17 Testing Visual Acuity

Abstract

This chapter describes how visual acuity is tested clinically. It outlines the basic principles involved in the design and clinical recording and interpretation of these different tests, as well as indicates the tests that are available for children and illiterate persons. A basic introduction to refraction and auto-refraction is given.

Introduction

Measurement of visual acuity is the most important part of the ocular assessment performed by the doctor and yet it is surprising how often the non-specialist omits it in examination. It has already been shown that the differential diagnosis of the red eye can be simplified by noting the vision in the affected eye. After injuries of the eye it is just as important to note the vision in the uninjured eye as it is to note that in the injured eye. Simple measurement of visual acuity is of course, of limited value without knowledge of the spectacle correction or whether the patient is wearing the appropriate spectacles or not. The best corrected visual acuity (i.e. with lenses in place) therefore needs to be recorded for each eye. This corrected visual acuity can also be estimated with a pinhole held in front of the eye. The effect of the pinhole is to eliminate the effect of refraction by the cornea and the lens on the extremely thin beam of light produced by the pinhole.

Measuring the visual acuity means measuring the function of the macula, which is of course only a small part of the whole retina. A patient may have grossly impaired visual acuity and yet have a normal visual field enabling him to walk about and lead a normal life apart from being able to read. This state of affairs is seen in patients with age related macular degeneration and can be compared with the situation in which a patient has grossly constricted visual fields but normal macular function, as is sometimes seen in retinitis pigmentosa or advanced primary open angle glaucoma. Here the patient appears to be blind, being unable to find his way about, but he may surprise the ophthalmologist by reading the visual acuity chart from top to bottom once he has found it.

The simplest way to measure visual acuity might be to determine the ability to distinguish two points when placed very close together (resolution). Such a method was supposed to have been used by the Arabs when choosing their horsemen. They chose only those who were able

N.R. Galloway et al., *Common Eye Diseases and their Management*,
DOI 10.1007/978-3-319-32869-0_17

Table 17.1 Testing visual acuity

Methods	Tests used dependent on age/ability/cooperation of patient
	For adults adopt Snellen type or LogMAR charts
	Younger pre-verbal children = Orthoptist judges whether the child has seen the stimulus or not
	Many qualitative assessments of whether a child can see or not
	Fixing and following a light
	Reaching for small toys
Why necessary?	Need quantitative assessments
	Monitor visual development in children
	Quantify any increase/decrease in visual acuity
	Determine and monitor treatment efficacy
	Disease progression
Principles	Need to test visual acuity UNIOCULARLY (one eye at a time), otherwise you will NEVER detect amblyopia – a visual acuity test with both eyes open only represents the visual acuity in the good eye
	Importance of crowded vision tests
	Crowded tests = letters or pictures in a line
	On a chart with other lines of letters/pictures above & below
	One row of letters/pictures with a surrounding box
	Harder to detect crowded letters/pictures
	More accurate visual acuity test
	Patients with amblyopia often have 'crowding': able to identify single letters well, but will struggle to identify letters in a line

to resolve the two stars which form the second 'star' in the tail of the Great Bear constellation. A point source of light such as a star, although it is infinitely small, forms an image with a diameter of about 11 μm on the retina. This is because the optical media are not perfect and allow some scattering of the light. In practice it is possible for a person with normal vision to distinguish two points apart if they are separated by 1 mm when placed 10 m away. Two such points would be separated by 2 μm on the retina. This might be surprising considering that a spot of light casts a minimum size of image of 11 μm due to scatter, but such an image is not uniform, being brighter in the centre than at the periphery. In fact, the resolving power of the eye is limited by the size of the cones, which have a diameter of 1.5 μm.

The principles and different ways of testing visual acuity in different persons are summarized in Tables 17.1 and 17.2.

In the clinic, the distance visual acuity is measured by asking the patient to read a standard set of letters, the Snellen chart. This is placed at a distance of 6 m from the eye. The single large letter at the top of this chart is designed to be just discernible to a normally sighted person at a range of 60 m. If the patient's vision is so poor that only this and no smaller letter can be seen at 6 m, then the vision is recorded as the fraction '6/60'. The normal-sighted person who can read the chart down to the smaller letters designed to be discerned at 6 m is recorded as having a visual acuity of 6/6. The normal range of vision extends between 6/4 and 6/9 depending on the patient's age. In some European countries, the visual acuity is expressed as a decimal instead of a fraction. Therefore 6/60 would be expressed as 0.1. In the USA, metres are replaced by feet, therefore 6/6 becomes 20/20. This is where the term "twenty twenty" vision originates from, meaning clear or near perfect vision. Recently, a new type of visual acuity chart has entered use in the clinic and in research studies. It is called the LogMAR chart and differs from the conventional Snellen chart (Fig. 3.1) by having 5 letters on each line rather than the "pyramid" shape of the Snellen chart. There are also smaller differences in type size between lines. The spacing between 2 lines is

Table 17.2 Visual acuity tests in children

1. Preferential looking	Used for young babies
	40 cm test distance
	Uses black and white square wave gratings against a grey background
	Gratings of decreasing width = higher spatial frequency (harder to see the gratings against the grey background)
	Child looks towards the gratings if seen
2. Kays pictures (now in crowded form, measured in LogMAR units)	Used for young verbal children
	3 m test distance
	Four pictures in a line, surrounded by a box = crowded
	Child names the pictures (can match pictures)
3. Cardiff acuity chart	Gross test based on preferential looking, and that child will look at picture rather than plain background
	Used mainly for screening in paediatric patients (12–36 months)
	Consists of single picture objects: house, fish, boat etc
	Pictures are in black and white against a grey background
	Test done at 1 m or 50 cm
	Examiner watches the child's eye movements, up or down to estimate gaze direction: in direction of picture
	Results may be recorded in Snellen, LogMAR or decimal notation
4. Stycar test	Similar to Kay
	Done at 3–6 m with different sized pictures
	Based on Snellen principle
	Chart consists of pictures of food items or toys
5. Sheridan Gardiner test	Used in children 2–6 years old
	Test done at 6 m (or 3, if the VA is worse than 6/60)
	Consists of letters HOTV at different sizes
	Child given a card with the letters arranged to give correct orientation, and asked to match them against those on the main chart
6. LogMAR crowded/uncrowded (measured in LogMAR units)	Used to test distance vision in school going children and adults
	Crowded: four letters in a line, surrounded by a box
	Uncrowded: single letters (no crowding)
	Used for young children more familiar with letters/shapes
	3 m test distance
	Child can name/match letters

equal to the size of letters in the previous line. Some of the advantages of using this new chart are that the measurement of poor visual acuity is more accurate as more larger letters are included and small changes in acuity are easier to detect (easier to detect disease progression or treatment success).

The near visual acuity is also measured using a standard range of reading types in the style of newsprint and here care must be taken to ensure that the correct spectacles for near work are used if the patient is over the age of 45 (Fig. 17.1). Normally the results of testing the near visual acuity are in agreement with those for measuring distance vision providing the correct spectacles are worn if needed.

The visual acuity of each eye must always be measured by placing a card carefully over one eye and then transferring this to the other eye when the first eye has been tested. The visual acuity of both eyes together is usually the same or fractionally better than the vision of the better of the two eyes tested individually. In certain special circumstances the binocular vision may be

Fig. 17.1 Reading glasses in presbyopia

worse than the vision of each eye tested separately (e.g. in cases of macular disease causing distortion).

A number of other tests have been developed to measure visual acuity in the non-literate patient. Infants below the reading age can be measured with surprising accuracy using the Stycar test. Here, letters of differing size are shown to the child, who is asked to point to the same letter on the card, which is given to him. Up to the age of 18 months or 2 years, the optokinetic drum may be used. This makes use of the phenomenon of optokinetic nystagmus produced by moving a set of vertically arranged stripes across the line of sight. When the stripes are sufficiently narrow, they are no longer visible and fail to produce any nystagmus. The eyes are examined using a graded series of stripes. This kind of test can be used to measure visual acuity in animals other than man. Other tests used in pre-school children include the Sheridan-Gardiner, Kay, or Cardiff Acuity cards which are summarized in Table 17.2. The 'E' test is a way of measuring the visual acuity of illiterate patients. This is based on the Snellen type but the patient is presented with a series of letter 'E's of different sizes and orientations and is given a wooden letter 'E' to hold in the hands. He is then instructed to turn the wooden letter to correspond with the letter indicated on the chart.

The Snellen type has the great advantage of being widely used and well standardised, but it must be realised that it is a measure of something more complex than simply the function of the macula area of the retina. It involves a degree of literacy and also speech, and testing shy children or elderly patients may sometimes be misleading.

Other ways of measuring visual acuity have been developed. Another way is to assess the patient's the ability to resolve a grating. Here, the word 'grating' refers to a row of black and white stripes where the black merges gradually into the white. Such a grating can be varied by altering either the contrast of black and white or the width of the stripes (the 'frequency'). Thus for a given individual, the threshold for contrast and frequency (contrast sensitivity) can be measured. This type of test has certain theoretical advantages over standard methods but it is not widely used clinically as a routine. Finally, the electrical potentials generated by the retina and optic nerve may be measured to give an estimate of visual acuity when the eye is presented with targets of varying size and contrast. This method is useful in infants and in the assessment of adults with non-organic visual loss.

Measuring for Spectacles

If a patient has not been recently tested for spectacles, then not only may the measurement of visual acuity be inaccurate, but the symptoms may be due to the need for a correct pair of glasses. The measurement, which determines the type of spectacles needed, requires skill developed by practice and the use of the right equipment. The most obvious way to measure someone for a pair of glasses is to try the effect of different lenses and ask the patient whether the letters are seen better with one lens or another. This is known as subjective testing and by itself it is not a very accurate method because some patients' observations as to the clarity of letters may be unreliable. Furthermore, a healthy young person may see quite clearly with a wide range of lenses simply be exercising the ciliary muscle (i.e. accommodation). Fortunately the refractive error of the eye can be measured by an objective method and an answer can be reached without consulting the patient. The method entails observing the rate of movement of the shadow of the iris against the red reflex from the fundus of the eye after interposing different strengths of lenses (retinoscopy). In order to make an accurate measurement of the spectacle requirement, both objective and subjective refractions are performed and the results compared.

Objective Refraction

The patient is fitted with a spectacle trial frame into which different lenses can be slotted. In the case of young children it is usually advisable to instill a mydriatic and cycloplegic drop beforehand to eliminate focusing. The ophthalmologist then views the eye to be examined through an instrument known as a retinoscope, from a distance of about one arm's length. The red reflex can be seen and the instrument is then moved slightly so that the light projected from the retinoscope moves to and fro across the pupil. The shadow of the iris on the red reflex is then seen to move, and the direction and speed of movement depend on the refractive error of the patient. By interposing different lenses in the trial frame, the movement of the iris shadow can be 'neutralised' and the exact refractive error determined. The trial frame can accommodate both spherical and cylindrical lenses so that the amount of astigmatism can be measured.

Subjective Refraction

Here, considerable skill is also needed because many patients become quite tense when being tested in this way and may not initially give accurate answers. Lenses both stronger and weaker than the expected requirement are placed in the trial frames and the patient is asked to read the letters of the Snellen chart and to say whether they are more or less clear. A number of supplementary tests are available which enable one to check the patients' answers. It can be seen that the word 'refraction' refers to the total test for glasses, although the same word refers to the bending of the rays of light as they pass from one medium to another. Accurate refraction takes 10 or 15 min to perform, or longer in difficult cases and it is an essential preliminary to an examination of the eye itself.

Automated Refraction

In recent years attempts have been made to develop an automated system of refraction, and instruments are now commercially available. They are, however, still expensive and not always accurate when there are opacities in the optical media, or when the patient over-accommodates. One further way of assessing the refractive error without asking the patient any questions is by making use of the visually evoked response. This is the name given to the minute electrical changes detectable over the back of the scalp when the eyes are exposed to a repeated stimulus, usually a flashing chequerboard. When fine checks are viewed, interposing different lenses can modify the response. This method is of great interest but it is still not very reliable and takes time to perform.

Considering the importance of the measurement of visual acuity, it is not surprising that a number of tests have been developed for this, but the simple Snellen chart remains an essential part of any doctors' surgery. It must be remembered that this is a measure of function in the centre of the visual field only and it is possible to have advanced loss of peripheral vision with normal visual acuity as is seen sometimes in patients with chronic glaucoma or retinitis pigmentosa. The assessment of the rest of the visual field has also been standardised and a number of instruments have been developed to measure it. These have already been described in Chap. 3 together with various other measurements of different aspects of vision.

Summary

After completing this chapter, the reader should appreciate the importance of measuring visual acuity, and the different methods that are used in clinical practice. The salient points are:

- Measuring visual acuity is the most important part of the ocular assessment performed in an ophthalmic examination. It indicates to the ophthalmologist how good the resolving power of the eye is, and is compared to the normal for the patient's age.
- The visual acuity is dependent on the resolving power of the fovea, but is influenced by medial opacities and refractive errors.
- Appropriate correction at distance and near vision should therefore be worn before this resolving power of the eye is determined.
- The power of spectacles can be measured by a trained person
- The refraction can be determined objectively, and subjectively.
- Auto-refractors are available.