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Visual Development and Visual Acuity Testing In Children

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INTRODUCTION

Visual impairment" is a broad term that is used to refer to any degree of vision loss that affects a person's ability to perform the usual activities of daily life. It does not refer to the kind of vision many of us have who need to wear eyeglasses or contact lenses to read a book comfortably or see highway signs when we're driving a car. Instead, visual impairment refers to a loss of vision that cannot be corrected to normal vision, even when the person is wearing eyeglasses or contact lenses. Because it is so broad a term, "visual impairment" usually includes blindness as well. A standard eye chart is necessary to make comparisons and to record people's visual acuity. The most common chart used in most doctors' offices is the Snellen eye chart. In 1862, a Dutch Ophthalmologist, Dr. Hermann Snellen, devised this eye chart. He determined that there was a relationship between the sizes of certain letters viewed at certain distances. The newborn's visual acuity is approximately 20/400, developing to 20/20 well after the age of six in most children. The measurement of visual acuity in infants, pre-verbal children and special populations (for instance, handicapped individuals) is not always possible with a letter chart. For these populations, specialised testing is necessary. As a basic examination step, one must check whether visual stimuli can be fixed, centered and followed. It has been well accepted that visual function assessment tells in general about the function of the entire globe. Since the visual system is immature in children and bound for developing amblyopia during the early years of life, the detection of visual loss in any one eye is mandatory to prevent them going in for permanent loss of vision. In other words this visual loss could be reversed, if detected and intervened with proper therapy at an appropriate age. This emphasises how accurate the visual acuity estimation should be especially in cases of motility disorder and in presence of refractive errors especially when they are unequal in nature. In diseases like cataract, glaucoma etc the visual acuity can be judged to a certain extent by the severity of disease whereas in strabismus it is difficult to do so because the decreased visual acuity is often due to the presence of amblyopia or and refractive errors.

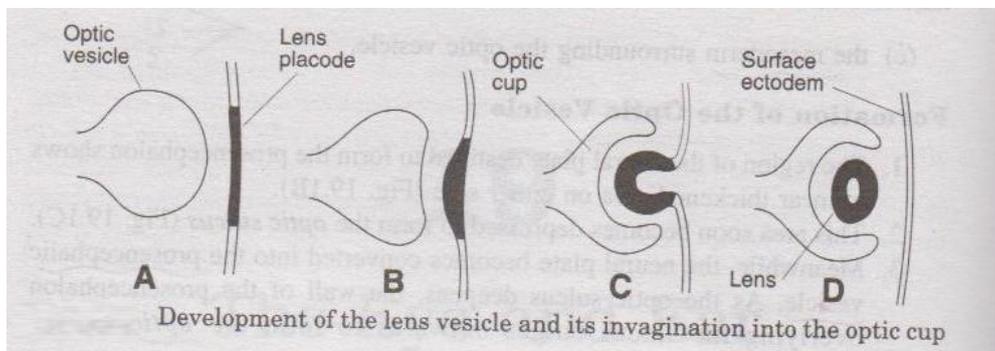
EMBRYOLOGY

Development of retina.

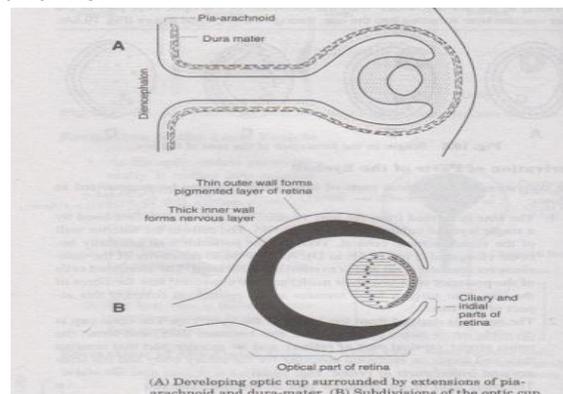
During fourth week of intra uterine life, two diverticulums develops from the lateral walls of diencephalon. Each hollow diverticulum consists of proximal tubular part, optic stalk and distal distended part, optic vesicle. The differential growth in the superior and lateral walls, the optic vesicle is converted into double layered optic cup. It contains outer wall, inner wall and space between them, the intra retinal space. During the further development this space is completely obliterated. Clinically the detachment of retina takes place along the cleavage of intra retinal space.

The outer wall of optic cup is lined by single layer of columnar cells. During 5th week, pigment granules appear within its cytoplasm and thus it is converted into pigmented layer of retina.

The inner wall of the optic cup differentiates differently in anterior one-fifth and posterior four-fifth part. The cells of posterior four-fifth part proliferates into nervous part of retina. It differentiates into three layers namely: ependymal, mantle and marginal layer. The cells of ependymal layer forms photoreceptors: rods and cones. The cells of mantle layer develops into outer nuclear, inner nuclear, ganglion cell layer and supporting cells. The marginal layer is traversed by the axons of the ganglion cells, and forms nerve fibre layer. These fibres grows into optic stalk and subsequently converts it into optic nerve. The differentiation of layers of retina is completed by 8th foetal month.



The anterior one-fifth part of inner wall of optic cup forms single layer of non nervous cells, which lines ciliary body and iris.





Development of lens

The thickening of the surface ectoderm overlaying the optic vesicle, forms lens placode, during the 6th week of intra uterine life. Soon it is converted into lens vesicle. After the formation of optic cup, it lies within the optic cup. The anterior wall of lens vesicle is lined by single layer of cuboidal epithelium. The cells of the posterior wall gradually becomes elongated, lose their nuclei, and converts into primary lens fibres. The secondary lens fibres develop from the equator of the lens and deposit in laminated manner. Growth of lens continues upto the 18 to 20th year.

Development of fibrous and vascular layers of eye

The mesoderm surrounding the optic vesicle differentiates into form a superficial fibrous layer and deeper vascular layer. Superficial fibrous layer forms sclera in posterior five-sixth part and substantia propria of cornea in anterior one-fifth part. Epithelium covering the superficial surface of cornea is derived from surface ectoderm. The inner vascular layer forms: choroid, ciliary body and iris.

The lens is encapsulated initially by vascular capsule, tunica vasculosa lentis. Posterior part of lens capsule is supplied by hyaloids artery. Later during 8th month of fetal life distal part of hyaloid artery disappears, eventually posterior part of vascular capsule disappears due to lack of vascular supply. The proximal part of hyaloid artery persists as central artery of retina. Pupil is initially closed by papillary membrane. During 6th to 7th month it disappears due to regression of the anterior choroid artery.

Vitreous is derived partly from ectoderm and partly from mesoderm.

Development of muscles of eye.

The sphincter papillae and dilator papillae muscles are of ectodermal origin, from optic cup. The ciliaris muscle mesodermal in origin.

Anterior and posterior chambers are formed by splitting of mesoderm.

Blood vessels of eye

They are mesodermal in origin. The central artery and vein of retina runs through the substance of optic nerve.

Visual development

The visual cortex is the part of the cerebral cortex (Area Number 17, 18 and 19) in the occipital lobe of the brain responsible for processing visual stimuli. The central 10° of field (approximately the extension of the macula) is represented by at least 60% of the visual cortex. Many of these neurons are believed to be involved directly in visual acuity processing.

In a full term infant, like brain the eyes are relatively well developed compared to other organs in the body. The axial length of the globe which is 17 mms grows fast in the initial 2 to 3 years of life and later very slowly reaching its adult size of around 24 mms by age 20 years approximately. At birth, the visual acuity is poor probably in the range of 6/60 and less. This is mainly because of the most immaturity of the visual processing system including the visual centers in the brain. The visual acuity rapidly improves in the initial 3 to 4 months of life, provided there is a clear media allowing a clear focused image formation at the fovea, which in turn sends the stimulus to lateral geniculate body and the visual centres in the occipital cortex towards their normal development both in anatomical and functional aspects factors

Visual mile stones

	Age	Visual mile stone
1	29 week gestation	Papillary reaction to light
2	Birth to 1 week	Fixation present, follows horizontally moving objects
3	4- to 8 weeks	Follows vertically moving objects
4	3 month	Watches movement of own hands
5	5 months	Blink response to visual threat [menace reflex]
6	6 months	VEP acuity adult level stereopsis
7	9 months	Visual differentiation and pickup small objects
8	3 years	Vision 6/9 to 6/6 on tumbling -E.
9	5 to 7 years	Stereopsis well developed.
10	10 years	End of critical period of monocular deprivation.

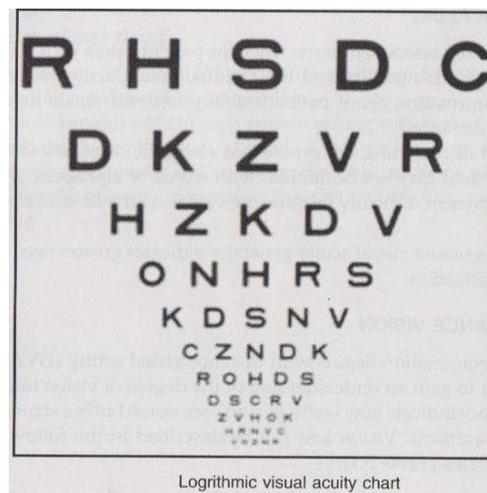
Visual acuity assessment

It has been well accepted that visual function assessment tells in general about the function of the entire globe. Since the visual system is immature in children and bound for developing amblyopia during the early years of life, the detection of visual loss in any one eye is mandatory to prevent them going in for permanent loss of vision. In other words this visual loss could be reversed, if detected and intervened with proper therapy at an appropriate age. This emphasises how accurate the visual acuity estimation should be especially in cases of motility disorder and in presence of refractive errors especially when they are unequal in nature. In diseases like cataract, glaucoma etc the visual acuity can be judged to a certain extent by the severity of disease whereas in strabismus it is difficult to do so because the decreased visual acuity is often due to the presence of amblyopia or and refractive errors.

Only with an experienced person it becomes possible to estimate the correct visual acuity in infants, toddler and preschool children since they are not verbal for subjective methods. Their attention span is little; necessitating an attentive observer with a lot of patience. Most of the time this can be achieved along with the cooperation of the parents. Though their role is important, they should not be interfering too much with the examiner's techniques. Adopting a particular method for a particular child allows proper monitoring during amblyopic therapy.

Clinical Methods of Assessment of Vision

Visual acuity can be estimated both objectively and subjectively. Subjective test can only be used in order children. Objective assessment is used when the patient is too young. Resenting occlusion of any one eye is an indicator of poor vision in that eye. Up to 6 months of age cover one eye and try to move the target object (mother's face, small toy) up, down, sideways always watching for a smooth pursuit movement with central fixation. Central fixation means that the patient looks directly at the target, not off center, and will smoothly and accurately follow the target. If the patient has trouble at fixing the target and appears to be looking off-center, indicates poor fixation and vision. On rough estimation, it is said that when the eyes have central, steady fixation and maintained equally well in both eyes the acuity is said to be 6/6, if one eye is dominant to fix and the other eye squints after a blink it is 6/9 in the squinting eye, when the squinting eye fixes only after covering the fixing eye but hold the fixation, it is about 6/12 to 6/18, able to fix but not hold it, the vision is around 6/24 to 6/60, in presence of unsteady fixation it is less than 6/60, Eccentric to no fixation it is less than 1/60. It is important to test each eye individually, as with both eyes open, the eyes will track together even if one eye is blind.



Measurement of visual acuity

The visual acuity tests can be grouped as follows-

Detection acuity tests

These assess the ability to detect the smallest stimulus without recognizing correctly. The common detection acuity tests are

- Dot visual acuity test.
- Catford drum test.
- Boek candy bead test.
- Stycar graded ball's test.
- Schwarting metronome test.



Recognition acuity tests

These are designed to assess the ability to recognise the stimulus or to distinguish it from other competing stimuli. They can be listed as follows

Direction identification test

- Snellen's e-chart test.
- Landolt's c-chart.
- Sjogren's hand test.
- Arrow's test.

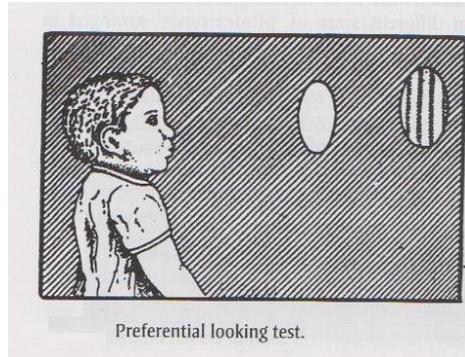
Letter identification tests

- Snellen's letter chart test.
- Sheridan's letter test.
- Flook's symbol test.
- Lipman's hotv test.

- | |
|---|
| (A) Test for children less than one year of age
1) Keeler acuity card.
2) Visual evoked potential (VEP). |
| (B) Children 1-3 years of age
1) Cardiff visual acuity test |
| (C) Children 3-5 years of age
1) Sheridan Gardiner test (Matching Test)
2) Crowding cards
3) "E" Test
4) Picture charts |
| (D) Children : 5 years and older
1) Snellen's test |

For infants or less able children, the test using the principle of preferential looking has been developed. It is a psychophysical method for early detection of deficits in the development of the visual system. This is based on the principle that a child looks at a patterned stimulus rather than an unpatterned one because a patterned grating is intrinsically more interesting than a uniform field. This means, if a grating consisting of alternating black and white stripes is paired with a uniform gray field, the infant will prefer to fixate the grating pattern. The infant's eye movements can then be used as a reliable measure of its ability to resolve the grating. Each kit has 18 cards, rectangular in shape with two areas one with stripes and the other uniform gray as the background with a central 2 mm opening for the examiner to view the child's response. The card is held in front of the child at 50 cms distance and the examiner who is sitting in front of the child is forced to make a choice by looking through the central hole regarding the child's preferred fixation. This is followed with the cards with less spaced stripes. Each card will have its equal

Snellen's acuity written at the corner which gives the accurate measurement. The disadvantages of this test are, it needs an experienced examiner and is a time consuming procedure.



Visual evoked potential (VEP)

Pattern reversal and sweep VEP have been used to estimate vision in infants.

Children 1-3 years of age

Cardiff visual acuity test

The Cardiff test is easy to use and those being tested require little or no explanation. This test consists of black and white stripes on a neutral grey background; the average luminance being equal to the background. The optotype fades completely into the background when the retinal image is not resolved, making it invisible rather than blurred. The Cardiff acuity test has many potential advantages over grating preferential looking tests in the clinic. It is quicker, more user-friendly and is generally liked by the children. The end point is often very clear cut, the child suddenly losing interest when no shape is perceived.

Children 3-5 years of age

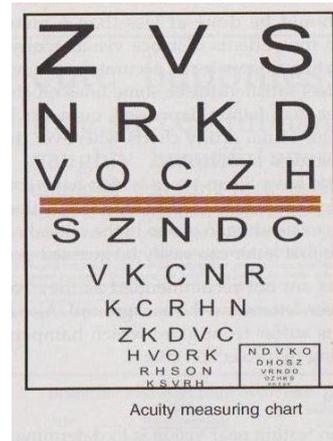
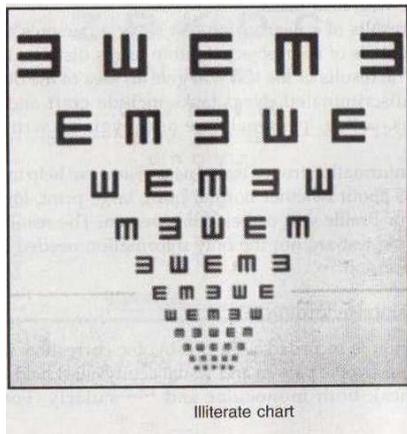
Sheridan Gardiner test (Matching Test)

This test uses letters which are basically circular, square or triangular shapes, which children can recognize and copy at an early age. The letters VTOHXAU are used and are shown to the child one at a time on flip-over cards. The child is given a key card showing all the letters, which he or a parent holds, and he points to the letter he sees. Most 3 year olds can be taught this test. It may be tried in younger children, who are able to co-operate.

It is best to teach the child how to do the test at ½-1m distance, first showing him the letter which most children find the easiest, asking him to find the matching letter. Once the ability is assessed, the flip charts are shown 6m, or if this is impossible at 3m; for the child to match the same letter in the key card which is given to him. A simpler version of the test using only the letters HDTV is available. The Sheridan Gardiner test is the most accurate of the illiterate vision tests. The choice of letters is large enough to avoid the child guessing and it is easy to use. Now at the market various types of matching cards are available like LEA symbols.

“E” Test

This test is also based on matching shapes, where a wooden or plastic letter E is turned up, down, to right or left to match the position of the E on the chart or card. The child should first be taught to do the test at a near distance. Young children have difficulty in matching the E when it is turned to right or left. Guessing can occur because the choice is limited to 4 positions. If this test is used try to use vertical presentation of E. However, this test is widely available and is easier to obtain than the Sheridan Gardiner test.



Children: 5 years and older

Snellen’s test

This test mainly comprises letters arranged in horizontal rows of diminishing size (linear vision charts). Similar charts use numbers instead letters. Vision measured with linear charts is normally slightly less than vision tested with single letters, as in the Sheridan Gardiner test. Linear vision is a better measurement of the patient’s true visual acuity and these charts should be used as soon as possible. To start with, it may be necessary for the examiner to point to each line or even to each letter but this should be avoided as soon as cooperation allows.



The acuity of vision is determined by the smallest retinal image, the form of which can be appreciated, and it is measured by the smallest object, which can be clearly seen at a certain distance. In order to discriminate the form of an object, its several parts must be differentiated; and if two separate points are to be distinguished by the retina, it is probably

necessary that two individual cones should be stimulated. Histological measurement has shown that the average diameter of a cone in the macular region is 0.004 mm; this therefore represents the smallest distance between two cones. It thus appears that a normal eye should be able to appreciate a retinal image of this size, and although the standard varies very markedly between individuals, this estimate has on the whole been corroborated by subjective experiments. These principles have been embodied in Snellen's Test Types, which are now used almost universally in testing the visual acuity.

CONCLUSION

It has been well accepted that visual function assessment tells in general about the function of the entire globe. Since the visual system is immature in children and bound for developing amblyopia during the early years of life, the detection of visual loss in any one eye is mandatory to prevent them going in for permanent loss of vision. In other words this visual loss could be reversed, if detected and intervened with proper therapy at an appropriate age. This emphasises how accurate the visual acuity estimation should be especially in cases of motility disorder and in presence of refractive errors especially when they are unequal in nature. In diseases like cataract, glaucoma etc the visual acuity can be judged to a certain extent by the severity of disease whereas in strabismus it is difficult to do so because the decreased visual acuity is often due to the presence of amblyopia or refractive errors. Visual acuity testing in children is most important in rule out amblyopia and refractive errors.

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