quality of that field is poor. They should be made aware of this deficit and its impact on peripheral awareness. Patients with extensive PRP should probably not drive. A further discussion about driving and low vision can be found in the Position paper on this topic from the American Academy of Ophthalmology [7].

The Pericentral field

The perifoveal field is most important for reading. The functional area must be a large enough for word recognition (as opposed to letter recognition) and there must be enough area to the right of fixation to guide the next saccade. Most patients with a central scotoma develop a Preferred Retinal Locus (PRL) below or to the right of the scotoma (retinally, above the lesion).

Even a 1° scotoma blocks 12 1M-letters at 1 meter (5' each) or 6 1M-letters at 50 cm. This would interfere significantly with reading. Yet the accuracy of standard perimetry is generally stated as 2°. Neither Goldmann nor Humphrey perimetry is helpful in this regard. Tangent screen testing can provide more accurate information, but fixation stability may be a problem. The Amsler grid is useful if the patient sees a change, but absence of reported changes does not mean absence of pathology. Here the well-known tendency of the brain to complete missing data and to fill in missing areas (such as the physiologic blind spot) plays a role. Thus, none of these tests can provide definitive information, although each may contribute to the overall picture. The Macular Mapping Test (MM test) is a computer program that provides a means of plotting pericentral changes on a regular computer screen. Sometimes it is possible to get an estimate of the size of an island of useful vision by instructing the patient to look at the center letter of a 5 letter line on the letter chart and by asking how many letters on either side are visible without eye movements.

Given this state of affairs it is extra important to listen carefully to the patient's reading performance at different letter sizes. The ability to read 2- or 3-letter words with relative ease while stumbling on long words is often indicative of patients with a very small functional area.

PRACTICAL HINTS

Patients with many small scotomata often have difficulty tracking. High magnification may make them worse, because it makes the letters too large for the available area. This is not uncommon in patients with drusen and geographic atrophy. These patients often lose their line while searching for the best area of fixation. They may be helped enormously by

underlining technique. Since they may also have reduced contrast sensitivity (see below), they will also benefit from increased illumination.

CONTRAST SENSITIVITY

Contrast Sensitivity describes the ability to detect objects of low contrast. Like visual acuity it can be a sensitive but non-specific indicator for a variety of problems in the visual system. Similar to visual acuity, which is defined as the reciprocal of symbol size, so Contrast Sensitivity is defined as the reciprocal of the contrast that can just be detected. High contrast sensitivity indicates the ability to detect low contrast objects. Low contrast sensitivity means that object must have more than average contrast to be detectable. Often increased illumination can compensate in part for reduced contrast sensitivity.

A finding of reduced Contrast Sensitivity can often explain why patients with apparently near-normal letter chart acuity complain that their vision is not optimal. Reduced contrast sensitivity may be seen in patients with more generalized retinal involvement, such as drusen and geographic atrophy. Such patients often are extremely responsive to an improvement in illumination, even more than to increased magnification.

Measuring and documenting contrast sensitivity is important for several reasons.

- It is a sensitive test for the **early detection** of certain conditions; especially those that leave high contrast visual acuity unaffected (e.g.: optic neuropathies, glaucoma, diabetes) and provides a means for **follow up** of such conditions.
- In Low Vision Rehabilitation, poor low contrast vision will predict significant difficulties in **activities of daily living** (ADL), since many ADL activities depend more on recognition of larger objects (sometimes of low or intermediate contrast) than on recognition of small details of high contrast. Typical low contrast tasks include driving in rain or fog, walking down steps, pouring milk into a white cup, recognizing faces, etc. Magnification is a useful remedy if small details of high contrast cannot be seen (e.g. reading); magnification does not help if an object (large or small) is not visible because of reduced contrast. Recognizing patients with reduced contrast sensitivity is important, since better illumination and enhancement of contrast in the environment are often more helpful than magnification.

Contrast sensitivity tests

The interaction between detail vision and contrast vision is expressed in the Contrast Sensitivity Curve. This curve indicates that for small letters a trade-off exists between letter size and contrast. With higher contrast smaller letters can be seen. The standard visual acuity chart measures the size threshold for high contrast. For very large letters of very low contrast, however, the curve becomes flat: visibility is no longer dependent on letter size.

One type of tests presents letters (or symbols) of constant size and decreasing contrast. An example is the **Pelli-Robson chart** [10]. This test measures the contrast threshold for large letters. To make sure that testing is done on the flat part of the curve, the letters and thus the chart, have to be large, so that the patient needs to be brought to the chart.

Another type of tests presents a **letter chart of reduced contrast** [8]. With this type of test different letter size thresholds will be found for different contrast levels. Care must be taken that all measurements are done at the same distance and with the same illumination.

The **SKILL card** (Smith-Kettlewell Low Contrast, Low Luminance card) [12] presents a standard near-vision letter chart on one side and a similar black-on-gray (rather than gray-on-white) card

on the other side. The combination of low luminance and low contrast makes the test more sensitive for early disease. Since the two tests are given one after the other, the requirement of equal distance and equal illumination is maintained easily.

Any of these methods require two tests and additional time, which often is not available in a busy practice. Thus, it is not surprising that contrast sensitivity is rarely measured in routine practice. This is overcome by the **Mixed Contrast card**. This card is identical to the reading cards discussed earlier, but has lines printed alternately in high and low (10%) contrast. It provides a quick and easy screening test by asking the subject on the same card: "What is the smallest black line you can read? What is the smallest gray line you can read?" The number of lines difference is a measure of the contrast sensitivity. Two or three lines difference is normal.

SUMMARY

We have discussed simple techniques that can be implemented in any office for accurate acuity measurement in the low vision range. Accurate acuity measurement is essential to take the guess work out of the selection of magnification aids.

We also described practical ways to estimate the effect of visual field changes and ways to assess changes in contrast sensitivity.

REFERENCES

1. Low Vision Test Chart for use at 1 meter, with 1 meter cord and occluder for accurate viewing distance. The chart also contains reading segments and comes with a special ruler to measure the reading distance in diopters. Designed by the author, who has no financial interest in its distribution. Available from: Precision Vision, 721 North Addison Rd., Villa Park, IL 60181.
2. Fletcher DC et al, The Scanning Laser Ophthalmoscope (SLO) and Macular Perimetry - Applications for Vision Rehabilitation, *in this issue*.
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4. Evans LS, Use of Spectacles and Magnifiers, *in this issue*.
5. Faye EE, The Role of Eye pathology in Vision Rehabilitation, *in this issue*.
6. Rubin GS, Vision and Reading, *in this issue*.
7. American Academy of Ophthalmology, Policy Statement on Vision Requirements for Driving, *in this issue*.
8. Bailey-Lovie Low Contrast Chart, designed by Ian Bailey. The chart follows the layout of the high contrast chart, but is printed at a reduced contrast (gray on white). Available from: School of Optometry, U.C. Berkeley.
9. LH Low Contrast Test, designed by Lea Hyvärinen, MD. The test uses LH symbols (suitable for children and adults) of 10 M size and is designed for hand-held use. Available from: Lighthouse Low Vision Products, 36-02 Northern Blvd., Long Island City, NY 11101.
10. Pelli-Robson Contrast Sensitivity Chart, designed by Dennis G. Pelli and D. G. Robson. The test uses letters of 35 M size and is designed as a wall chart. Available from: Clement-Clark, 3128-D East 17th Ave., Columbus, OH43219-2300.
11. Vistech Contrast Test System, designed by Arthur Ginsburg. The test uses gratings of 5 different spatial frequencies and is designed as a wall chart. For low vision use the chart has also been calibrated for use at 1 meter.
12. The Smith-Kettlewell Institute Low Luminance (SKILL) chart, developed at the Smith-Kettlewell Eye Research Institute in San Francisco. The 2-sided card has high contrast, high luminance (black-on-white) letters on one side and low contrast, low luminance (black-on-gray) letters on the other. Available from: Smith-Kettlewell Eye Research Institute, 2232 Webster St., San Francisco, CA 94115.