Chapter

Ophthalmologic Examination of the Child

Suzana Konjevoda, Neda Striber, Samir Čanović and Ana Didović Pavičić

Abstract

The ophthalmologic examination of the child consists of an assessment of the physiological function, anatomic eye, and visual system status. A comprehensive eye examination of the child should include history of presenting problem, patient's and family's medical histories, estimation of fixation and measurement of visual acuity, assessment of binocular vision, Bruckner test, assessment of ocular motility, Hirschberg's test, cover/uncover test, and assessment of anterior and posterior segments. The order of examination may vary depending on the child's cooperation. The record of the child's level of cooperation during the examination is of great benefit in the interpretation of the results.

Keywords: examination, strabismus, child, visual acuity, binocular vision, ophthalmological assessment

1. Introduction

The ophthalmologic examination of the child consists of anamnesis or, in this case, heteroanamnesis, physiological function evaluation, and anatomic eye and visual system status. The record of the level of cooperation of the child with the examination is of great benefit in the interpretation of the results. The order of the examination may vary depending on the level of child's collaboration. The visual acuity test should be done before the fusion break test, as well as the visual acuity and bulbomotor examination before using cycloplegic [1].

Examination should include the following elements:

1. Anamnesis

2. Clinical examination

The following tests are of particular importance when examining a child but are indispensable when there is a strabism. If we do not set suspicion of strabism when we examine the child, we can skip some of the following steps:

- Estimation of fixation and measurement of visual acuity

- Testing of binocularity/stereovision

- Binocular red reflex (Brückner) test
- Motility/versions and vergency
- Hirschberg's test
- Cover/uncover test
- Strabismic angle measurements
- Examination of the anterior eye segment
- Skiascopy
- Fundus examination

There are numerous divisions of strabismus—according to the time of occurrence, presumed etiology, direction of visual axes, that is, clinical manifestation, frequency, affected eye—only to name some [2]. The simplest is the one dividing the strabismus on congenital and acquired forms. In the former, in the vast majority of cases, the etiology is unknown. Actually, it is not present from the birth on but usually occurs and develops in the first months of life. Therefore it might be better to name them early onset strabismus than congenital [3].

On the contrary, acquired strabismus occurs later, and usually the cause of the disorder is discovered.

Sometimes early onset strabismus is also named primary, in which case the eyes are healthy. Secondary strabismus is a consequence of an eye disease.

The strabismus terminology also includes consecutive forms, describing the cases that in time, spontaneously or as a consequence of extraocular muscle surgery, and changes the visual axes direction, from convergent to divergent or vice versa.

Primary importance of strabismus is that it can lead to amblyopia. The risk for it is much higher in unilateral forms—only one eye is constantly deviating. Consequently, due to asymmetric input, active suppression of the impulses from the deviating eye occurs, later leading to amblyopia. In alternating strabismus, the child switches fixation between the two eyes, and the risk of amblyopia is much lower. Nevertheless, in both forms, due to different visual axes direction, stereopsis is lost. Another possible consequence of strabismus is anomalous head posture. By turning or tilting the head, the patient seeks the position in which he or she still can maintain both eyes directed to the fixation point—this state is named orthotropia. Sometimes patients have manifest strabismus even in anomalous head position, but that position gives them better vision. The underlying cause can be nystagmus or the different tonus in antagonistic muscles.

2. Ophthalmologic examination of the child

2.1 Anamnesis

The ophthalmological examination begins with an anamnesis; when we talk about the examination of a child, it is actually about heteroanamnesis. The information is usually obtained from a parent or guardian of a child. There are general anamnesis (past illnesses), ophthalmic history, family history, drug taking, and drug allergy. Attention should be paid to premature birth, family history, and hereditary diseases in the family [4].

The general (hetero)anamnesis should also be very detailed. Important data are also about prenatal development—risk factors and possible complications in pregnancy. Intrauterine growth failure, the presence of other anomalies, or premature labor is associated with a higher frequency of strabismus. Even 35% of premature infants develop strabismus, often associated with higher refractive anomalies. Therefore, an ophthalmologic examination of each premature child is recommended, certainly within the first year of life, preferably at the age of 6 months.

Family anamnesis often reveals the existence of other family members who have strabism or refractive anomalies. If one parent squints, the risk of a child having strabism is 15%, and if both parents have strabismus, that risk is as high as 45%. If the family history is positive to strabismus, refractive errors, and weakness, an ophthalmic examination is required before the age of 3.

Ophthalmological anamnesis: It is important to find out when the strabismus occurred—in the first months of life or later, whether the occurrence is sudden, "overnight," or whether it was gradual, in the beginning only intermittent, becoming constant with time. It is important to know when the child is tired or sick and whether it changes during the day. Sometimes the eye is deviating only when the child is looking in the far distance or while "daydreaming" and at near fixation and with attention eyes that are straight. Some squints are manifest only under certain circumstances—for example, when exposed to the bright light (intermittent exotropia) or when the child wants to see some tiny details at near (accommodative esotropia). It is also important to know whether the strabismic angle is stable—increasing, decreasing, or constant through the follow-up. Sometimes parents are not sure about the direction of deviation. Photos or drawings of convergent and divergent forms of strabismus help parents to show what they see in their child. It is always necessary to ask whether the deviation changed the direction—sometimes early convergent strabismus with time changes to divergent type. Therefore the parents should be asked whether in the beginning there was an inward turn of the eye, toward the nose, only later to change to outward turn. Very important question is which eye is deviating—always the same or the child switches fixation between the eyes, while the other eye is deviating. Often the parents of the child with divergent squint say that they never know what the child is looking at. In vertical forms, parents usually say that in some gaze direction, child's eyes are looking strange or weird. Parents can also share the information about some unusual head position and whether that is present all the time awake or only when the child is trying to see something better. Sometimes the anomalous head position occurs only during prolonged looking in the same direction. The information about anomalous head position is also important in view of strabismus treatment prognosis. If there was a period in life when the patient constantly held the head in the same anomalous position, it might be presumed that it was for maintaining the learned binocularity that could return after surgical correction of strabismus. In sudden occurrence of strabismus, somewhat older child can tell it's parents that it sees double. Younger children are not able to tell that, but it can be noticed that the child squeezes one eye to avoid diplopia. The younger the child, the period of double vision will be shorter, because suppression will develop sooner, so sometimes parents forget about this information if not specifically asked.

2.2 Clinical examination

Inspection is the first part of the clinical examination of the patient with strabismus. Even when we talk to parents, we can observe the child—whether there is an impression of the wrong orientation of the sight axes and where the sight axes are oriented (convergent, divergent, and vertical strabismus) [5].

3. Evaluation of fixation and visual acuity

The visual function test methods depend on the age of the child.

By the age of 2 of the child, a subjective reflection may be used to examine the reflection of blinking on a very light pupil reflex, fixation, and the monitoring of the colorful objects that are offered to the child for looking at [6].

The first examination is binocular and then monocular: is the fixation of child's view on the object, is fixation maintained, and is the object of fixation followed. Fixation reflex can be examined at the 3–4 months of age.

Objective methods can cause optokinetic nystagmus (OKN), examine cortical visual evoked potentials (VEP), and evaluate visual acuity with a preferential looking test.

3.1 Determination of fixation type

Occlusion of one eye is made.

1. If the child instantly fixes the source of the light, whose reflex is in the center of the pupil, then it is central fixation.

2. If a child looks at the source of the light, but the eye which has to take the fixation does not come to the middle position, it is eccentric fixation.

3. If the baby does not fix with an eye, then there is no fixation at all.

4. Determination of visualization by test pictures (star and circle) that are projected on the retina.

3.2 Preferential looking test

The method of visual acuity that is based on the observation of the child's eyes, to which of the two offered fields will the child first look at (homogeneous gray and striped black and white). Children prefer to look at more interesting, striped objects. As the width of the black and white stripes becomes more and more like a gray homogeneous field, it is harder to spot the difference, and if the child is aware of the slightest difference between the stripes, the visual acuity is neat.

This method is suitable for using from the 4 months of age.

3.3 Examination of visual acuity in children 2: 4 years of age

After the child starts to speak, the visual acuity is examined by standardized tests with close-range and distance-based image optotypes. These are the first tests that examine the visual acuity quantitatively [7].

The most commonly used standardized tests are Lohnlein's tables and Lea symbols.

Lea test table consists of four symbols (circle, square, house, and heart) that are shown in each of the following order in a smaller size. Tested at 3 meters distance and not at 5 or 6 meters as well as other tests and less environment distracts the child. The same symbols can be used to examine visual acuity at close. The test is standardized according to Snellen's table.

3.4 Examination of visual acuity in children older than 4 years

The gold standard for testing is Snellen's tables. Snellen's board consists of rows of optotypes (letters, numbers, and hooks). Each part of Snellen's optotype corresponds to a visual angle of 1 minute, unlike the image optotypes that do not hold that rule, such as the smallest pictures of image optotypes that should match the visual acuity of 1.0, that actually correspond to the visual acuity of 0.66.

Landolt's rings are also based on the Snellen's principle (the width of the ring opening is 1 angular minute). The flaw is that it can only be used with the children who learned how to tell time.

3.5 Visual acuity test weaker than 0.1

It can be done with individual Snellen's optotypes. We approach the child gradually, and at the distance at which the optotype is properly recognized, we note the visual acuity in the form of a break. If a child from 1 meter of distance detects the direction of Snellen's largest optotype, then the visual acuity is 1/60. If the child does not reveal it, we ask him to count the fingers on our hand and write down where the child is at a distance (30 cm, right in front of the eye).

If we doubt the weaker eyesight, we are examining the sensation of light and the projection in the dark room. It is tested with a lamp at a distance of 1 meter and by turning on the light from the upper, lower, left, and right sides. We write down neat sense of light and projection as L+ P+.

4. Binocular vision tests/stereo vision tests

Binocular single vision is simultaneous viewing of both eyes at the same point of fixation, which realizes a single image of the object [8].

4.1 Binocular vision elements by worth

Simultaneous perception (at the same time, at the two corresponding retinal points of both eyes, a likeness of approximately the same size is created.)

Fusion reflex (a psycho-optical reflex that connects two figures to one if they are formed at corresponding points).

Stereovision (stereopsis—disparate characters merge with a sense of space and depth) or depth perception can be characterized as the highest degree of binocular vision.

4.2 Motor binocular vision component

Motility and ocular motor balance make the motor component of binocular vision. The muscular system of eye mobility has enabled the image of the fixation object to be held in the fovea in each eye individually, and that fusion segment is called the motor fusion.

Sensory component will at the level of the visual cortex of two visible impressions merge into one. The sensory component consists of a retinal correspondence and a reflection of binocular vision. Its basis is normal retinal correspondence thanks to which we see single using two eyes, because the characters formed centrally merge creating a single perception.

4.3 Tests for stereopsis examination

Testing with Bagolini's striated glasses is the most important test of simultaneous perception, because of its minimal dissociation results which are the most similar to the natural viewing of the patient [9]. The glass slides used in the test are longitudinally twisted and turn the small lamp into a luminous line vertical to the glass' striation. The straps are oriented right and left in front of the eye so that the lines are at right angles. The orientation of the line as the patient sees it is usually marked on the edge of the glass slide itself with dots. It is very important to know how the slides are oriented, because our interpretation of the test result depends on it. Usually they are set to have a right eye line at 135° and left at 45°. In the state of orthotropy and proper binocular vision, the patient sees two lines passing through the light itself, like the letter X. If there is strabismus and simultaneous perception, the patient will see both lines, but they will not cross in the light itself. If Bagolini's slides are oriented as indicated above (right line at 135°, left at 45°), the patient with esotropia sees two lines and one light on each one, and the lines will be crossed over the light (non-crossed double images). If it is a case of exotropy, the lines are crossed under the light (crossed double images). If there is a central scotoma on a stray eye, the line of the eye in the middle of the light will not be visible but only the ends of the line. Depending on their position, we can also find out whether they are associated with normal or anomalous retinal correspondence. Finally, in the case of suppressing a stray eye, the patient will see only one line—the one of the eye which is fixing the light.

This test can be performed not only in the straightforward but in different directions of view. It is advisable to examine the direction of view where the smallest, or visible, axis of the eye is the closest (e.g., in the V exotypically downward model) to assess whether a functional case with potential binocularity or only esthetic case (constant exclusion of one eye with Bagolini's). This test can also be performed after the prism adaptation test, whereby both sight axes are directed to the fixation object. Bagolini's striated glass is placed in front of the lenses, and the patient's responses are evaluated.

With the fusion test using the prisms, we can examine whether there is bifunctional fixation and what is the potential of motor and sensory fusion. In the test, we use a prism of strength of 14 or 15 diopters because the induced fusion motor displacement is large enough to be perceived. It is very good for small children within the first year of life; in older children the cooperation in this test is somewhat weaker.

The test is carried out by drawing the child's attention to the fixing object of fixation of the appropriate size and placing the base of the prism temporally.

Titmus test is tested with polarizing glasses. After the spectacles are placed, the respondents are given cards with different characters displayed in different depth positions. The first test is a test of the rough Fly-fly test. The person with stereo vision sees the fly in three dimensions, and the baby catches the wings of the fly with its fingers. The following is examined for the finer stereopsis: the characters are placed in rows, and in each row one character rises above the others. The last test is circle test, four circles within nine groups; one circle of each group rises. Titmus test quantifies the level of stereopsis in the angle seconds.

Lang test card is a screening test designed for early detection of problems with stereoscopic vision in children. Two versions of the test plates are available, which differ only according to the 3D objects to be recognized. The Lang test 1 displays a star, a cat, and a car, while the Land test 2 displays a moon, a truck, and an elephant, each of them appearing on a different level. No glasses are necessary for the Lang Stereo Test.

5. Hirschberg's test

Using the Hirschberg's test, we determine the size of the squinting angle depending on the position of the reflex position on the cornea when simultaneously illuminating both eyes.

The patient is said to look at the top of the lamp. The position of the light reflex in relation to the center of the cornea of one eye and the position of the reflex light of one in relation to the other eye are compared.

The difference in the position of reflection on the cornea of the right and left eye raises the suspicion of strabismus. If the reflex is shifted from the center of the eye nasally, the impression of divergent strabismus of that eye is obtained, if shifted temporally—convergent. Reflex shift upward points to hypotrophy and downward to hypertrophy of that eye. It is important to note that it is always necessary to compare the position of reflexes on the right and left eye, since sometimes it is seen that reflexes of both eyes are slightly decentralized. Only the difference in position indicates the existence of strabismus. In small children where measurement of the strabic angle is not yet possible by other methods, the deviation can be semiquantitatively determined by the reflex position. In this case 1 mm difference in the reflex position corresponds to the angle of about 7°. With this test we can easily examine the existence of angle difference in different directions of view. The child follows the source of light as we look at the change in the position of the reflex on the corneas.

The reflex shift for 1 mm is equal to the displacement of 7°, which is 15 DP.

According to the reflex position, the angle is determined according to the following anatomic determinations: if the reflex at the periphery of the pupil is 15° or 30 DP, the reflex in the center of the iris determines the angle of 30° or 60 PD; the limbus position determines the angle of 45° or 90PD.

Hirschberg test is fast and simple, but unfortunately not accurate enough. Both the specificity and the sensitivity are rather low.

There are cases of eccentric fixation where one could, based on corneal reflex position, presume the presence of strabismus that actually is not there (false positive, low specificity). Eccentric fixation is common in ectopia of macula lutea due to retinopathy of prematurity. Strabismus associated with eccentric fixation might be operated on only if the eccentric viewing eye is not the better, fixating eye. The angle formed by visual axis and central pupillary axis is called angle kappa, and it is present in most people. Positive angle kappa (nasal shift of the corneal reflex) gives the impression of divergent strabismus, whereas negative angle kappa (temporal shift of the corneal reflex) resembles convergent strabismus. The asymmetry of angle kappa between the eyes can arouse the suspicion of strabismus that actually is not present (false positive, low specificity). In small strabismic angles—microstrabismus—the difference in corneal light reflex position is too small to be detected (false negative, low sensitivity).

6. Brückner's test

A very fast, equally simple, but more sensitive test is a test of observation of red eye reflection of the bottom of the eye or the Brückner's test. It is easy to perform and is very accurate right in the first year of life; from about 4–5 months when foveal fixation is already developed, it has its value in small angles of squinting, anisometropia and amblyopia, high hypermometry and myopia, and cataracts in young, noncooperative children.

With simultaneous enlightenment of both eyes with ophthalmoscope light, through the ophthalmoscope, we see whether there are differences in intensity between the light of reflex of the right and left eye fundus. It is best to use a direct ophthalmoscope, where illumination and observation are coaxial. We sit on about 70 cm from the patient and several times briefly illuminate both eyes, to prevent narrowing of the pupils to the light.

Reflexes in the eye opening of the child facing the straight line will be dark, while the reflection of the eye in deflection will be significantly brighter.

The phenomenon arises because of the anatomical structure of the fovea itself, that is, the recesses, causing all the light that vertically falls on the fovea, that is, the foveola does not return to the ophthalmoscope but is reflected in the other direction in the eye of the patient—that is why the reflex of the eye fixed by the fovea is darker. With this test we can detect very small deviations of the position of the axes—but the deviation of 1–2° gives a difference in the light of the reflex. In addition to the detection of strabismus, this test also reveals the existence of refractive anomalies (amethropy and less anisometropia) by the analysis of light distribution in the pupil. Significant hypermetropia will be shown as inferiorly positioned bright semiprecious red reflection, while significant myopia will be shown as a super bright light half-moon in a red reflex.

The absence of a reflection from the eye bottom points to the blur of optical eye media (cornea, lens, or glass body). White or very bright reflexes (leukocytes) cause pathological changes in the eyelid, such as coloboma or retinoblastoma. It is important to note that even at this test, the accuracy of the detection of strabismus is not complete, because the difference in reflex can be caused by even greater anisometropies. From a highly amethropic eye, the beam of light is divergently reflected, so the reflex from such eye is dark, although the eye may be in deflection (falsely negative result).

7. Motility

When examining the eye movement, we first look at each eye separately (the other eye is folded by the hand) from the primary eye position in the direction of the action of each muscle in particular (movements of duction). The movements of one eye are called duction. The upward movement is elevation or supraduction and downward depression or infraduction. The inward move, toward the nose, is adduction and outward abduction. Torsional or rotational movements can be examined by head tilt—head tilt to the shoulder on the same side as the eye under investigation will cause incycloduction and to the opposite shoulder excycloduction. The movements of both eyes in the same direction are called versions. Right gaze is called dextroversion and left levoversion, upgaze supraversion, and downgaze infraversion. Oblique gaze directions are called supra-dextro/−levoversion and infra-dextro/−levoversion. Torsional movements can be examined here as well—right head tilt will cause levocycloversion (rotation to the left) and left head tilt dextrocycloversion (rotation to the right) [10].

The movements of both eyes in the opposite direction are called vergencies. If the eyes simultaneously move toward the nose, it is called convergence and outward—divergence. Simultaneous incyclorotation of both eyes usually accompanies convergence—this is called incyclovergence and with excyclorotation with divergence, excyclovergence.

Due to relative position of the extraocular muscles and eye globe, isolated action of vertical muscles—superior and inferior rectus muscles—should be examined in slight abduction (cca 20–25°) and superior and inferior oblique muscles in more accentuated adduction (cca 50°), because in the middle there is a combination of rectus and oblique muscle actions in the sense of elevation and depression.

The primary eye position exists when eyes fix an object that is at their height straight in front of them or in infinity (beyond 6 meters). All other positions in the eye that come up with the action of certain muscles are the diagnostic (secondary) positions of the eyes that are in the direction of the action.

There are nine viewpoints—the primary (straightforward), the central vertical position (straight and up, straight and down), and cardinal (up and left, left, down and left, up and right, right, down and right).

When there is a case of very young children, who still have no developed attention, eye movements are tested with a doll's head maneuver. Turning the head to one side causes a reflex eye shift to the opposite side, unless there is a mechanical restriction of movement or a myogenic weakness.

8. Cover/uncover test

The most accurate test for the detection of manifest strabismus is the eye cover test or the cover test [11].

The patient fixes the object in front of him. Penlight could be used for fixation, but it is better to use a target with shape (picture or an optotype), especially at near, because it stimulates accommodation, and the influence of accommodation on the deviation could be assessed in the same time.

The examiner alternately covers and uncovers only one eye. Coverage and uncoverage are performed several times, and we analyze eye positioning movements.

Cover test–test of coverage, the occluder covers the fixing eye. It follows the action of the other, uncovered eye.

Uncover test—detection test, the occluder uncovers-detects the fixing eye. When detecting, we follow the movement setting of the recently uncovered eye.

In the orthophoria, the eyes are not moving, no adjustment movement is present, and the cover test is negative.

Cover test is always tested with and without correction and in different directions of looking.

The test is very sensitive—it can reveal deviations as small as 1°. There are motoric and sensoric prerequisites that have to be fulfilled to make the test meaningful and valid—patient's fovea must be healthy, the eye must not be blind, and the eye must be able to move to take up fixation.

If the deviating eye is deeply amblyopic, it is hard for the patient to take up the fixation. Such eye often makes wondering movements trying to fixate the object, and sometimes it is hard to detect the direction of the first movement. In patients with nystagmus, it is also hard to detect the direction of the uncovered eye. Another disadvantage of the test is that it is not suitable and reliable in very small children (first year of life).

Cover test is followed by alternating cover test that can reveal latent strabismus (heterophoria) or additional latent component of manifest strabismus. The cover is alternated between the eyes and relatively fast, so the patient is fixating only monocularly—either by the right or the left eye. To relax the fusional mechanisms, the cover is held in front of the eye a little bit longer. The eye under cover could be observed from the side to see the slow slide of the eye into the anomalous position of muscular tone balance. When it stops, we quickly shift the cover on the other eye and observe now uncovered eye—what kind of movement and in what direction it makes. The magnitude of latent deviation indicates the amount of necessary effort to keep orthotropia—if the latent deviation is large, the demand on the central nervous system for keeping binocularity is substantial and can cause asthenopic symptoms. The direction of movement, just like in cover test, tells us what kind of heterophoria is present. In esophoria the eye shift is outward and in exophoria in the opposite direction—inward. In vertical phorias, if the right eye comes from above, and the left from below, we designate the movement as right over left (R/L) or plus vertical difference (+VD). If the movement is in the opposite direction—the left eye comes from above and the right from below—it is left over right deviation (L/R) or minus vertical difference (−VD).

Alternating cover test is followed by uncover test. After a few seconds of occlusion of one eye, the eye is uncovered and observed to see is there a fusional movement in order to regain binocularity. This test is very important because it give us information about the capacity of central fusional mechanisms that maintain binocularity. If the stress of dissociation under cover is too much for the system, the uncovered eye will stay in deviated position. Sometimes at near the fusional movement regains orthotropia, and at distance testing the uncovered eye does not move and stays in tropia. This is often the case in intermittent exotropia. Sometimes the uncovered eye does not reach the position of orthotropia; the deviation is decreased only for its latent component to the level of manifest deviation. If that manifest strabismic angle is small enough, visual system can even in this position preserve some level of binocularity, albeit anomalous. Uncover test can also be utilized in another important aspect. It can qualitatively determine the strength of eye dominance in patients with strabismus. The straight-looking eye is covered in order to shift the fixation to the strabismic eye. After a few seconds of stabilizing fixation on the accommodative object, the cover is removed. The speed of fixation shift to the uncovered eye indicates the strength of dominance but also the presence and level of amblyopia of the strabismic eye [12]. This could be semi-quantified, according to the length of holding fixation by the uncovered eye in bi-ocular viewing conditions. Based on this quantification, the length of dominant eye occlusion for treating amblyopia can be recommended even in preverbal children.

9. Strabismic angle measurement

There are objective and subjective methods for strabismic angle measurement. Objective methods include prism cover test (PCT) and Hirschberg test. The latter has already been described, together with its drawbacks, but usually it is the first test used for orientation about the direction and magnitude of deviation to shorten the measurement with PCT. Subjective methods are based on patient's response and therefore are suitable for older children and adults. They include Maddox cross method, Hess-Lancaster test, and tangent screen. They are based on diplopia recognition, and the dissociation is elicited by colored (red/green) or stripped glasses (Maddox rod) through which the patient looks. Dissociation could be also by physical separation of images, like in classic Maddox wing that is used for near deviation measurement or in major haploscope (synoptophore) with separate projection of images in the right and the left eye. In Hess-Lancaster or tangent screen method, the deviation is measured on calibrated screen in front of the patient on which the colored lights are projected. In Maddox cross method, calibrated cross with numbers representing degrees of deviation related to the distance on which the patient is seated and point light in the center is used for measurement. The dissociation is elicited by dark red glass in front of one eye, while the patient fixates the light in the center of the cross with the other eye. The patient is asked if he/she sees one or both lights—red and white. If the patient sees only one light, either orthophoria is present (both visual axes are directed toward the light) or there is suppression of one eye. If there are two lights—red and white—heterophoria is present. According to the relative position of the red and white light, the direction of deviation of the eye with the red glass is determined. If the red glass is in front of the right eye (the patient fixates the white light with the left eye), and the red light is on the right side of the white light, there is uncrossed diplopia, indicating esophoria. If the red light is on the left side of the white, crossed diplopia is present indicating exophoria. Similar is with vertical deviations—red over white light speaks for hypophoria of the eye with the red glass and red below white for hyperphoria of the same eye. The position of the red light on the Maddox cross determine strabismic angle in degrees.

The most accurate method for strabismic angle measurement is prism cover test (PCT). Similar to cover test, there are subtypes of this test—one that measures manifest deviation called simultaneous prism cover test (SPCT) and the one measuring the whole deviation (manifest and latent) called alternating prism cover test (APCT). This enables the determination of heterophoria component in the whole strabismic angle.

In SPCT, the prism with apex directed toward the direction of deviation is placed in front of the strabismic eye simultaneously with placing the occluder in front of the straight-looking eye. We observe the residual eye movement and change the prism strength as long as the eye under prism does not move anymore. This is the way to measure the manifest part of strabismic angle.

SPCT is followed by APCT in which we leave the found strength of prism in front of the eye, but now we shift the occluder between the eyes and observe possible movements. If there is a residual movement, we increase the strength of the prism to the point when eyes are still. The found prism strength equals the whole strabismic angle—added manifest and latent deviation. It is important to know that sometimes in measuring esotropia with very weak or no binocular potential, it is impossible to achieve the state without eyes' movements—there is always the same small outward movement from eso position. One should decrease the strength of the prism to the value when the movement increases and again increase the strength to the point of smallest outward movement—state of small microstrabismus—and this is the true value of measured angle.

Both tests are performed at near and far distance fixations, but in small children sometimes this is not possible. Some entertaining distance fixation objects (animated feature or dancing mechanical toy giving attractive sounds) significantly improve child's cooperation.

10. Skiascopy/retinoscopy

The retinoscope is an instrument used to objectively determine the refractive strength of the eye. It works on the principle that the retinoscopic probe projects a beam of light into the eye and then observes the light reflecting on the retina. Depending on the refractive strength of the eye, the beam of the light coming out of the eye will be of different character, with the myopia of the radiating ray converging, at the hypermetropia the output rays diverge, and in the emetropy the radiating rays leaving the eye are parallel.

During examination, the examiner performs small movements with the retinoscope up/down and left/right, and in the pupil observes the movement of the "shadow of light," and then uses different lenses in the eye to neutralize the reflex.

In the miope, the light reflex moves in the opposite direction to the retinoscope movement, and in the hypermetropic light, reflexion moves in the same direction.

Skiascopy is performed only when cycloplegic accommodations are pharmacologically excluded. To achieve cycloplegia in newborns and infants, tropicamide in 0.5% concentration is used. In older children 1% tropicamide is used. The drops should be instilled twice, 10 minutes apart, and the maximal cycloplegia is reached in 35–40 minutes. In this age, 1% cyclopentolate, minimally stronger acting cycloplegic, could also be used. Maximal cycloplegia is reached in 40–50 minutes. Atropine in 1% concentration is due to prolonged cycloplegia rarely used, but sometimes in children with limited cooperation or if variable result of refraction is found with shorter acting medications, this cycloplegic could also be used. The skiascopy is useful in prescribing corrective lenses to patients who cannot undergo subjective examination of visual acuity (adults with limited intellectual ability and children with a high accommodative eye power that must be excluded because it can mask an objective refraction error).

11. Fundoscopy

In children with strabismus, inspection of the eye fundus is unavoidable part of the examination. Organic disease as the cause of the eye deviation must be excluded. Posterior pole scars, coloboma, but also malignancies such as retinoblastoma can lead to instability or loss of fixation and strabismus. Unfortunately, peripherally situated tumors do not have to give signs of the disease in the beginning. Therefore, ophthalmoscopy in mydriasis is recommended even within usual, routine ophthalmological examination in children. Indirect binocular ophthalmoscope is the instrument of choice, due to its simplicity, speed, and the possibility to examine peripheral parts of the retina. It is recommended to use the least light intensity that still gives reliable picture to encourage child's cooperation. The attention and gaze direction change could be achieved by sound toys, like in motility exam, in order to get a glimpse on peripheral retina. Loupe of 20 diopter is usually used, as it gives optimal relation between field of vision and image magnification. If some pathological change is found, other loupes with less dioptric power (e.g., 16 d), giving bigger image, can be used, but the field of vision is less here. They are also suitable for posterior pole examination.

Author details

Suzana Konjevoda[1], Neda Striber[2]*, Samir Čanović[1] and Ana Didović Pavičić[1]

1 General Hospital Zadar, Zadar, Croatia

2 Childrens' Hospital Zagreb, Zagreb, Croatia

*Address all correspondence to: striber.neda@gmail.com

References

[1] Willshaw H, Scotcher S, Beaty S. In: Willshaw HE, editor. A Handbook of Paediatric Ophthalmology. Birmingham, UK; 2000

[2] Čelić M, Dorn V. Strabizam i Nistagmus. Zagreb: Medicinska Naklada; 2004

[3] Jin YH. Strabismus. Ulsan: UUP; 2001. pp. 205-225

[4] Lang J. Strabismus: Diagnostik, Schielformen, Therapie. 4. izdanje ed. Bern, Gottingen, Toronto, Seattle: Hans Huber Verlag; 1994

[5] Rosenbaum AL, Santiago AP, editors. Clinical Strabismus Management. Philadelphia, London, Toronto, Montreal, Sydney, Tokyo: W.B. Saunders Company; 1999

[6] Bremond-Gignac D, Copin H, Lapillonne A, Milazzo S, European Network of Study and Research in Eye Development. Visual development in infants: Physiological and pathological mechanisms. Current Opinion in Ophthalmology. 2011;**22**(Suppl):S1-S8

[7] Dorn LJ. Vid i vidna oštrina u male djece. Paediatria Croatica. 2004;**48**(Suppl 1):247-254

[8] Von Noorden GK. Binocular Vision and Ocular Motility. St Louis: Mosby; 1996

[9] Petrinović DJ. The Script from Continuing Education Course: "Diagnostic and Therapeutic Procedures in Strabology and Pediatric Ophthalmology". Zadar; 2008-2017

[10] Boergen KP. Oblique Muscles Disorders. Courses of Continuing Education: "Diagnostic and Therapeutic Procedures in Strabology and Pediatric Ophthalmology". Zadar; 2008-2017

[11] Von Noorden GK, Campos EC. Binocular Vision and Ocular Motility: Theory and Management of Strabismus. 6th ed. St. Louis, Missouri: Mosby; 2002

[12] Dickey CF, Metz HS, Stewart SA, Scott WE. The diagnosis of amblyopia in cross-fixation. Journal of Pediatric Ophthalmology and Strabismus. 1991;**28**(3):171-175