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ASSESSMENT AND MANAGEMENT OF PEDIATRIC PATIENTS WITH AMBLYOPIA – CLINICAL GUIDELINE FOR FINNISH OPTOMETRISTS

An Innovation Project

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ABSTRACT

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Purpose: This thesis project aimed to construct clinical guidelines for Finnish optometrists on assessing and managing pediatric patients with amblyopia.

Methods: This innovation project is a literature review analysis-based research project for Finnish optometrists. The Finnish Ethical Council of Optometry (OEN) ordered the guideline. The innovation project was performed between February 2023 and August 2023. The project included a literature review and clinical practice guideline. The first phase was a literature search on pre-existing valid guidelines and recommendations on amblyopia assessment and management. Competence and geographical points of view were used in the selection. The second phase was to conduct a comprehensive literature review of the Pediatric patient's amblyopia assessment and management. The final phase was to produce the clinical guideline based on the literature review and valid existing guidelines and recommendations.

Results: The first result of this innovation project is a literature review on amblyopia in Pediatric patients based on the literature search. The second result is a clinical guideline for Finnish optometrists about pediatric patients' amblyopia assessment and management. The clinical guideline consists of anamnesis / patient history, ocular examination, and management, including occlusion therapy, penalization, new treatments, follow-up evaluation and treatment compliance, and interaction with pediatric patients. The guideline is presented in English and Finnish.

Conclusions: The results confirm the necessity of this guideline, as there was no publicly available amblyopia guideline in Finland. Finnish optometrists are already involved in amblyopia assessment and management in university clinics and private hospitals. Given the aging population, the demand for healthcare services is expected to increase. Therefore, there is a growing need for collaboration between ophthalmologists and optometrists, as well as a re-evaluation of our respective responsibilities.

Keywords: amblyopia, guidelines, optometry, amblyopia assessment, amblyopia management

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1 INTRODUCTION

The need for healthcare services will increase due to the aging population, and the prevalence of lifestyle diseases is also rising. As a result, securing enough competent healthcare professionals and maintaining the quality of service will become more challenging. Therefore, in eye care, it is crucial to develop new strategies and redefine work divisions to ensure adequate public healthcare resources. Even presently, the resources for public healthcare are insufficient. The situation is further exacerbated by the COVID-19 pandemic, which leads to prolonged waiting periods for receiving adequate care. It is essential to address the provision of eye care for the elderly by future specialized clinical professionals. However, we must also not overlook the need to reform children's eye care.

In Finland, ophthalmologists have traditionally been the sole professionals responsible for caring for children with amblyopia. However, an increasing number of optometrists have received training in amblyopia assessment and management at university hospitals and private clinics, as optometric education has become more clinically focused. Consequently, there is a need for a clinical guideline specific to Finnish optometrists regarding the assessment and management of pediatric patients with amblyopia. The literature review conducted as part of this innovation project also provides additional information for healthcare professionals.

This thesis aims to create guidelines for Finnish optometrists regarding assessing and managing children's amblyopia, intending to increase knowledge in this area. The guideline has been commissioned by the Finnish Ethical Council of Optometry (Optometrian Eettinen Neuvosto - OEN), which operates under the Finnish Association of Vision and Eye Care (Näe Ry) and the Finnish Optometry Union (Suomen Optometrian ammattilaiset - SOA Ry).

2 THEORETICAL BACKGROUND

The theoretical background consists of visual development, the definition of amblyopia, the prevalence of amblyopia, underlying factors contributing to amblyopia, assessment of amblyopia, and finally the management of amblyopia.

2.1 Visual Development

Infants are born with undeveloped visual systems, with incomplete ocular and neurological components. They are typically born hyperopic, allowing their eyeballs to reach the correct size through growth. Various factors, including visual stimulation and postnatal nutrition, influence the maturation of their visual system. (Brémond-Gignac et al. 2011; Daw 2014, 103.)

During infancy, infants can observe and recognize their mother's face, perceive colors, detect biological motion, and discern depth. Their light and dark adaptation at birth will likely be close to normal. However, their visual acuity is significantly poor, measuring less than 10 % of normal, which means they are considered legally blind. (Daw 2014, 27.)

The basic visual capacity is generated shortly after birth and improves rapidly during the first year (Brémond-Gignac et al. 2011). Visual acuity develops quickly over six months of age with contrast sensitivity, vernier acuity, stereoscopic acuity, orientation, direction, and motion sensitivity. Infants have eye movements such as saccades, smooth pursuit, some vergence optokinetic nystagmus, and fixation. However, these will develop more and become more accurate as visual acuity, motion perception, and depth perception improve. Eye movements and perception develop hand in hand, depending on each other's improvement. (Daw 2014, 27.)

Various factors influence visual development, including nutrition, visual stimulation, and premature birth. Abnormal visual input during critical periods can lead to developmental abnormalities and potential long-term visual impairment. Infants have sensitive periods in visual development when they are more susceptible to anomalies and require normal visual input for typical development. The timing of these sensitive periods varies depending on specific aspects of vision. The critical

window for motion visually evoked potential (VEP) is from 2 months up to 2 years, grating acuity is from birth to at least 5 years old, while for Snellen acuity, it extends up to approximately 10 years, and for contrast sensitivity up to approximately 7 years. On the other hand, peripheral vision continues to develop until the early teenage years. Still, the maturation of the visual system goes on for many years, and some components of visual capability develop until the late teens. (Brémond-Gignac et al. 2011; Daw 2014, 162.)

Emmetropization is the natural process of reducing refractive error in the eye during normal growth, which occurs soon after birth. It involves a complex interplay between genetic and environmental factors. During normal development, the growth rate of the eyeball is linked to overall child growth, leading to emmetropization. While the visual system is initially immature at birth, basic visual capacity improves rapidly in the first year. This process involves an increase in the axial length of the eyeball, corneal changes, and lens adjustments, resulting in improved focusing on the retina. However, the maturation of the visual system continues over several years, with some aspects reaching full maturity in the late teens. (Brémond-Gignac et al. 2011; Ansons & Davis 2014, 32-33.)

Changes in vision and eyes can occur in all stages of development, although the first three months of a child's life are the most important for the visual system's development (Seppänen 2021). If the visual pathway's normal development is disturbed by amblyogenic factors it causes structural and functional impairment of the visual cortex, and impaired form of vision (Birch 2013). If visual perception is deficient, it quickly leads to permanent visual impairment if left untreated (Seppänen 2021). Inadequate visual experience during the first years of life can result in a diminished vision called amblyopia (Birch 2013). In stimulus deprivation cases the critical period is from a few weeks after birth to 10 years of life (Daw 2014, 155). The earlier abnormal development is noticed, the better the outcome is (Seppänen 2021).

2.2 Definition of Amblyopia

Amblyopia, commonly called lazy eye, primarily means a loss of vision (Daw 2014, 123; Osborne et al. 2018). More specifically, amblyopia is defined as a decrease in visual acuity in one or both eyes without evident structural and pathological anomalies (Ohlsson et al. 2001). Amblyopia is a neurodevelopment disorder that occurs when discordant binocular visual experience occurs during

the first years of life (Birch & Kelly 2023). Usually, the sooner amblyopia is diagnosed and started to treat the better the outcome is (Mostafaie et al. 2020).

Amblyopia is the maldevelopment of visual function in the critical period of visual development, that is not immediately resolved by the correction of refractive error and continues from birth through the first 7–8 years of life (Taylor & Elliott 2014; Osborne et al. 2018). Amblyopia arises due to ocular factors that disrupt the normal visual development of one or both eyes during the critical period. This disruption leads to reduced visual acuity, a characteristic feature of amblyopia. (Osborne et al. 2018.) The difference in best corrected visual acuity is two Snellen lines or more (or >1 log unit) (Salmon 2020, 708). The term amblyopia comes from Greek, literally meaning 'blunt sight' (Daw 2014, 95). Amblyopia develops in early childhood where form deprivation or abnormal binocular interaction has led to cortically deprived vision (Mostafaie et al. 2020). The primary visual cortex and extra-striate, visual cortex V1 and V2 areas, are affected by all types of amblyopia. Additionally, magnetic resonance studies have shown that anisometropic amblyopia is also associated with decreased values in fractional anisotropy in the optic radiation, right superior longitudinal fasciculus, and inferior longitudinal fasciculus/inferior frontal occipital fasciculus. (Hernández-Rodríguez & Piñero 2020.)

In the context of early-life visual impairment in one eye, individuals may instinctively and involuntarily favor their unaffected eye for visual tasks, a phenomenon known as suppression. The lack of use of one eye results in that eye not learning to see properly. (Osborne et al. 2018.) Amblyope watching with the non-amblyopic eye also affects some deficits in properties other than acuity, both monocular and binocular visual afferent function deficits such as reduced contrast sensitivity, depth perception, interocular suppression, and efferent function abnormalities such as unstable and inaccurate fixation. This is presumably because of the responses of cells in the cortex's binocular areas that have been affected by watching with an amblyopic eye. Also, children with unilateral amblyopia exhibit higher accommodative errors in their amblyopic eye during monocular viewing, leading to potential unintentional defocusing of the retinal image during patching therapy for amblyopia. (Daw 2014, 123; Manh et al. 2015; Ghasia & Wang 2022.) If amblyopia is not treated properly and vision in one or two eyes stays poor or there is a loss of three-dimensional vision, it can affect participation in sports and future employment (Antonio-Santos et al. 2020).

2.3 Prevalence of Amblyopia

Amblyopia is considered one of the most important causes of visual impairment and it is the most common visual problem among children before school age (Ohlsson et al. 2001; Hashemi et al. 2018; Mostafaie et al. 2020). It is a noteworthy vision problem worldwide and an important public health concern. The public health strategies of early screening, treatment, and management are important. The reported incidence is 1–5 % worldwide and 2–4 % in North America, but the reported prevalence varies greatly between studies, from 0.05 to 7.54 %. In Hu et al study, the worldwide pooled prevalence of amblyopia was 1.36 %, and in Mostafaei's study 3.4 %. (Mostafaie et al. 2020; Hu et al. 2022; Sii et al. 2023). The prevalence of amblyopia varies in different parts of the world, especially in Africa (Mostafaie et al. 2020). However, the highest prevalence of amblyopia is in European countries (Hashemi et al. 2018). Hu et al meta-analysis indicates the prevalence of amblyopia does not vary according to the geographical area, publication year, age, sample size, and economic status. Although the prevalence varies significantly between boys and girls, with a higher prevalence in boys. (Hu et al. 2022.) Altogether amblyopia is the most common cause of children's monocular vision loss (Birch 2013).

2.4 Underlying Factors Contributing to Amblyopia

Amblyopia is a monocular or bilateral reduction of best-corrected visual acuity (BCVA) (Cruz et al. 2022). Many different issues can lead to the disruption of the signals reaching the visual cortex; unequal alignment (strabismus), refractive error (anisometropia or isoametropia), or form deprivation (e.g., cataract), and the severity of amblyopia depends on the age at initiation and the type of asymmetry. Amblyopia is not a diagnosis but rather a condition with an underlying root cause. (Daw 2014, 95; Hensch & Quinlan 2018.) These issues are defined more precisely later under the subheaders. An asymmetry of the visual input across the eyes leads to reduced visual acuity (Hensch & Quinlan 2018). These can be divided into motor and sensory problems (Daw 2014, 95). Motor problems include different misalignments of the two eyes and incompatibility of the information from two retinas (strabismus). Sensory problems include retinal diffusion of the image (cataract), uneven image focusing between the two retinas (anisometropia), improper alignment of the optical axis (astigmatism), and excessive growth of the eyeball (myopia). (Hensch & Quinlan 2018.) If there is an immediate improvement in visual acuity after refractive correction, it

indicates a simple refractive error, not amblyopia. If treating the underlying cause does not improve the condition, then amblyopia is considered to be present. (Cruz et al. 2022). Sometimes there is not any obvious reason for amblyopia, this is called idiopathic amblyopia (Ansons & Davis 2014, 286).

Sensory and motor systems are linked, and deficits in one system will cause deficits in the other. If the underlying deficit is not treated, there is a danger that the connections in the visual cortex will become rewired to compensate for the deficit and it becomes permanent. Rewiring connections depends on the nature of the deficit. Usually, visual acuity drops but there can also be other effects that depend on the cause of amblyopia. (Daw 2014, 95.) Table 1 contains the International Statistical Classification of Diseases and Related Health Problems (ICD) codes for amblyopia.

TABLE 1. International ICD-10 diagnosis code for amblyopia (ICD-10 2023).

Diagnosis	**ICD-10 CM**
Amblyopia, unspecified	H53.00
Deprivation amblyopia	H53.01
Refractive amblyopia, including anisometropic and isoametropic amblyopia	H53.02
Strabismic amblyopia	H53.03
Amblyopia, suspect	H53.04

2.4.1 Refractive Amblyopia

Untreated unilateral or rarely bilateral refractive errors can develop amblyopia (Cruz et al. 2022). Anisometropic amblyopia is due to a difference in refractive error between two eyes (Salmon 2020, 707). Anisometropia can be because of hyperopic or myopic differences between two eyes. (Levi et al. 2015). Hyperopia, also called hypermetropia or farsightedness stands for the too-short axial length of the eye (Pascual et al. 2014). Myopia meaning near-sightedness, occurs when the eyeball is too long compared to the power of the eye's optics (Daw 2014, 103). Anisometropia can also result from meridional amblyopia, specifically anisoastigmatism, which occurs due to image blur in one meridian. It can be unilateral or bilateral caused by uncorrected astigmatism. (Salmon 2020, 708.) Astigmatism is a cylindrical factor in the eye's refractive system (usually in the cornea) where lines along one axis are in focus, and lines along the perpendicular axis are out of focus.

Anisometropia is probably caused by the axial length difference between eyeballs (Daw 2014 100-101.) Anisometropia degrees that are likely to lead to amblyopia include 1.50D of anisohyperopia, 2.00D of anisoastigmatism, and 3.00D of anisomyopia (Lueder et al. 2017). In anisometropia the other eye is the one that is focused and the other unfocused, therefore the unfocused eye's retinal image is degraded (Daw 2014, 124). In most hyperopic anisometropic amblyopia cases, there is asymmetrical accommodation without refractive correction (Toor et al. 2018). The more ametropic one receives an unfocused, blurred image in a mild form of visual deprivation. (Salmon 2020, 707). This affects the connections between the retina and the cortex, and they do not make as precise a topographic map as they do in the normal eye (Daw 2014, 124). Anisometropic amblyopia can also occur at the same time as strabismic amblyopia i.e., combined amblyopia (Cruz et al. 2022). In anisometropia, many factors are degraded in proportion to each other. Vernier and Snellen's acuity is decreased in proportion to the loss of resolution measured by grating acuity. Contrast sensitivity is lowered because of spatial uncertainty. (Daw 2014, 142.)

Isoametropic amblyopia, meaning amblyopia where the refractive error is similar in both eyes, is a less common form of refractive amblyopia, where visual acuity is reduced in both eyes (Cruz et al. 2022). This bilateral ametropic amblyopia is due to high symmetrical refractive errors, usually hyperopia, but can also be because of myopia or astigmatism (Salmon 2020, 708). Refractive errors including anisometropia, hyperopia, and astigmatism are the major risk factors of amblyopia. Astigmatism is the most important risk factor (11.5 %), then hyperopia (1.24 %) anisometropia (1.13 %), and last myopia (0.43 %). (Meng et al. 2021.)

2.4.2 Strabismic Amblyopia

Strabismus is an eye muscular control defect where the eyes look in different directions (Daw 2014, 96). Strabismic amblyopia is a consequence of abnormal binocular interaction where there is continued monocular suppression of the deviating eye (Salmon 2020, 707). If the deviation angle is relatively small, the result is not very different from anisometropia: there will be poor acuity and contrast sensitivity in the squinting eye (Daw 2014, 126).

Eccentric fixation, mostly seen in esotropic eyes, where the angle of deviation is proximately between five to fifteen prism diopters and stays relatively constant and comitant during early

childhood, is a monocular condition where a new point of fixation is formed away from the retina (Daw 2014, 126-127; Evans 2022). If the connections form a new point of fixation to higher areas of the cortex dealing with central vision, it can create anomalous retinal correspondence. Pseudofovea's acuity is limited by the density of ganglion cells in the retina and the size of their receptive fields. Acuity can never get better than the spacing of the ganglion cells in the retina, no matter how precisely the connections between cortex and retina are rearranged. (Daw 2014, 126-127.) Microstrabismus may co-exist with strabismic amblyopia (Salmon 2020, 708). In strabismic amblyopia Snellen and vernier acuity lowered more than grating acuity. Still, the main issue is the loss of binocular function following the loss of stereoscopic vision. (Daw 2014, 123, 39.) Approximately 2-8 % of the general population develops strabismus, with approximately 1.84 % of those individuals also developing amblyopia (Taylor & Elliott 2014; Meng et al. 2021).

2.4.3 Stimulus Deprivation Amblyopia

Stimulus deprivation amblyopia (SDA) occurs when there is a deprivation of vision in one or both eyes due to factors such as media opacities, ptosis, cataracts, hemangioma (blood-rich swelling on the lid), vitreous obstruction due to bleeding, or aphakia (absence of the crystalline lens). Nevertheless, the most typical cause of SDA is congenital or infantile cataracts in one eye. SDA is often associated with other conditions like microphthalmia (small eye), coloboma (incomplete formation of the eye), optic nerve hypoplasia (underdeveloped optic nerve), or retinal abnormalities. Cataracts, which cause clouding of the lens, can lead to significant visual impairment and increase the risk of amblyopia. It occurs due to blockage of vision in the eye which affects disuse or lack of information of clear retinal images. Cataract surgery is recommended early in cases of unilateral or bilateral cataracts. However, after lens removal, accommodation is lost, and there may be anisometropia and differences in image size between the treated and normal eyes, which can be challenging to address. Bilateral cataracts are often inherited or caused by maternal infection or radiation, while unilateral cases are usually idiopathic or traumatic. Genetic mutations, maternal infections, and trauma are significant causes of childhood cataracts, but the exact cause remains unknown in many cases. (Daw 2014 102-103; Taylor & Elliott 2014; Wilson 2015; Mohammadpour et al. 2019; Wilson & Edward M. 2019; Antonio-Santos et al. 2020; Salmon 2020, 708.)

Stimulus-deprivation amblyopia is considered the most challenging type to treat. Early insult to the visual system makes it severe and resistant to treatment, resulting in a poor visual prognosis.

Parents often notice symptoms such as a whitish pupil or droopy eyelid in the baby's first year. Diagnosis typically occurs after addressing the underlying cause and managing refractive errors with spectacles or contact lenses. While less common, stimulus-deprivation amblyopia is estimated to affect less than 3 % of individuals with amblyopia, although the exact prevalence is unknown. (Taylor & Elliott 2014; Antonio-Santos et al. 2020.)

2.5 Assessment of Amblyopia

Various tests must be performed before understanding the deficit's whole nature (Daw 2014, 143). Also, a detailed history should be taken in all cases, especially parents' opinion of their child's vision, the age at onset, and the duration of any strabismus present not forgetting the family history (Ansons & Davis 2014, 290).

Amblyopia affects a variety of other visual functions than visual acuity (Webber & Wood 2005). Spatial location is distorted, vernier acuity is degraded, the details on objects are distorted and shapes are not recognized properly (Daw 2014, 142). There can also be defective accommodation and oculomotor deficits, including unsteady fixation and inaccurate tracking (Webber & Wood 2005). Motion perception and counting different objects might not be as accurate as in people with normal vision (Daw 2014, 142). Plenty of other properties are also affected, such as a reduction in the ability to detect shapes, perception, counting ability, and the ability to follow several objects at once. Moreover, the image in one eye is suppressed by the image in the other to avoid diplopia and confusion arising when the eyes look in different directions. Some of these faults are seen in binocular viewing in the amblyopic as well as in the fellow eye. (Daw 2014, 123, 39.)

2.5.1 Screening in Finland

At the Finnish maternity clinic, the primary goal of a child's vision examination is to screen and refer children who have a squint, reduced visual acuity, or suspicion of eye disease. Noticed recent strabismus is always a reason to send to an ophthalmologist. A delay in the development of visual communication is a sign of brain dysfunction. It affects the child's development and family dynamics, so the baby should be sent for further examinations and the family for early childhood

rehabilitation. (Seppänen 2021.) More specific age-related vision screening and criteria for referral for further examinations are presented in Tables 2 and 3.

TABLE 2. Examination of vision and criterion for referral for further examinations at the maternity clinic (Hyvärinen 2017).

Age	Examination	The criterion for referral to further studies
New-born	The appearance of the eyes	Abnormality in the structure of the eyes or lids, abnormal pupil shape or reaction to light, constant strabismus of one eye
	Red reflex	Dim or absence red reflex
4–6 weeks	Eye contact	Missing or unusual eye contact. Parent-baby interaction hasn't begun.
	The appearance of the eyes	There is an abnormality in the structure of the eyes or lids. Abnormal pupil shape or reaction to light. Constant strabismus of one eye.
	Red reflex	Dim or absence red reflex
	Anamnesis about the eye and eyesight problems of the immediate family (Amblyopia, refractive error, strabismus, tumors)	Down syndrome eye examinations; hypotonic babies
4 months	Eye contact, smile response	Missing or unusual eye contact. Problems in early interaction: vision (accommodation and fixation difficulties) and hearing to be clarified.
	The appearance of the eyes	There is an abnormality in the structure of the eyes or lids, for example, size difference (glaucoma).
	Red reflex	Dull or absent red reflex
	Gaze alignment and convergence	Imprecise eye tracking
	Hirschberg test	Strabismus, constant or intermittent
8 and 18 months	Like 4 months old	Like 4 months old + tear duct problems
	Direct cover test	Even intermittent squinting is an emergency, if the eyes have already been straight and the squinting has started suddenly. Strabismus does not have to come up at the reception.
	Examining the pincher grip	The use of vision is not age-appropriate, looks closely, is not interested in pictures, and eye-hand coordination is imprecise.

Age	Examination	The criterion for referral to further studies
	Finding out if the baby recognizes family members before they have said anything	Does not recognize faces but recognizes voices.
3 years	Near visual acuity (if the child is cooperative)	Binocular vision is less than 0.5 or there is at least a two-line difference between two eyes if both eyes are managed to test abnormal head position, for example, tilting
	Hirschberg test	Strabismus
	Direct cover test	Strabismus or asymmetric reaction for cover
4 years	Near and distance visual acuity	Near vision: binocular visual acuity is less than 0.5. Distance vision: the binocular near visual acuity is less than 0.5 unless near visual acuity is 0.5 or better (=near-sightedness) OR Binocular near vision is two lines or worse than distance vision. Binocular near vision is more than two lines worse than distance vision (reasons: accommodation weakness or farsightedness)
	Hirschberg test	Strabismus
	Direct cover test	Strabismus or asymmetric reaction for cover
5 or 6 years	Examination, if necessary, like at 4 years old, especially if the child is going to a psychologist's examination or the child has visual-motor disorders	Near vision: The binocular near visual acuity is less than 0.63. Distance vision: the binocular near visual acuity is less than 0.63 unless near visual acuity is 0.63 or better (=near-sightedness) OR Binocular near vision is more than two lines worse than distance vision (reasons: accommodation weakness or farsightedness)

TABLE 3. Vision examinations are performed at the maternity clinic (Hyvärinen 2017).

Red reflex	**Age**	Examined by the age of six weeks and after that also in connection with the health checks performed at the age of four, eight, and 18 months.
	The criterion for referral to further studies	Congenital cataracts, structural abnormalities of the eyes, and the abnormal light reaction of the pupil.
Hirschberg test	**Age**	It is done at every visit to the clinic from the age of four months.

	Test result	The examination reveals only strabismus.
	Conducting examination	Aim the light (pencil lamp or otoscope lamp without an ear funnel) into the child's eyes directly in front of the child from a distance of about 50 cm. Observe the location of the spot of light in the eyes. Normally, the light reflex is located symmetrically, slightly to the side of the nose from the center. If the eye squints inward, the reflection is seen from the center of the cornea on the side of the temple. The examination will continue with a cover test.
Cover test	**Implementation**	To study strabismus, close-up tests are performed on small children (the object to be viewed is at a distance of 30 cm). The test is performed both at a distance and at a near distance, at a stage when visual acuity and the ability to cooperate have developed so that fixation is reliably successful even at a distance of four meters.
	Conducting examination	Ask the child to look at a 5 cm size fixation picture from a distance of 30 cm. Cover the left eye first with the hand coming from above. Observe the right eye and see if it moves. The cover test is done for both sides separately. The eyes are allowed to rest for a while before moving on to examining the other eye.
	Interpretation of the examination	Corrective movement is the opposite of strabismus. When the right eye squints out, the right eye makes a corrective movement inward, i.e., in the nose's direction, when the left eye is covered. There is no tropia if covering the eye does not cause corrective movements in the uncovered eye. If the covering causes a corrective movement in both eyes, it is an alternating strabismus. If the baby or child's reaction to covering the eyes is asymmetrical, i.e. if the child accepts covering one eye but avoids covering the other eye, it may be a case of abnormal vision in the eye that is not disturbed by the covering. The reason must be found out, even if the eye is not squinting.
Pincher grip	**Conducting examination**	A few small dark cake-decorating candies are sprinkled on the examination table behind the child sitting. Let's turn the child on his stomach to lean on the arms. Let's see if the child notices the candies and how the child grabs them.
	Interpretation of the examination	Eye-hand coordination and recognition of a small object are normal if the child picks up a very small object, tries to do it with a tweezer grip, and keeps her supporting hand well.
High-risk group		Those whose siblings or at least one of the parents have been diagnosed with strabismus. Those with another diagnosed disability, motor or cognitive developmental delay, hypotonia, hearing impairment, or a diagnosed illness that often

	involves visual impairment or major refractive errors (such as Down syndrome).
Examining the eyes and determining the refractive error of children belonging to the risk group	It must be ensured during early development and ensure that functional vision examinations are carried out regularly as part of early childhood rehabilitation.
Recording in the patient report	Abnormalities in the development of sensory functions in close relatives (amblyopia, strabismus, visual and hearing impairments) and inherited diseases should be recorded.
Ophthalmologist's examination	An ophthalmologist's examination is recommended, even if reduced vision or abnormal eye position has not been detected. In particular, squinting that starts between half a year and three years of age can lead to permanent vision loss in the squinting eye if left untreated.

In Finland, schoolchildren undergo comprehensive vision assessments during grades 1, 5, and 8, corresponding to ages 7, 11, and 15, as part of their routine health check-ups. In addition, vision is always examined when a student, parent, or someone else, for example, a teacher, suspects vision impairment or the student has eye-related symptoms. A vision examination may also be necessary in connection with learning difficulties, headaches, or driving ability. (Jauhonen et al. 2021.) Abnormal color vision is also a reason for referral during the 8th grade if there are plans for a profession that requires the ability to distinguish colors (Hyvärinen 2017).

The reduced visual acuity of a first-school grader should be checked with a re-measurement made at a different visit before being sent for further examinations. Older students can also be re-measured in uncertain situations, for example within a month. If the child has been treated by an ophthalmologist due to amblyopia, further examinations are necessary only if the visual acuity has decreased from the level reached at the end of the treatment. Screening limits only apply to asymptomatic students. If the student has vision-related symptoms, further examinations by an ophthalmologist are necessary, even if the values in the screening are normal. (Jauhonen et al. 2021.)

Referral criteria are the same in all school grade levels where vision is screened: 1, 5, and 8. Criteria for further referral are: Monocular distance visual acuity falls below 0.8 better in decimal notation, monocular near visual acuity falls below 0.63 or there are symptoms related to vision and eyes. Abnormal color vision is also a reason for referral during 8th grade if there are plans for a profession that requires the ability to distinguish colors. (Hyvärinen 2017.)

For students who are at least 8 years old in the second school grade, school healthcare can use a licensed optometrist to help them when assessing the need to send them to an ophthalmologist (Jauhonen et al. 2021). The regulation on healthcare professionals (564/1994, 16 §) states that a licensed optician is not permitted to independently prescribe eyeglasses for a child under the age of eight (Asetus Terveydenhuollon Ammattihenkilöistä 564/1994, 16 §). The co-operate optometrist must have a limited right to prescribe medication. If necessary, the optometrist can prescribe glasses to correct the refractive error. School health care must receive feedback from the optometrist's examinations and see to the referral to an ophthalmologist if anything other than a refractive error appears, vision remains reduced after the refractive error has been corrected, or the student has symptoms. When a student has symptoms related to the eyes or vision, or a symptom-free student breaks the screening limit, and cooperative optics are not available, the student is referred to an ophthalmologist. (Jauhonen et al. 2021.)

2.5.2 Screening Worldwide

Routine vision screening and comprehensive eye exams are typical in industrialized nations. Recommendations enable early detection of vision impairment from amblyopia and refractive errors. (Asare et al. 2022.) Due to practical reasons, it is focused on Western countries. In the United States, routine comprehensive eye exams and vision screening are recommended by American Optometric associations within the first 4-6 weeks after birth, 6 and 12 months of age, at least once between 3 and 5 years of age, and before first school grade and annually thereafter (American Optometric Association 2021). In the United Kingdom, eyes will be checked within 72 hours of birth, between 6 and 8 weeks old, around 1 year or between 2 and 2-and-a-half years, and around 4 or 5 years old, and after that vision screening is usually carried out in the child's school. However, this does not happen in all areas and then the child is recommended to take their local optometrist for an eye examination. (Public Health England 2017; NHS 2023.) In Australia health departments in each state and territory have their guidelines regarding vision screening for children. A vision screening may be required for children turning 4 years old as one part of a health check. (Asare et al. 2022.) In Australia's national children's vision screening project, there is a suggestion that eye screening should be done as close to birth as possible, and ideally within the first three

months of life, between the ages of three to six months, after 18 months and before 5 years (between 3.5–5 years) (Murdoch Childrens Research Institute 2008).

The European Council of Optometry and Optics (ECOO) states that eye care practitioners will provide an age-appropriate examination of a child's eyes and vision. Especially with young children, the goal is to identify those whose visual development is not normal, those who require refractive corrections, and have or are at risk of developing amblyopia or strabismus. Measuring monocular visual acuity that corresponds child's age is important. (ECOO 2013.) Amblyopia screening can target lowered visual acuity, refractive risk factors, or both. Young children's screening reduces amblyopia prevalence remarkably and it is recommended or mandated in numerous countries. (Horwood et al. 2021.)

2.5.3 Patient History

Patient history generally includes the following, although it varies with the child's problems and needs:

- Demographic information, such as gender, date of birth, and details of the parent or caregiver.
- The person providing the historical information and their relationship to the patient, including any language barriers.
- Identification of healthcare providers involved in the child's care.
- The main complaint and reason for the eye examination.
- Current eye problems.
- Ocular history, including past eye issues, diseases, diagnoses, and treatments.
- Overall systemic history, including birth weight, gestational age, prenatal and perinatal history (involving pertinent aspects such as maternal tobacco, alcohol, and drug consumption during pregnancy), as well as previous hospital admissions and surgeries, and general health and development, including any developmental delays.
- Alterations in behavior and approach to regular tasks.
- Current systemic diseases, medications, and known allergies.

- Family history of eye conditions and relevant systemic conditions, including eye conditions of siblings. (Cruz et al. 2022; Leslie et al. 2016.)

Children with an increased risk of amblyopia such as ptosis, gestational age less than 30 weeks, birth weight less than 1500 grams, cerebral palsy, syndromes with ocular involvement such as Down syndrome, and a family history of amblyopia or strabismus should be referred for an ophthalmologic examination as soon as the risk factor is identified. The ocular history may suggest that the child or someone in the family has a weak or lazy eye and/or strabismus. Then it should lead to further questioning about earlier treatment and surgery and the time, duration, and success of these treatments. Blurred vision, headaches, or asthenopia can suggest decompensated heterophoria or accommodative insufficiency or excess at that distance. Parents may tell that they have seen eye squint or abnormal head posture. Double vision especially when tired can indicate that heterophoria is breaking down to heterotropia (typically horizontal diplopia) or remote near point of convergence. Sometimes children report seeing double when they see blurry. (Barrett 2014; McConaghy & McGuirk 2019).

General health and medical questions may indicate a systemic condition that can affect eye health, accommodation, or binocular vision problems (Barrett 2014). It is important also to know of any infection, drugs or medications, metabolic disease, or trauma (Scheiman & Wick 2020). It is good also to ask the parent about the pregnancy and birth history. If the baby is born premature and with low birth weight or disorders of the central nervous system or with significant birth complications, there is a high prevalence of ocular abnormality in particular strabismus. (Barrett 2014.) Sometimes the questioning around changes to behavior and common habitual tasks may help to understand the defect (Leslie et al. 2016).

2.5.4 Ocular Examination

The eye examination consists of an assessment of the physiological function and the anatomic status of the eye and visual system (Cruz et al. 2022). In brief, the examination should cover the observation for ptosis, the presence of cataracts, and corneal opacities; the evaluation of pupil function; and vision testing and the examination of ocular motility and alignment, including corneal light reflection the binocular red reflex test, and cover/uncover tests (McConaghy & McGuirk

2019). Mentioning about child's level of cooperation can be useful in interpreting the results and comparing results over time. More specifically normally the following key elements are included in the examination:

- Binocular red reflex (Brückner) test
- Binocularity testing
- Assessment of fixation pattern
- Assessment of visual acuity
- Binocular alignment and ocular motility
- Accommodation test
- Pupillary examination
- External examination
- Anterior segment examination
- Cycloplegic retinoscopy/refraction with subjective refinement when indicated
- Funduscopic examination

Color vision testing and visual field testing may also be included in the examination. (Cruz et al. 2022; Leslie et al. 2016.)

A binocular red reflex (Brückner) test is performed in a darkened room. The examiner shows an ophthalmoscope light toward the eyes approximately 45–75 centimeters away and compares the reflex in both eyes for asymmetry in position, color, and intensity. (McConaghy & McGuirk 2019.)

Binocularity or binocular vision involves sensory fusion, stereopsis, fusional vergence (motor fusion), and other coordinated binocular eye movements. Amblyopia, strabismus, refractive error, and deprivation can disrupt sensorimotor fusion. The evaluation of binocular vision varies depending on the diagnosis, with tests like the Worth 4-Dot Test for sensory fusion, the Randot Stereo Test for stereopsis, and prism bar or rotary prism for fusional motor vergence. Assessing stereopsis is important for evaluating binocular alignment. Sensory function testing should be conducted before using dissociating examination techniques such as occlusion or cover testing. Some suitable clinical tests that can be used to evaluate a child's stereopsis include: the Titmus Fly, Lang I & II, Frisby Test, TNO stereo test, Preschool Assessment of Stereopsis with a Smile test, and Randot Preschool Steroacuity Test. (Leslie et al. 2016; Cruz et al. 2022.)

Fixation and following are assessed by drawing the child's attention to the examiner to a hand-held light, toy, or other fixation target and then slowly moving the target. Fixation can be mentioned for each eye as "fixes and follows" or "central, steady, and maintained," along with any qualifying findings, such as eccentric, not central, not steady, or not maintained. These methods help measure visual acuity in young children who cannot perform conventional visual acuity tests. (Cruz et al. 2022.) Evaluating fixation can be done more adequately for older patients with a direct ophthalmoscope with green light and the patient is looking toward a so-called spider web with another eye covered. This can be done also with the Watzke method which is done with a slit lamp and Volk 90 D lens and the patient focuses on a 1x1mm light beam. (Lindberg 2022.)

Visual acuity is one of the most important tests when diagnosing amblyopia. In almost all cases there is a loss of visual acuity and contrast sensitivity Reduced visual acuity is measured also after best-corrected refraction. When visual acuity is reduced even after refractive correction and amblyogenic factor, usually strabismus or anisometropia is present with no other ocular or visual cortical abnormality is currently the critical component of amblyopia diagnosis. Visual acuity testing in young children relies mostly on objective observations. It is limited by cognition and concentration. Qualitative methods (e.g., assessing fixation preference) may be used, although quantitative tests (e.g., preferential looking) are more accurate. Preferential-looking tests rely on the observation that infants prefer to look at patterned rather than plain surfaces. Children look at a striped panel when they can discern it. Vision must be checked monocularly for near and distance. Using an adhesive patch is the preferred choice over an occluder for covering the eye during testing, as children may try to look around the occluder, potentially leading to the oversight of amblyopia. Most children under 3 years old and some older children cannot complete a visual acuity test and then amblyopia diagnosing must rely on fixation preference. In older children, testing methods are more objective and rely on the child's identification of pictorial or letter optotypes in Snellen, decimal, or logMAR notation. Visual acuity must be rechecked after refractive correction. Some improvement in visual acuity can be expected with only refractive correction. Amblyopes' visual acuity is usually better when reading single letters than letters in a row. This crowding effect occurs to a certain extent in normal individuals but is more significant in amblyopes and must be considered when testing preverbal children. (Birch 2013; Daw 2014, 142; McConaghy & McGuirk 2019; Antonio-Santos et al. 2020; Salmon 2020, 707.)

Binocular alignment and ocular motility can be evaluated using several tests. These include the corneal light reflection, binocular red reflex (Brückner) test, and cover tests. Cover tests involve covering one eye and observing for any refixation movement of the fellow eye to detect tropias. Ocular versions and ductions, including oblique gaze, should be assessed in all infants and children. Eye movements can be examined by observing spontaneous eye movements in uncooperative children. It is important to perform binocular alignment testing before applying cycloplegic eye drops, as alignment may change after their administration. (Cruz et al. 2022; Leslie et al. 2016.)

Accommodation can be assessed by different methods before cycloplegia. The accommodative response is evaluated with a dynamic retinoscopy called monocular estimation method retinoscopy (MEM). It may also help to evaluate a child with asthenopia who has high hyperopia or accommodative insufficiency. A child focuses on a small target displayed on a MEM card attached to the retinoscope. When the accommodation is accurate, the retinoscope light appears as a neutral retinoscopic reflection or as a slight movement, indicating mild hyperopia or a lag of accommodation. Accommodative amplitude can be assessed with a push-up method where a target (usually a small letter or object) is moved towards or away from the child's eyes. The child is instructed to focus on the target and report when it becomes blurred. The distance between the target and the eye, when blurring occurs, provides an estimation of accommodation amplitude. The assessment of accommodative facility typically involves the use of flipper lenses (+2.0 diopters and -2.0 diopters) that are repeatedly shifted in front of the child's eyes while they observe a small text. The child is instructed to focus on the target and indicate when it becomes clear, at which point the lenses are changed again. The number of shifts per minute is recorded during this process. (Scheiman & Wick 2020; Cruz et al. 2022.)

Pupillary examination in children is essential for assessing the integrity of the visual pathway and the function of the pupillary muscles and nerves. The PERRLA (Pupils Equal, Round, React to Light and Accommodation) test is used to assess the normal functioning of the pupils, ensuring they are equal in size, round, and responsive to both light and accommodation. It is a standard part of the pupillary examination. On the other hand, the swinging flashlight or RAPD (Relative Afferent Pupillary Defect) test is used to detect asymmetry in the pupillary response between the eyes. When a light is shone alternately between the eyes, a reduced or absent constriction in one pupil compared to the other indicates the presence of RAPD. This finding suggests an abnormality in the afferent pathway carrying visual information from the affected eye to the brain

and can help identify optic nerve or visual pathway disorders. The RAPD test is valuable in diagnosing and monitoring certain visual impairments in children. (Barrett 2014.)

External examination of the eyes and lids, inspection for ptosis, and assessment of ocular motility are valuable for detecting risk factors for amblyopia in infants and children. Head position examination in children involves evaluating the alignment, orientation, and posture of the head about the body. Key aspects assessed during the examination include head tilt, where the examiner observes if the head is consistently or intermittently tilted to one side, potentially indicating ocular misalignment. The examiner also checks for habitual head turns, which could suggest the presence of strabismus or other visual abnormalities. Additionally, the overall head posture is assessed for any deviations from normal alignment, such as forward or backward positioning or asymmetry. Compensatory movements made by the child to maintain binocular vision, such as head tilting for eye alignment, are noted. Associated signs like abnormal head movements or facial asymmetry may also be observed. A comprehensive head position examination is typically conducted by an eye care professional to evaluate eye alignment, and coordination, and diagnose conditions like strabismus or nystagmus that may impact visual development and function. (Leslie et al. 2016; McConaghy & McGuirk 2019.)

Anterior segment examination in children involves evaluating the front structures of the eye, including the cornea, iris, lens, sclera, conjunctiva, and anterior chamber. The examiner assesses the clarity, transparency, and integrity of these structures, looking for any abnormalities such as corneal opacities, iris irregularities, lens disorders, or shallow anterior chambers. Additional tests, such as tonometry or fluorescein staining, may be used to measure intraocular pressure or assess corneal surface integrity. Anterior segment examination is an important component of a comprehensive eye evaluation in children, aiding in the diagnosis and management of various eye conditions. (Barrett 2014; Leslie et al. 2016.)

Cycloplegic retinoscopy is essential for achieving accurate refraction in children, given their higher accommodation compared to adults. Determining refractive errors in children is important for diagnosing and treating amblyopia and strabismus. Cycloplegic refraction with retinoscopy, followed by subjective refinement, is recommended. Cyclopentolate hydrochloride 0.5 % or 1 % is commonly used for its rapid cycloplegic effect, similar to atropine but with a shorter duration. Short-term side effects may include hypersensitivity reactions, fever, dry mouth, and nausea. Severe reactions should be referred to emergency care, and physostigmine may be administered.

Typically, cyclopentolate 1 % solution is used for term infants over 12 months old. For children under 12 months, a combination of tropicamide (0.5 %) and phenylephrine hydrochloride (2.5 %) can also be employed to achieve proper dilation and cycloplegia. In certain cases, higher concentrations or repeated applications may be necessary. In some cases, such as heavily pigmented irises, topical ophthalmic atropine sulfate 1 % solution may be required to achieve maximum cycloplegia. Possible short-term side effects include hypersensitivity reactions, fever, dry mouth, rapid pulse, nausea, vomiting, flushing, somnolence, and, rarely, behavioral changes such as delirium. Punctal occlusion is beneficial in reducing these side effects. Any significant corrective prescription must be taken care of before amblyopia can be diagnosed. (Antonio-Santos et al. 2020; Scheiman & Wick 2020; Cruz et al. 2022.)

Funduscopic examination is important to diagnose any visible organic disease or lesions before starting treatment for amblyopia. Organic disease can occur simultaneously with amblyopia and patching trials may still be indicated in the presence of organic disease. More investigations such as imaging or electrophysiology should be considered if acuity does not respond to the treatment. When conducting an eye examination, it is important to thoroughly assess the optic disc, macula, retina, vessels, and choroid. The preferred method involves using an indirect ophthalmoscope and condensing lens after proper dilation. However, examining the peripheral retina of an awake young child can be challenging. In such cases, additional techniques like using an eyelid speculum and performing scleral depression may be necessary. This may require measures such as swaddling, sedation, or even general anesthesia. (Antonio-Santos et al. 2020; Salmon 2020, 708; Cruz et al. 2022.)

Color vision tests for children assess their ability to perceive and differentiate colors accurately. Color vision should be tested If visual acuity does not improve despite adequate treatment. Amblyopia alone does not affect color vision, so a monocular color vision test may indicate the undiagnosed organic defect. The Ishihara color vision test is commonly used and involves plates with colored dots forming numbers or shapes. Like the Ishihara test, the HRR (Hardy-Rand-Rittler) Pseudoisochromatic Plates require children to identify hidden figures. The Panel D-15 test, also known as the Farnsworth D-15 test and the more comprehensive and complex Farnsworth-Munsell 100 Hue Test are both color vision tests used to assess color vision deficiencies, specifically red-green color deficiencies. These tests can be used for older children who have developed the necessary cognitive and visual skills. (Ansons & Davis 2014, 83-84; Barrett 2014.)

Because amblyopia affects eye movements such as poor fixation, longer latency for saccades, incapacity to smoothly follow an object moving away from the nose, and slow inaccurate movements in visually guided reaches, it results in lower reading speed. In binocular viewing, amblyopes have one-half to three-quarters reading speed compared to a normal person. (Daw 2014, 123, 39.) Amblyopia can also complicate activities of daily life, lower self-perception, and lower quality of life (Birch & Kelly 2023).

2.6 Management of Amblyopia

Amblyopia treatment aims to optimize vision and depth perception. Optical correction is the first-line treatment, followed by occlusion or atropine therapy. Treatment duration can span several months. New approaches focus on binocular methods and perceptual learning. Improvement is more common in early ages and bilateral cases, while unilateral amblyopia may have limited visual acuity improvement after managing the underlying eye condition. (Taylor & Elliott 2014; Asper et al. 2018; Osborne et al. 2018; Antonio-Santos et al. 2020; Levi 2020.) Amblyopic eye improves most during a critical period, around 7-8 years for strabismic amblyopia. Anisometropic amblyopia may take longer. Occlusion therapy and/or atropine can help older age groups. Bilateral amblyopia benefits from managing primary eye issues, while unilateral may not see improvement. (Osborne et al. 2018; Salmon 2020, 708).

2.6.1 Optical Correction

When there is amblyopia with refractive error, optical treatment should be the first line of treatment. Optical treatment of refractive, strabismic, or combined-mechanism amblyopia usually improves visual acuity considerably and often results in the resolution of amblyopia. If after spectacle use visual acuity differences remain, improved visual acuity will most likely make occlusion or penalization easier and may improve compliance with further treatment. (Asper et al. 2018.)

In cases of high refractive error, spectacles may lead to differences in perceived image size or shape, which can hinder the development of binocular vision. Contact lenses could be the solution for spectacle-induced aniseikonia. (Tian et al. 2014.) Contact lenses are also used to correct

aphakia (unilateral or bilateral) high degreases of myopia and aniso-myopic amblyopia where contact lens is for the more myopic eye and provide the remaining prescription in spectacles. They are rarely used for other purposes with children under six years of age. (Ansons & Davis 2014, 47; Park 2019.) The problem with contact lenses is that they are expensive, and parents have difficulty in inserting and removing them leading to increased rates of noncompliance and possible corneal injury. However, contact lenses may stay in place better than glasses for young children. (Tian et al. 2014.)

When considering the prescription of glasses for infants and children up to six years old, several important questions should be taken into account. Firstly, it is crucial to determine whether the child's refractive error falls within the normal range for their age. Secondly, assessing whether the child's refractive error will naturally correct itself over time is important. Furthermore, it is necessary to consider whether the current level of refractive error will negatively impact the child's visual development or functional vision. In addition, the potential benefits of prescribing spectacles should be evaluated to determine if they will enhance visual function or improve functional vision. Lastly, it is important to determine if prescribing glasses will interfere with the natural process of emmetropization. To address these questions, clinicians must review the available evidence regarding the natural progression of refractive errors and the expected normal range for each specific age group. (Brémond-Gignac et al. 2011; Leat 2011.)

Research suggests that children with significantly high refractive errors are less likely to naturally adjust and achieve emmetropia than children with lower refractive errors. For infants aged three months the likelihood of emmetropization is greater than 80 % if the cycloplegic spherical equivalent refraction is within the range of 2 or 3 diopters. However, the probability is below 50 % when the refraction exceeds 5.0 diopters. This probability drops to less than 20 % if the refraction surpasses 7.0 diopters. (Leat 2011.)

At 3 months of age, infants demonstrate the ability to effectively adjust their focus for various levels of moderate farsightedness. The relationship between changes in their refractive error and their accommodative response suggests that this focusing mechanism could serve as a plausible visual signal in the process of emmetropization. It's uncertain whether strabismus affects the process of emmetropization, or if individuals who don't undergo emmetropization and therefore maintain higher hyperopia, are at a higher risk of developing strabismus. (Leat 2011.)

Most studies recommend prescribing the full amount of anisometropia and astigmatic correction. Regarding the correction of hyperopia, most studies allowed for an under-correction of 0.50 to 1.50 diopters less than cycloplegic refraction. Some studies either did not prescribe for hyperopia or left it to the prescriber's discretion if the hyperopia was less than +3.00 diopters. Therefore, the recommendation is to fully correct anisometropia and the astigmatic component, while under-correcting hyperopia symmetrically by 0.50 to 3.00 diopters. However optical correction should be tailored to the individual child together with consideration of the findings of the clinical examination, visual symptoms, ocular alignment, and patient history. (Leat 2011; Asper et al. 2018; Park 2019.)

In one-year-olds with 3.50 diopters or more in one meridian, and four-year-olds with the most hypermetropic meridian of 2.00 diopters or more, there is an increased likelihood of monocular or binocular amblyopia. Additionally, if there is an increasing or unchanged refractive error between one and four years, the risk of amblyopia also increases. Studies have shown that partial correction of hyperopia greater than 3.50 diopters in infants can lead to improved visual acuity at four years and may reduce the occurrence of esotropia. Infants who maintain more than 4.00 diopters of hyperopia are more prone to developing esotropia. Studies have also indicated a connection between high uncorrected hyperopia and poorer acuity in children. In the first year of life, the visual system may have low sensitivity to uncorrected astigmatism. However, starting from one year onwards, there is evidence that uncorrected astigmatism, especially oblique astigmatism, is linked to meridional amblyopia. (Leat 2011; Asper et al. 2018; Park 2019.)

2.6.2 Occlusion Therapy

Occlusion, sometimes called patching therapy, in front of the normal eye to encourage the use of the amblyopic eye is the most effective treatment (Salmon 2020, 708). The normal eye is usually covered with an adhesive patch (Antonio-Santos et al. 2020). The regimen, full-time or part-time, depends on the patient’s age and the amblyopia’s density (Salmon 2020, 708). Occlusion therapy typically lasts between 2 and 6 hours per day depending on the visual acuity (Osborne et al. 2018). The most rapid improvement and on the other hand the greater risk to induce amblyopia in the normal eye is expected of the younger patients. Therefore, regular examination of visual acuity in both eyes during treatment is very important. Usually, the better the visual acuity is before starting

the occlusion the shorter the duration required. Although this varies between different patients. If there has been no improvement in six months of effective occlusion, more occlusion most likely will not be productive. (Salmon 2020, 708.) Implementing occlusion therapy can be challenging for parents as children often find it confusing and uncomfortable. This is particularly true for patching therapy, which can be especially difficult for families with toddlers who frequently remove the patch. Caregivers need to understand the importance of patching for their child's treatment. Implementing reward systems and patching diaries with stickers can improve compliance in older children. Clinicians need to educate families on the proper patching technique, applying the adhesive patch directly to the skin rather than on the spectacles. (Oltra 2015; Antonio-Santos et al. 2020.) Opaque black contact lenses can be also one option for total occlusion, although there is not yet insufficient experience with this method to permit any critical evaluation of its effectiveness (Ansons & Davis 2014, 48). Poor compliance is the single greatest obstacle to improvement (Salmon 2020, 708).

Inverse occlusion is used only in special cases if persistent (stable) false fixation outside the fovea is detected. Inverse occlusion aims to achieve fixation that changes place (labile fixation). The amblyopic eye is covered continuously for 1–4 weeks full-time and the lability is assessed weekly. A strict alternating cover is started once the fixation has been made variable. Covering the healthy eye for four consecutive days, followed by covering the amblyopic eye or simultaneous viewing without the occlusion for one day. After that again covering the healthy eye for four consecutive days, followed by covering the amblyopic eye or simultaneous viewing without the covering for one day and maintaining this rhythm. The goal is to achieve foveal fixation and thus a prerequisite for improving visual acuity. Follow-up is initially every two weeks when the place of fixation is checked. When foveal fixation is detected, follow-up intervals are extended. If foveal fixation is not achieved despite trying for two months, there is no reason to continue full occlusion. Obtaining or remaining fixation on the fovea cannot be guaranteed. (Lindberg 2022.)

2.6.3 Penalization

Penalization, an alternative to occlusion therapy, involves using atropine to blur the non-amblyopic eye. Atropine 1 % dilates the pupil and reduces accommodation, forcing the amblyopic eye to be used for near-vision tasks. The blurring effect is greater in hyperopic eyes, where spectacle correction can be reduced to enhance the atropine's impact. Atropine eye drops are typically

applied twice weekly. It is considered an effective treatment for mild to moderate amblyopia (visual acuity of 0.25 or better in decimal notation), particularly anisometropic amblyopia. Patch occlusion may yield quicker results, but atropine is preferred when compliance with patching is an issue. Possible short-term side effects of atropine include hypersensitivity reactions, fever, dry mouth, rapid pulse, nausea, vomiting, flushing, somnolence, and, rarely, behavioral changes such as delirium. Punctal occlusion is beneficial in reducing these side effects. Penalization offers the advantage of being difficult to circumvent and poses fewer psychosocial challenges compared to patching, especially for school-age children. (Oltra 2015; Osborne et al. 2018; Antonio-Santos et al. 2020; Salmon 2020, 708; Scheiman & Wick 2020; Cruz et al. 2022.)

2.6.4 New Treatments

In the past 20 years, significant advancements have been made in understanding the nature and neural mechanisms of vision loss in amblyopia. Additionally, it has been found that neural plasticity persists beyond the sensitive period. (Levi 2020.) In current treatments for amblyopia, the main emphasis is on visual acuity and sometimes secondary binocular vision outcomes. Healthcare for amblyopic children should be more comprehensive and consider the whole person and consider multiple competencies, including reading, self-perception, quality of life, and the burden of treatment. (Birch & Kelly 2023.) Significantly during the last decade, there has been a resurgence of research into new approaches to amblyopia treatment which both in children and adults emphasize that monocular therapies might not be the most effective in binocular disorder (Levi 2020). A new binocular treatment might be more approachable and easier for children to tolerate (Tailor et al. 2022).

New approaches include perceptual learning, video game play, and binocular methods (Levi 2020). During treatment, they can also play computer games or watch movies through special lenses or modified computers (Tailor et al. 2022). These binocular treatments aim to reduce inhibition of the amblyopic eye by the strong non-amblyopic eye and enhance binocular fusion and stereopsis (Levi 2020). These treatments are done with both eyes open and match the visual information shown to the better eye to the level of vision in the amblyopic eye (Tailor et al. 2022).
There have been optimistic results and binocular treatment is likely comparable to conventional patching treatment, but it is not yet possible to draw robust conclusions regarding the overall safety

and sustained effectiveness of binocular treatment (Tailor et al. 2022). Consequently, research should investigate these intersecting areas to address how best to treat the effects of amblyopia in everyday life functioning, how to design personalized approaches to treatments, and how to take into account other determinants of health so it will lead to clinicians, educators, and scientists using this information to develop programs and interventions to prevent or ameliorate slow reading, visuomotor impairment, and low self-perception and quality of life in amblyopic children. This approach may transform vision care into whole-person healthcare. (Birch & Kelly 2023.)

2.6.5 Follow-up Evaluation and Treatment Compliance

Amblyopia treatment efficacy is evaluated by assessing at various time points changes for example in visual acuity. Progress is indicated when the patient begins to discern progressively smaller objects with the amblyopic eye. If there is no change in visual acuity in both eyes, the treatment intensity or modality may need to be increased or switched to pharmacologic penalization. If the visual acuity improves in the amblyopic eye and the fellow eye remains stable, the same treatment regimen can be continued. If the visual acuity decreases in the amblyopic eye and the fellow eye is stable, a reassessment of refractive status, visual acuity, pupillary examination, and adherence is recommended. Alternative diagnoses like optic nerve hypoplasia, macular abnormalities, or other anterior visual pathway disorders should be considered if no improvement is observed despite good compliance. If the visual acuity decreases in the fellow eye, iatrogenic amblyopia should be suspected, prompting a re-evaluation of refractive status and visual acuity in both eyes. If reverse amblyopia is confirmed, treatment should be interrupted, and a follow-up scheduled. Resumption of amblyopia therapy can occur once visual acuity returns to the pre-treatment level. Resolving amblyopia is typically defined as achieving a visual acuity difference of one line or less between the two eyes. Then treatment can be gradually discontinued depending on the underlying factors contributing to amblyopia. (Birch 2013; Taylor & Elliott, 2014; Oltra 2015; Asper et al. 2018; Osborne et al. 2018; Birch & Kelly 2023.)

While treatment is most effective in the early years of life, it can still be successful in children up to 12 years old and may even benefit those between 13 and 17 years old. However, it should be noted that not all individuals achieve normal visual acuity despite extended treatment, with failure rates ranging from 15 % to 50 %. Factors contributing to this outcome may include delayed initiation of

treatment or poor treatment adherence. Additionally, individual differences in treatment response cannot be solely attributed to adherence, suggesting the possibility of inadequate standard treatments or underlying retinal, optic nerve, or gaze control abnormalities limiting visual acuity recovery. (Birch 2013; Taylor & Elliott 2014; Oltra 2015; Asper et al. 2018; Osborne et al. 2018; Birch & Kelly 2023.)

2.6.6 Interaction with Pediatric Patients

Effective communication and rapport-building are crucial in pediatric healthcare. The initial minutes of the meeting set the tone, prioritizing attention to the child and then the parents. Complimenting young children's clothing or toys and asking older children about their well-being helps establish a connection. Eye contact at the child's level, clear instructions, and the use of interesting toys aid examination comprehension. Active participation from parents, child, and examiner fosters positive interaction. (Heikinheimo et al. 2016; Helve & Solantaus 2020; Kolho 2020; Salmon 2020, 708.)

Different from adult examinations, prompt anamnesis, and clinical examination without urgency are performed in pediatric cases. Anamnesis can be obtained from parents or the child. With time, children calm down, allowing for clarification and agreement. Inspection plays a significant role in pediatric examinations. Reciprocal understanding and effective communication between patients, parents, and healthcare professionals are central. Gaining the patient's trust involves knowledge, honesty, genuine interest, and active listening. Two-way interaction allows for questions, clarifications, and support. Even non-medically justified concerns from parents should be taken seriously. Children should be treated with dignity and trust. Dealing with distressed children requires gentle determination and a calm demeanor. Practitioners don't need all the answers and can honestly admit when they don't know. (Heikinheimo et al. 2016; Hagnäs et al. 2017; Kolho 2020.)

Parents play a vital role in processing information and adapting to care instructions. Parents must understand that amblyopia treatment is essential, that visual improvement happens in early childhood and that visual improvement happens in early childhood and visual acuity cannot be improved in adults. Providing written information during stressful situations is beneficial. Communication about the disease and treatment should match the child's understanding. Regular

check-ups should inquire about family coping. Parents want to participate in their child's care. Amblyopia requires a comprehensive approach, considering its impact on child development. Awareness of challenges such as reading proficiency and visuomotor skills is essential for parents, educators, and clinicians. Comprehensive interventions can enhance overall well-being in children with amblyopia. (Heino-Tolonen 2017; Laaksovirta 2017; Helve & Solantaus 2020; Kolho 2020; Salmon 2020, 708; Birch & Kelly 2023.)

3 THE PURPOSE, OBJECTIVES, AND TASKS OF THE RESEARCH DEVELOPMENT WORK AND THE DIFFERENT STAGES

3.1 Purpose of the Study Statement

This thesis project aimed to construct clinical guidelines for Finnish optometrists on assessing and managing pediatric patients with amblyopia.

3.2 Statement of the Research Question

What are the key elements that Finnish optometrists should include in the assessment and management of amblyopia in pediatric patients, and what knowledge should they possess?

3.3 Summary Description of the Experimental Design

This innovation project is a literature review analysis-based research project for Finnish optometrists. The Finnish Ethical Council of Optometry (OEN) ordered the guideline. The innovation project was performed between February 2023 and August 2023. The project included a literature review and clinical practice guideline. The first phase was a literature search on pre-existing valid guidelines and recommendations on amblyopia assessment and management. Competence and geographical points of view were used in the selection. The second phase was to conduct a comprehensive literature review of the Pediatric patient's amblyopia assessment and management. The final phase was to produce the clinical guideline based on the literature review and valid existing guidelines and recommendations. An IBR approval or a statistical analysis was not required for this literature review analysis-based research project.

3.4 Study Objectives

The first aim of this study was to perform a literature search and selection.

The second aim was to produce the clinical guideline for Finnish optometrists: assessment and management of Pediatric patients with amblyopia.

3.5 Methodology

This thesis is an innovation project that consists of two parts. The first part of this innovation project is a literature review on amblyopia in Pediatric patients based on the literature search. The second part is the clinical guideline for Finnish optometrists about the assessment and management of Pediatric patients with amblyopia based on the literature review and valid existing guidelines and recommendations.

3.5.1 Project Co-operation

The Finnish Ethical Council of Optometry (Optometrian Eettien neuvosto; OEN) which is operated by the Finnish Association of Vision and Eye Care (Näe Ry) and Finnish Optometry Union (Suomen Optometrian Ammattilaiset, SOA Ry) has ordered optometrist's Pediatric comprehensive eye exam clinical guideline. Subjects were further divided into strabismus, amblyopia, and myopia management. OEN has given guidance to perform a master's thesis for students who are completing the master's degree in Clinical Optometry. They unanimously state that drawing up coherent guidance and instructions in Nordic countries or internationally is good. OEN highlights that they have the decision-making power, and the guidance will not become valid as they stand. OEN will not participate in making the master's thesis. OEN decided that the final guidance will be also delivered to SSLY's government for the statement and OEN still keeps the rights for further use. (OEN, 2020.) Previously, there were no publicly available amblyopia management and assessment guidelines for optometrists or ophthalmologists in Finland or the Nordic countries.

3.5.2 Timeline

The thesis project started initially in the spring of 2022 with topic selection, ideation, and drafting of a thesis study plan. January 2023, the thesis study plan was completed, and a literature search on current guidelines was conducted. Between February and March 2023, there was a major literature search and definition of specific aims and research questions. The writing of the theoretical background started in March and continued until June 2023. Guideline creation, writing the

conclusions and discussion, and finalizing the thesis took place in July and August 2023. A more specific timetable is presented in Table 4.

The thesis was produced as a part of a master's degree program in Clinical Optometry studies. There are financial liabilities for the Bror Biese Foundation regarding this thesis project.

TABLE 4. A timetable of thesis milestones.

Time	Subject matter
Spring 2022	Thesis ideation and topic selection Thesis study plan draft
January – February 2023	Thesis study plan Literature search on current guidelines
February – June 2023	Student-supervisor meeting Librarian meeting Literature search Defining specific aims and research question
March – June 2023	Writing of the theoretical background Student-supervisor meeting
July 2023	Making the guideline Writing the conclusions and discussion
July – August 2023	Thesis finalization

3.5.3 Conducting a Comprehensive Literature Search

A literature search was done using the PubMed, and EBSCO databases. Keywords included amblyopia, treatment or care or assessment or management or contact lenses or spectacles or occlusion or atropine or virtual reality, and child or infant. The full text had to be free and published in English. By careful selection, supplementary literature was obtained from relevant ophthalmology books, studies, and articles. The search was limited between the years 2012 and 2023 and with a critical approach some older studies in the 21st century were also included.

The literature search for current guidelines regarding children's amblyopia assessment and management was made between the 23rd of January and the 24th of February 2023. The search was conducted by using online databases where the main search term was amblyopia guideline. The literature search for the theoretical background was conducted between February 2nd and June 30th, 2023.

3.5.4 Development of Guideline

The guideline is based on the literature review and valid existing guidelines and recommendations. It was built between July 1st to July 31st.

4 IMPLEMENTATION OF THE RESEARCH DEVELOPMENT WORK

4.1 Specific Aim 1

The first aim of this study was to perform a literature search and selection.

4.1.1 Methods

The first phase of this study was to do a literature search on pre-existing valid guidelines and recommendations on amblyopia assessment and management. Competence and geographical points of view were used in the selection. The second phase was to conduct a comprehensive literature review of Pediatric patients' amblyopia assessment and management.

4.1.2 Results

The existing guidelines selected for further analysis:

- American Academy of Ophthalmology, Amblyopia Preferred Practice Pattern 2022 (Cruz et al. 2022).
- Optometry Australia, Clinical Practice Guide, Pediatric Eye Health and Vision Care 2016 (Leslie et al. 2016).
- American Optometric Association, Care of the Patient with Amblyopia 1994 (Rouse et al. 1994).
- The College of Optometrists, Guidance for Professional Practice, Examining Younger Children 2020 (The College of Optometrists 2022).
- Community Eye Care, Eye Care Guidelines, Amblyopia 2022 (Community Eye Care 2022).

4.2 Specific Aim 2

The second aim was to analyze the literature and describe the key elements of amblyopia assessment and management in pediatric patients.

4.2.1 Methods

In the second phase, an analysis was conducted to identify and outline the fundamental elements of amblyopia assessment and management in pediatric patients. This analysis was based on a critical review of evidence-based literature and selected guidelines.

4.2.2 Results

The theoretical background answers the research question: “What are the key elements that Finnish optometrists should include in the assessment and management of amblyopia in pediatric patients, and what knowledge should they possess?” The theoretical background consists of visual development, the definition of amblyopia, the prevalence of amblyopia, underlying factors contributing to amblyopia, assessment of amblyopia, and management of amblyopia.

Underlying factors contributing to amblyopia are divided into three categories: refractive amblyopia, strabismic amblyopia, and stimulus deprivation amblyopia. The assessment of amblyopia is categorized into four main areas: screening in Finland, screening worldwide, patient history, and ocular examination. The management of amblyopia encompasses various approaches, including optical correction, occlusion therapy, penalization, new treatments, follow-up evaluation and treatment compliance, and interaction with pediatric patients.

4.3 Specific Aim 3

The third aim was to produce the clinical guideline for Finnish optometrists: assessment and management of Pediatric patients with amblyopia.

4.3.1 Methods

The final phase was to produce the clinical guideline based on the literature review and valid existing guidelines and recommendations.

4.3.2 Results

This innovation project produced a clinical guideline for Finnish optometrists about Pediatric patients' amblyopia assessment and management. The guidelines are presented in both English and Finnish, with the Finnish version included in the appendix.

Adherence to valid legislation is mandatory when utilizing this guideline. According to the current law, a licensed optician is not allowed to independently prescribe eyeglasses for a child under the age of eight.

1. **Anamnesis / Patient history**

- Demographic information
    - Gender, date of birth, and details of the parent or caregiver
    - The person providing the historical information and their relationship to the patient, including any language barriers
- The main complaint and reason for the eye examination
    - Current eye problems
- Ocular history
    - Past eye issues, diseases, diagnoses, and treatments
- Overall systemic history
    - Birth weight, gestational age, prenatal and perinatal history (relevant factors like alcohol, tobacco, and drug use during pregnancy), past hospitalizations and surgeries, and general health and development, including any developmental delays
    - Current medications, and known allergies
- Alterations in behavior and approach to regular tasks

- Family history of eye conditions and relevant systemic conditions, including eye conditions of siblings

2. Ocular examination

- Binocular red reflex
    - Brückner test
- Binocularity
    - Sensory fusion, retinal correspondence, stereopsis, suppression, fusional vergence (motor fusion), and other coordinated binocular eye movements
- Fixation
    - Especially with younger patients who cannot perform conventional visual acuity tests using toys, pearls, etc.
    - For older patients can be done more adequately with a direct ophthalmoscope or slit lamp and Volk 90 D lens
- Visual acuity
    - Without correction and with correction
    - Monocularly for near and distance
    - Cover the other eye thoroughly e.g., with an adhesive patch
    - Preferential-looking tests for younger children
    - In older children, pictorial or letter optotypes in Snellen, decimal, or logMAR notation
    - Take the crowding effect into account
- Binocular alignment and ocular motility
    - Corneal light reflection, binocular red reflex test, and cover tests
    - Ocular versions and ductions, including oblique gaze
- Accommodation
    - Accommodative response (dynamic retinoscopy MEM)
    - Accommodative amplitude (push-up method)
    - Accommodative facility (flipper lenses +2.0 D and -2.0 D)
- Pupillary responses
    - PERRLA (Pupils Equal, Round, React to Light and Accommodation)
    - Swinging flashlight or RAPD (Relative Afferent Pupillary Defect)
- External examination

    - Eyes and lids, inspection for ptosis, head position examination
- Anterior segment examination
    - Front structures of the eye; cornea, iris, lens, sclera, conjunctiva, and anterior chamber
    - Assessing clarity, transparency, and integrity
    - Additional tests, e.g., tonometry to measure intraocular pressure and fluorescein staining assessing corneal surface integrity
- Cycloplegic retinoscopy/refraction with subjective refinement when indicated
    - Essential for achieving accurate refraction in children
    - For children under 12 months, a combination of Tropicamide (0.5 %) and Phenylephrine hydrochloride (2.5 %)
    - For children over 12 months Cyclopentolate hydrochloride 0.5 % or 1 %
    - For some children with heavily pigmented irises atropine sulfate 1 % may be necessary
    - Punctal occlusion is beneficial in reducing side effects
- Funduscopic examination
    - Assessing the optic disc, macula, retina, vessels, and choroid
    - For younger children indirect ophthalmoscope and Volk lens
    - For older children slit lamp
- Additional tests:
    - Color vision
        - Monocularly e.g., Ishihara, HRR Pseudoisochromatic Plates, Panel D-15, Farnsworth-Munsell 100 Hue Test
    - Visual fields
        - Automated static perimetry test or kinetic visual field test

3. Management

The goal of amblyopia treatment is to enhance vision and depth perception. The treatment of amblyopia depends on its cause. The primary treatment is optical correction, with occlusion or atropine therapy as secondary options. Modern approaches emphasize binocular methods and perceptual learning.

The treatment duration can extend over several months. Better outcomes are often seen in younger individuals and cases affecting both eyes, while unilateral amblyopia may show limited improvement in visual acuity after addressing the underlying eye condition. The amblyopic eye experiences the most improvement during a critical period, typically around 7–8 years of age.

Optical correction

- Optical treatment is the first-line approach for amblyopia with refractive error, and it often leads to significant improvement in visual acuity and resolution of amblyopia.
- In cases of high refractive error, spectacles may lead to differences in perceived image size or shape, which can hinder the development of binocular vision. Contact lenses can be considered as an alternative, particularly for aniseikonia and bilateral or unilateral aphakia.
- When prescribing glasses for infants and young children, several important factors should be considered, such as the child's refractive error within the normal range for their age, the potential impact on visual development and functional vision, and the likelihood of natural correction over time.
- Children with significantly high refractive errors are less likely to achieve emmetropia naturally compared to those with lower refractive errors. Full correction of anisometropia and astigmatism is generally recommended, while hyperopia can be under-corrected by 0.50 to 1.50 diopters.
- One-year-olds with 3.50D or more in one meridian and four-year-olds with 2.00D or more hypermetropic meridian have an increased risk of amblyopia. Partial correction of hyperopia in infants may improve visual acuity and reduce the occurrence of esotropia. Uncorrected astigmatism, especially oblique astigmatism, can lead to meridional amblyopia starting from one year of age.
- However optical correction should be tailored to the individual child together with consideration of the findings of the clinical examination, visual symptoms, ocular alignment, and patient history.

Occlusion Therapy

- Occlusion therapy, also known as patching therapy, is the most effective treatment for amblyopia, involving covering the normal eye with an adhesive patch to encourage the use of the amblyopic eye.

- The duration of occlusion therapy depends on the patient's age and the density of amblyopia. Typically, it lasts between 2 and 6 hours per day, and regular visual acuity examinations in both eyes during treatment are essential.
- Implementing occlusion therapy can be challenging for parents and caregivers, especially with patching therapy. Compliance is crucial for successful treatment, and using reward systems and patching diaries with stickers can help improve compliance.
- Inverse occlusion is used in specific cases with persistent false fixation outside the fovea. The aim is to achieve labile fixation, and strict alternating cover is used to promote foveal fixation. Follow-up is necessary to assess progress, and if foveal fixation is not achieved after trying for two months, full occlusion may not be beneficial.

Penalization

- Penalization is an alternative to occlusion therapy for amblyopia and involves using atropine eye drops to blur the non-amblyopic eye. Atropine 1 % dilates the pupil and reduces accommodation, forcing the amblyopic eye to be used for near-vision tasks.
- Atropine penalization is particularly effective for mild to moderate amblyopia, especially anisometropic amblyopia (with a visual acuity of 0.25 or better in decimal notation). It is typically applied twice weekly and is preferred over patching when compliance with patching is a concern.
- Atropine offers advantages over patching, as it is difficult to circumvent and poses fewer psychosocial challenges, especially for school-age children. Minor side effects may include light sensitivity and redness.

New Treatments

- In the past 20 years, significant advancements have been made in understanding amblyopia and its neural mechanisms, with research showing that neural plasticity persists beyond the sensitive period.
- Current treatments for amblyopia mainly prioritize visual acuity and sometimes secondary binocular vision outcomes. However, a more comprehensive approach to healthcare is essential, considering multiple competencies such as reading, self-perception, quality of life, and treatment burden for amblyopic children.
- New approaches to amblyopia treatment, like perceptual learning, video game play, and binocular methods, offer promising alternatives. Binocular treatments aim to reduce

inhibition of the amblyopic eye and enhance binocular fusion and stereopsis, potentially improving overall effectiveness compared to conventional patching. Further research is needed to ascertain the safety and sustained efficacy of these new methods.

Follow-up Evaluation and Treatment Compliance

- Amblyopia treatment efficacy is evaluated by monitoring changes in visual acuity over time. Progress is indicated by improvements in the ability to discern progressively smaller objects with the amblyopic eye.
- If there is no improvement in visual acuity in both eyes, the treatment intensity or approach may need to be adjusted, and pharmacologic penalization can be considered. Reassessment of refractive status, visual acuity, and adherence is recommended if visual acuity decreases in the amblyopic eye.
- Treatment for amblyopia is most effective in early childhood, but success can still be achieved in children up to 12 years old, and some benefits may be seen in those aged 13 to 17 years. However, not all individuals achieve normal visual acuity despite extended treatment, with failure rates varying due to factors such as delayed initiation of treatment, poor adherence, and individual differences in treatment response. Underlying retinal, optic nerve, or gaze control abnormalities may also limit visual acuity recovery in some cases.

Interaction with Pediatric Patients

- Effective communication and rapport-building are essential in pediatric healthcare. Prioritizing attention to the child and parents, complimenting young children's interests, and using engaging toys aid in establishing a connection during the examination.
- Pediatric examinations require prompt anamnesis and clinical assessment without urgency. Reciprocal understanding and active communication between patients, parents, and healthcare professionals are vital for gaining trust and addressing concerns. Dealing with distressed children requires gentle determination and a calm demeanor, with practitioners being honest about their knowledge and limitations.
- Parents play a crucial role in processing information and adapting to care instructions. They should be well-informed about amblyopia treatment, especially its significance in early childhood. Providing written information during stressful situations and matching communication to the child's understanding is beneficial. Comprehensive interventions

should address amblyopia's impact on child development, including challenges in reading proficiency and visuomotor skills, to enhance overall well-being.

4.4 Reliability of the Research Development Work

The literature search for current guidelines regarding children's amblyopia assessment and management was made in January 2023. The search was conducted by using reliable online databases where the main search term was amblyopia guideline. Content advisors from Oulu University of Applied Sciences (OUAS) evaluated the literature search strategy and results to enhance the reliability of the process.

The literature search for the theoretical background was conducted for most parts in February and March 2023. A literature search was done using the PubMed, and EBSCO databases. Keywords included amblyopia, treatment or care or assessment or management or contact lenses or spectacles or occlusion or atropine or virtual reality, and child or infant. The full text had to be reliable, free, and published in English. The search was limited between the years 2012 and 2023 and with a critical approach some older studies from the 21st century was also included.

4.5 Ethicality of the Research Development Work

Research and development work is defined as the systematic and coherent activity of producing new information or developing new products, models, services, processes, and methods. Research and development work must follow good scientific practice and the ethical principles of research on human research. Polytechnic Universities of Applied Sciences are committed to following these guidelines and practices in their theses. (Koivisto & Aro 2019.)

An IBR approval or a statistical analysis was not required for a literature review analysis-based research project. There is no need to apply for ethical approval for this innovation project because there isn't any clinical analytic study. The research will comply with The Finnish National Board on Research Integrity TENK guidance of the responsible conduct of research; The research will follow the practices recognized by the scientific community meaning honesty, general diligence, and accuracy in the research, recording, and presentation of results, and evaluation of research and its results. Research is subject to data acquisition, research, and evaluation methods that comply with

the criteria of scientific research and are ethically sustainable. The research implements the transparency and responsible scientific communication inherent in scientific information when publishing the results of the research. Researchers shall take due account of the work and achievements of other researchers, respecting the work of other researchers appropriately referring to their publications, and giving them the value and significance of their achievements in their research and the publication of its results. The research is planned, conducted, and reported, and the data generated in it are stored as required by the requirements for scientific information. (Tutkimuseettinen neuvottelukunta 2021.) The effectiveness of these guidelines is based on a voluntary commitment to adhere to them by all universities, universities of applied sciences, and other research organizations in the sphere of public funding as well as the most important financers. Oulu University of Applied Sciences has committed to following the Responsible Conduct of Research (RCR) guidelines. (Tutkimuseettinen neuvottelulautakunta 2022.)

4.6 Evaluation of the Research Development Work

The Finnish Ethical Council of Optometry (Optometrian Eettinen Neuvosto; OEN), operated by the Finnish Association of Vision and Eye Care (Näe Ry) and the Finnish Optometry Union (Suomen Optometrian ammattilaiset, SOA Ry), has commissioned a comprehensive clinical guideline for optometrists regarding pediatric eye exams. Subjects were further divided into strabismus, amblyopia, and myopia management. OEN has guided students who are completing their master's degree in Clinical Optometry to perform a master's thesis. They unanimously acknowledge the importance of developing coherent guidance and instructions for the Nordic countries or internationally. However, OEN clarifies that their guidance does not automatically become valid, and they will not directly participate in the creation of the master's thesis. The final guideline will also be submitted to the government of SSLY for review, and OEN will retain the rights for further use. (OEN 2020). Previously, there were no public amblyopia management and assessment guidelines specifically tailored for optometrists or ophthalmologists in Finland or the Nordic countries. This children's amblyopia assessment and management guideline has been developed specifically for use by Finnish optometrists.

5 DISCUSSION

There is a pressing and undeniable need for a clinical guideline specifically designed for Finnish optometrists to effectively address the assessment and management of pediatric patients with amblyopia. The need arises due to the prevalence of amblyopia in children, the evolving field of optometry, and the limited healthcare resources. A specific guideline is crucial to ensure appropriate assessment and management, tailored to the practices of Finnish optometrists. It allows for the effective involvement of optometrists, sharing the responsibility and optimizing healthcare utilization.

A clinical guideline is essential for amblyopia assessment and management due to fragmented care practices, varying decision-making responsibilities among healthcare providers, and the need for a stronger focus on scientific research, increased multidisciplinary communication, and standardized practices across different healthcare settings.

Idiopathic amblyopia, which refers to cases without any obvious reason, is more common in unilateral cases. The diagnosis of idiopathic amblyopia is based on extensive testing to exclude subclinical binocular vision or pathological anomalies before concluding it. Idiopathic causes can include genetic mutations, maternal infections, and abnormalities in the visual cortex. (Ansons & Davis 2014, 286; Daw 2014, 102-103; Taylor & Elliott 2014; Wilson 2015; Mohammadpour et al. 2019; Wilson & Edward M. 2019; Antonio-Santos et al. 2020; Salmon 2020, 708.) Knowing the cause of amblyopia is crucial to determine the most effective treatments for amblyopia. In the future, more research is needed in this field to reduce the number of idiopathic cases of amblyopia.

The prevalence of amblyopia can vary across different regions and countries. Higher prevalence in certain regions, including Europe, could be attributed to various factors such as differences in screening and diagnostic practices, genetic predisposition, environmental factors, and access to healthcare services. It is important to note that prevalence rates are influenced by the methodology and criteria used in studies conducted in different regions. While more research may have been conducted in Europe, it does not necessarily imply that the actual prevalence of amblyopia is significantly different from other regions. Further research and comparative studies are needed to understand the prevalence and associated factors on a broader scale.

6 CONCLUSIONS

The increasing need for healthcare services due to an aging population and the rising prevalence of lifestyle diseases poses significant challenges in securing enough competent healthcare professionals and maintaining service quality. Therefore, in the field of eye care, it is crucial to develop new strategies and redefine work divisions to ensure adequate allocation of public healthcare resources. In Finland, optometrists are increasingly involved in amblyopia assessment and management, necessitating the development of clinical guidelines specific to Finnish optometrists for the assessment and management of pediatric patients with amblyopia. As the number of optometrists with the skills to assess and manage amblyopia treatment increases, the effectiveness of the treatment will improve, allowing ophthalmologists to focus on other patient groups where their specialized knowledge is more crucial.

This work resulted in the creation of new guidelines, commissioned by the Finnish Ethical Council of Optometry, to enhance knowledge and improve eye care services for children with amblyopia in Finland. The pilot use of these guidelines was not included in this project, but it should be incorporated in the subsequent phases or steps.

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REFERENCES

American Optometric Association 2021. Recommended eye examination frequency for pediatric patients and adults. Search date 24.4.2023. https://www.aoa.org/healthy-eyes/caring-for-your-eyes/eye-exams?sso=y

Ansons, A. M., & Davis, H. 2014. Diagnosis and Management of Ocular Disorders (fourth). WILEY Blackwell.

Antonen, J., Häppölä, O., Jokelainen, K., Kainu, A., Kallela, M., Kankaanpää, M., Kiiski, J., Kivelä, T., Kolho, K.-L., Korkeila, J., Lauha, M., Laukkanen, J., Matikainen, M., Myllärniemi, M., Oroza, V., Paananen, J., Rihkanen, H., Rissanen, T., Saha, H., Vuento, M. 2020. Potilaan tutkiminen (Korhonen Päivi, Mustajoki Sami, & Salonen Tapani, Eds.). Kustannus Oy Duodecim.

Antonio-Santos, A., Vedula, S. S., Hatt, S. R., & Powell, C. 2020. Occlusion for stimulus deprivation amblyopia. The Cochrane Database of Systematic Reviews. Search date 13.2.2023. https://doi.org/10.1002/14651858.CD005136.PUB4

Asare, A. O., Wong, A. M. F., Maurer, D., Kulandaivelu, Y., Saunders, N., & Ungar, W. J. 2022. Economic evaluations of vision screening to detect amblyopia and refractive errors in children: a systematic review. Canadian Journal of Public Health = Revue Canadienne de Santé Publique, 113(2), 297. Search date 13.2.2023. https://doi.org/10.17269/S41997-021-00572-X

Asetus terveydenhuollon ammattihenkilöistä 564/1994 - Ajantasainen lainsäädäntö - FINLEX ® 1994. Search date 2.3.2023. https://finlex.fi/fi/laki/ajantasa/1994/19940564

Asper, L., Watt, K., & Khuu, S. 2018. Optical treatment of amblyopia: a systematic review and meta-analysis. Clinical and Experimental Optometry, 101(4), 431–442. Search date 13.2.2023. https://doi.org/10.1111/CXO.12657

Barrett, B. T. 2014. Clinical Procedures in Primary Eye Care (D. B. Elliot, Ed.; Fourth). Elsevier.

Birch, E. E. 2013. Amblyopia and binocular vision. Progress in Retinal and Eye Research, 33(1), 67–84. Search date 15.3.2023. https://doi.org/10.1016/J.PRETEYERES.2012.11.001

Birch, E. E., & Kelly, K. R. 2023. Amblyopia and the whole child. In Progress in Retinal and Eye Research (Vol. 93). Elsevier Ltd. Search date 19.5.2023. https://doi.org/10.1016/j.preteyeres-.2023.101168

Brémond-Gignac, D., Copin, H., Lapillonne, A., & Milazzo, S. 2011. Visual development in infants: physiological and pathological mechanisms. Current Opinion in Ophthalmology, 22 Suppl. Search date 11.5.2023. https://doi.org/10.1097/01.ICU.0000397180.37316.5D

Community Eye Care 2022. Eye Care Guidelines, Amblyopia. Search date 2.8.2023. https://communityeyecare.scot.nhs.uk/guideline-links/amblyopia/

Cruz, O. A., Repka MBA, M. X., Hercinovic MPH, A., Cotter OD MS, S. A., Lambert, S. R., Hutchinson, A. K., Sprunger, D. T., Morse, C. L., Wallace MPH, D. K., Academy of Ophthalmology Preferred Practice Pattern Pediatric Ophthalmology, A., & Panel, S. 2022. Amblyopia Preferred Practice Pattern®. Ophthalmology, 130, P136–P178. Search date 22.5.2023. https://doi.org/10.1016/j.ophtha.2022.11.003

Daw, N. W. 2014. Visual Development (Third). Springer.

ECOO 2013. Guidelines for Optometric and Optical Services. Search date 24.4.2023. https://ecoo.info/wp-content/uploads/2014/01/Guidelines-for-Optometric-and-Optical-Services-in-Europe.pdf

Evans, B. J. W. 2022. Amblyopia and Eccentric Fixation. In Pickwell's Binocular Vision Anomalies (Sixth, Vol. 6, pp. 173–197). Elsevier.

Ghasia, F., & Wang, J. 2022. Amblyopia and fixation eye movements. Journal of the Neurological Sciences, 441, 120373. Search date 22.6.2023. https://doi.org/10.1016/J.JNS.2022.120373

Hagnäs, M., Timonen, M., Keinänen-Kiukaanniemi Sirkka, & Vatjus, R. 2017. Viestintää vai vuorovaikutusta? Search date 27.4.2023. https://www.duodecimlehti.fi/duo13821

Hashemi, H., Pakzad, R., Yekta, A., Bostamzad, P., Aghamirsalim, M., Sardari, S., Valadkhan, M., Pakbin, M., Heydarian, S., & Khabazkhoob, M. 2018. Global and regional estimates of prevalence of amblyopia: A systematic review and meta-analysis, 26(4), 168–183. Search date 13.2.2023. https://doi.org/10.1080/09273972.2018.1500618

Heikinheimo, M., Mertsola, J., & Renko, M. 2016. Lapsi vastaanotolla. In M. Heikinheimo, J. Rajantie, & M. Renko (Eds.), Lastentaudit. Kustannus Oy Duodecim.

Heino-Tolonen, T. 2017. Turvattomuuden kokemisesta kohti arjen helpottumista. Tampereen yliopisto. Search date 20.4.2023. https://trepo.tuni.fi/bitstream/handle/10024/101905/978-952-03-0512-3.pdf?sequence=1&isAllowed=y

Helve, O., & Solantaus, T. 2020. Vuorovaikutus lasten ja vanhempien kanssa. In P. Hietanen, J. Kaleva-Kerola, & E. Pyörälä (Eds.), Lääkärin ja potilaan vuorovaikutus (pp. 95–108). Kustannus Oy Duodecim.

Hensch, T. K., & Quinlan, E. M. 2018. Critical periods in amblyopia. Search date 15.5.2023. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6047524/

Hu, B., Liu, Z., Zhao, J., Zeng, L., Hao, G., Shui, D., & Mao, K. 2022. The Global Prevalence of Amblyopia in Children: A Systematic Review and Meta-Analysis. Frontiers in Pediatrics, 10. Search date 13.2.2023. https://doi.org/10.3389/FPED.2022.819998/FULL

Hyvärinen, L. 2017. Näkö. In P. Mäki, K. Wikström, T. Hakulinen, & T. Laatikainen (Eds.), Terveystarkastukset lastenneuvolassa ja kouluterveydenhuollossa: Menetelmäkäsikirja (Vol. 4). THL. Search date 8.5.2023. https://www.julkari.fi/handle/10024/135858

ICD-10 2023. ICD10data. Search date 12.6.2023. https://www.icd10data.com/search?s=amblyopia

Jauhonen, H.-M., Lindahl, P., Vasara, K., & Hietanen-Peltola M. 2021. Näöntarkkuuden tutkiminen kouluterveydenhuollossa. Terveyden Ja Hyvinvoinnin Laitos. Search date 8.5.2023. https://www.terveysportti.fi/apps/dtk/nko/article/kou00001?toc=1112230

Kääriäinen, M. 2007. Potilasohjauksen laatu: hypoteettisen mallin kehittäminen. Oulun yliopisto, hoitotieteen ja terveyshallinnon laitos. Search date 27.4.2023. http://jultika.oulu.fi/files/isbn-9789514284984.pdf

Koivisto, K., & Aro, P. 2019. Ammattikorkeakoulun opinnäytetöiden eettiset kysymykset. EPookki. Search date 9.5.2023. http://www.oamk.fi/epooki/2019/ammattikorkeakoulun-opinnaytetoiden-eettiset-kysymykset/

Kolho, K.-L. 2020. Lapsipotilaan tutkiminen. In P. Korhonen, S. Mustajoki, & T. Salonen (Eds.), Potilaan tutkiminen. Kustannus Oy Duodecim.

Laaksovirta, H. 2017. Vakavasta sairaudesta keskusteleminen potilaan ja omaisten kanssa. Journal of Religion and Health, 11. Search date 27.4.2023. https://doi.org/10.1007/S10943-016-0249-0

Leat, S. J. 2011. To prescribe or not to prescribe? Guidelines for spectacle prescribing in infants and children. Clinical and Experimental Optometry, 94(6), 514–527. Search date 26.6.2023. https://doi.org/10.1111/J.1444-0938.2011.00600.X

Leslie, S., Martin, T., Hanna, S., Nearchou, C., Jackson, L., Baker, R., & Megaloconomos, M. 2016. Clinical Practice Guide, Pediatric Eye Health and Vision Care, Optometry Australia. Search date 15.3.2023. https://www.optometry.org.au/wp-content/uploads/Professional_support/Guidelines/-optometry_australia_paediatric_eye_health_and_vision_care_guidelines_-_august_2016.pdf

Levi, D. M. 2020. Rethinking amblyopia 2020. Vision Research, 176, 118–129. Search date 15.3.2023. https://doi.org/10.1016/J.VISRES.2020.07.014

Levi, D. M., Knill, D. C., & Bavelier, D. 2015. Stereopsis and amblyopia: A mini-review. Vision Research, 114, 17. Search date 22.5.2023. https://doi.org/10.1016/J.VISRES.2015.01.002

Lindberg, L. 2022. Silmätautien Käsikirja (M. Seppänen, K. Kaarniranta, N. Setälä, & H. Uusitalo, Eds; Third).

Lueder, G. T., Archer, S. M., Hered, R. W., Karr, D. J., Kodsi, S. R., Kraft, S. P., Paysse, E. A., & Nischal, K. 2017. Basic and Clinical Science Course. Pediatric Ophthalmology and Strabismus. Section 6. American Academy of Ophthalmology. Search date 24.8.2023. https://www.aao.org/assets/5e0f04a7-77a1-457b-81af-2f650333faae/636312517616000000/-bcsc1718-s06-pdf

Manh, V., Chen, A. M., Tarczy-Hornoch, K., Cotter, S. A., & Rowan Candy, T. 2015. Accommodative Performance of Children with Unilateral Amblyopia. Investigative Ophthalmology & Visual Science, 56(2), 1193. Search date 26.6.2023. https://doi.org/10.1167/IOVS.14-14948

McConaghy, J. R., & McGuirk, R. 2019. Amblyopia: Detection and Treatment. American Family Physician, 100(12), 745–750. Search date 1.6.2023. https://www.aafp.org/pubs/afp/issues/2019-/1215/p745.html

Meng, Z., Fu, J., Chen, W., Li, L., Su, H., Dai, W., & Yao, Y. 2021. Prevalence of Amblyopia and Associated Risk Factors in Tibetan Grade One Children. Ophthalmic Research, 64(2), 280–289. Search date 23.6.2023. https://doi.org/10.1159/000511264

Mohammadpour, M., Shaabani, A., Sahraian, A., Momenaei, B., Tayebi, F., Bayat, R., & Mirshahi, R. 2019. Updates on managements of pediatric cataract. Journal of Current Ophthalmology, 31(2), 118. Search date 29.5.2023. https://doi.org/10.1016/J.JOCO.2018.11.005

Mostafaie, A., Ghojazadeh, M., Hosseinifard, H., Manaflouyan, H., Farhadi, F., Taheri, N., & Pashazadeh, F. 2020. A systematic review of Amblyopia prevalence among the children of the world. Romanian Journal of Ophthalmology, 64(4), 342. Search date 13.2.2023. https://doi.org/-10.22336/RJO.2020.56

Murdoch Children's Research Institute 2008. NATIONAL CHILDREN'S VISION SCREENING PROJECT. Search date 29.5.2023. https://www.rch.org.au/uploadedFiles/Main/Content/ccch/-DiscussPaper_VisionScreenProject.pdf

NHS 2023. Eye tests for children. Search date 29.5.2023. https://www.nhs.uk/conditions/eye-tests-in-children/

OEN 2020. Optometrian Eettinen Neuvosto OEN Päätös – Optometristin tutkimus- ja hoito-ohjeistukset. In Course material.

Ohlsson, J., Villarreal, G., Sjöström, A., Abrahamsson, M., & Sjöstrand, J. 2001. Visual acuity, residual amblyopia and ocular pathology in a screened population of 12–13-year-old children in Sweden. Acta Ophthalmologica Scandinavica, 79(6), 589–595. Search date 7.4.2023. https://doi-.org/10.1034/J.1600-0420.2001.790609.X

Rouse, M. W., Cooper, J. S., Susan, O. D., Cotter, A., Leonard, O. D., Press, J., Barry, O. D., Tannen, M., Amos, J. F., Beebe, K. L., Cavallerano, O. D. J., Lahr, O. D. J., & Wallingford, O. D. R. 1994. Optometric Clinical Practice Guideline Care of the Patient with Amblyopia. American Optometric Association. Search date 15.3.2023. https://www.aoa.org/AOA/Documents/Practice-%20Management/Clinical%20Guidelines/Consensusbased%20guidelines/Care%20of%20Patient%20with%20Amblyopia.pdf

Oltra, E. 2015. Amblyopia Treatment Modalities. American Academy of Ophthalmology. Search date 23.6.2023. https://www.aao.org/education/disease-review/amblyopia-treatment-modalities

Osborne, D. C., Greenhalgh, K. M., Evans, M. J. E., & Self, J. E. 2018. Atropine Penalization Versus Occlusion Therapies for Unilateral Amblyopia after the Critical Period of Visual Development: A Systematic Review. Ophthalmology and Therapy, 7(2), 323. Search date 13.2.2023. https://doi.org/10.1007/S40123-018-0151-9

Park, S. H. 2019. Current Management of Childhood Amblyopia. Korean Journal of Ophthalmology: KJO, 33(6), 557. Search date 23.6.2023. https://doi.org/10.3341/KJO.2019.0061

Pascual, M., Huang, J., Maguire, M. G., Kulp, M. T., Quinn, G. E., Ciner, E., Cyert, L. A., Orel-Bixler, D., Moore, B., & Ying, G. S. 2014. Risk Factors for Amblyopia in the Vision in Preschoolers Study. Ophthalmology, 121(3), 622-629.e1. Search date 22.5.2023. https://doi.org/10.1016/-J.OPHTHA.2013.08.040

Public Health England 2017. Vision screening for 4 to 5 year olds. Search date 24.4.2023. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/653434/vision_screening_parent_leaflet.pdf

Saha, H. 2020. Lääkäri ja potilas. In P. Korhonen, S. Mustajoki, & T. Salonen (Eds.), Potilaan tutkiminen. Kustannus Oy Duodecim.

Salmon, J. F. 2020. Kanski's Clinical Ophthalmology A Systematic Approach (Ninth). Elsevier.

Scheiman, M., & Wick, B. 2020. Clinical Management of Binocular Vision Heterophoric, Accommodative and Eye Movement Disorders (Fifth). Wolters Kluwer.

Seppänen, M. 2021. Näön tutkiminen lastenneuvolassa. In J. Jousimaa (Ed.), Lääkärin käsikirja. Kustannus Oy Duodecim. Search date 8.5.2023. https://www.terveysportti.fi/apps/dtk/ltk/article/-ykt00662/search/n%C3%A4%C3%B6ntutkimus%20lastenneuvolassa

Sii, S. S. Z., Chean, C. S., Kuht, H., Bunce, C., Thomas, M. G., & Rufai, S. R. 2023. Home-based screening tools for amblyopia: a systematic review. Eye, 1. Search date 2.3.2023. https://doi.org-/10.1038/S41433-023-02412-3

Speedwell, L. 2007. Pediatric contact lenses. In A. J. Phillips & L. Speedwell (Eds.), Contact lenses (Fifth). Elsevier.

Tailor, V., Ludden, S., Bossi, M., Bunce, C., Greenwood, J. A., & Dahlmann-Noor, A. 2022. Binocular versus standard occlusion or blurring treatment for unilateral amblyopia in children aged

three to eight years. The Cochrane Database of Systematic Reviews. Search date 13.2.2023. https://doi.org/10.1002/14651858.CD011347.PUB3

Taylor, K., & Elliott, S. 2014. Interventions for strabismic amblyopia. Cochrane Database of Systematic Reviews, 2014(7). Search date 13.2.2023. https://doi.org/10.1002/14651858.-CD006461.pub4

The College of Optometrists 2022. Guidance for Professional Practice, Knowledge, skills and performance, Examining younger children. Search date 15.3.2023. https://www.college-optometrists.org/clinical-guidance/guidance/knowledge,-skills-and-performance/examining-younger-children

Tian, C. Y., Peng, X. J., Fan, Z. J., & Yin, Z. Q. 2014. Corneal refractive surgery and phakic intraocular lens for treatment of amblyopia caused by high myopia or anisometropia in children. Chinese Medical Journal, 127(11), 2167–2172. Search date 13.2.2023. https://mednexus.org/-doi/pdf/10.3760/cma.j.issn.0366-6999.20140361

Toor, S., Horwood, A. M., & Riddell, P. 2018. Asymmetrical accommodation in hyperopic anisometropic amblyopia. The British Journal of Ophthalmology, 102(6), 772. Search date 29.5.2023. https://doi.org/10.1136/BJOPHTHALMOL-2017-310282

Tutkimuseettinen neuvottelukunta 2021. Hyvä tieteellinen käytäntö (HTK). Search date 9.5.2023. https://tenk.fi/fi/tiedevilppi/hyva-tieteellinen-kaytanto-htk

Tutkimuseettinen neuvottelulautakunta 2022. Ihmistieteiden ohjeeseen sitoutuneet organisaatiot. Search date 9.5.2023. https://tenk.fi/fi/eettinen-ennakkoarviointi/ihmistieteiden-ohjeeseen-sitoutuneet-organisaatiot

Wallace, D. K., Repka, M. X., Lee, K. A., Melia, M., Christiansen, S. P., Morse, C. L., & Sprunger, D. T. 2018. Amblyopia Preferred Practice Pattern®. Ophthalmology, 125(1), P105–P142. Search date 22.5.2023. https://doi.org/10.1016/J.OPHTHA.2017.10.008

Webber, A. L., & Wood, J. 2005. Amblyopia: prevalence, natural history, functional effects, and treatment. Clinical and Experimental Optometry, 88(6), 365–375. Search date 22.5.2023. https://onlinelibrary-wiley-com.ezp.oamk.fi:2047/doi/epdf/10.1111/j.1444-0938.2005.tb05102.x

Wilson, E. M. 2015. Pediatric Cataracts: Overview. American Academy of Ophthalmology. Search date 29.5.2023. https://www.aao.org/education/pediatric-center-detail/pediatric-cataracts-overview

Wilson, & Edward M. 2019. Updates on managements of pediatric cataract. Journal of Current Ophthalmology, 31(2), 118. Search date 29.5.2023. https://doi.org/10.1016/J.JOCO.2018.11.005

Tätä opasta käytettäessä on noudatettava voimassa olevaa lainsäädäntöä. Nykyisen lain mukaan laillistettu optikko ei voi itsenäisesti määrätä silmälaseja alle kahdeksanvuotiaalle lapselle.

1. **Anamneesi / Esitiedot**

- Yhteystiedot
    - Sukupuoli, syntymäaika ja huoltajan tiedot
- Tiedot vastaanotolla olevasta saattajasta ja hänen suhteensa potilaaseen, mukaan lukien asiointikieli
- Pääasiallinen tulosyy
    - Nykyiset silmäongelmat
- Silmähistoria
    - Aikaisemmat silmäongelmat, sairaudet, diagnoosit ja hoidot
- Muut oleelliset terveystiedot
    - Syntymäpaino, raskausajan ja synnytyksen historia (oleelliset tiedot, kuten alkoholin, tupakan ja huumeiden käyttö raskauden aikana), aikaisemmat sairaalahoitojaksot ja leikkaukset sekä yleinen terveys ja kehitys, mukaan lukien mahdolliset kehitysviiveet
- Nykyiset lääkitykset ja tiedossa olevat allergiat
- Muutokset käyttäytymisessä arkisissa askareissa
- Perheen silmäsairauksien ja merkittävien systeemisten sairauksien historia, mukaan lukien sisarusten silmäsairaudet

2. **Silmätutkimus**

- Binokulaarinen punaheijaste
    - Brücknerin testi
- Binokulariteetti
    - Sensorinen fuusio, verkkokalvovastaavuus, stereonäkö, supressio, konvergenssi ja muut silmänliikkeet
- Fiksaatio

    - Erityisesti nuoremmilla potilailla, jotka eivät pysty suorittamaan perinteisiä näöntarkkuustestejä
    - Vanhemmilla potilailla voidaan tutkia tarkemmin suoralla oftalmoskoopilla tai mikroskoopilla ja Volk 90 D -linssillä
- Näöntarkkuus
    - Ilman korjausta sekä parhaan näöntarkkuuden tuottaneella refraktiolla
    - Monokulaarisesti lähelle ja kauas
    - Ei-tutkittava silmä tulee peittää huolellisesti, esimerkiksi laastarilla
    - Nuoremmille lapsille katseen suuntausta tutkiva testi, esim. viivajuovastot
    - Vanhemmilla lapsilla kuvalliset tai kirjain optotyypit, kuten Snellen
    - Huomioi crowding-efekti niin lähi- kuin kaukonäöntarkkuuksia mitatessa
- Katsesuunnan kohdistus ja silmänliikkeet
    - Hirschberg, binokulaarinen punaheijaste ja peittokoe lähelle ja kauas
    - Silmänliikkeet (versiot ja duktiot)
- Akkommodaatio
    - Akkommodaation taso (dynaaminen skiaskopia MEM)
    - Akkommodaatiolaajuus (push-up -menetelmä)
    - Akkommodaatiojousto (flipperilasit +2.0 D ja -2.0 D)
- Pupillireaktiot
    - PERRLA (Pupils Equal, Round, React to Light and Accommodation): pupillit ovat samankokoiset, pyöreät ja reagoivat valoon ja akkommodaatioon.
    - RAPD (Relative Afferent Pupillary Defect): relatiivinen afferentti pupilli vika
- Ulkoinen tarkastus
    - Silmät ja luomet, ptoosin tarkkailu, pään asennon tutkiminen
- Etuosatutkimus
    - Silmän etuosan rakenteet; sarveiskalvo, värikalvo, mykiö, sidekalvo ja etukammio
    - Arvioi kirkkaus, läpinäkyvyys ja eheys
    - Lisätestit, esim. silmänpaineen mittaaminen ja fluoreseiinivärjäys
- Sykloplegeinen skiaskopointi/refraktointi ja tarvittaessa subjektiivinen refraktio
    - Välttämätön tarkan refraktion saavuttamiseksi lapsilla
    - Alle 12 kuukauden ikäisille lapsille käytetään usein tropikamidia (0.5 %) ja fenyyliefriinihydrokloridia (2.5 %)

    - Yli 12 kuukauden ikäisille lapsille syklopentolaattia 0.5 % tai 1 %
    - Joillekin lapsille, joilla on voimakkaasti pigmentoituneet iirikset, voi olla tarpeen käyttää atropiinia 1 %
    - Nenänpuoleista silmäkulmaa (kyyneltiehyttä) painetaan sivuvaikutusten vähentämiseksi
- Silmänpohjan tutkimus
    - Papilla, makula, verkkokalvo, verisuonet ja suonikalvo
    - Nuorempien lapsien tutkimisessa epäsuora oftalmoskooppi ja Volk-linssi
    - Vanhempien lapsien tutkimisessa biomikroskooppi
- Lisätestit:
    - Värinäkötestit
        - Monokulaarisesti esim. Ishihara, HRR-pseudoisokromaattiset levyt, Panel D-15, Farnsworth-Munsell 100 Hue -testi
    - Näkökenttätesti
        - Automaattinen tai kineettinen näkökenttätesti

3. Hoito

Amblyopian hoidon tavoitteena on parantaa näköä ja syvyysnäköä. Hoidon valinta riippuu amblyopian juurisyystä. Ensisijainen hoitomuoto on taittovoiman korjaus, ja toissijaisina vaihtoehtoina ovat peittohoito ja atropiinihoito. Uusimat hoitomuodot korostavat binokulaarisia hoitomenetelmiä.

Hoito kestää useita kuukausia. Parempia tuloksia saavutetaan yleensä nuoremmissa potilaissa, yleensä noin 7–8 vuoden ikään asti.

Silmälasit/piilolinssit

- Amblyopian hoitona käytetään ensisijaisesti silmälaseja taittovirheen korjaamiseksi, jos taustalla korjausta vaativaa taittovirhettä. Jos näöntarkkuus korjaantuu ikätasoiseksi ja symmetriseksi pian silmälasien käytön jälkeen, ei kyseessä ole amblyopia.
- Suurissa taittovoimissa silmälasit voivat aiheuttaa kuvakokoeroa, mikä vaikeuttaa binokulaarisen näön kehittymistä. Erityisesti anisometropian ja unilateraalisen tai bilateraalisen afakian tapauksissa piilolinssit voivat olla silmälaseja parempi vaihtoehto.

- Lasten silmälasimäärityksessä on otettava huomioon useita tärkeitä tekijöitä, kuten lapsen ikätasoinen normaali taittovirhe, vaikutus näönkehitykseen ja toiminnalliseen näköön sekä luonnollisen korjautumisen todennäköisyys ajan kuluessa (emmetropisaatio).
- Korkean taittovirheen omaavilla lapsilla on pienempi todennäköisyys emmetropisoitumiseen. Anisometropian ja astigmatismian täysi korjaaminen on yleensä suositeltavaa, kun taas hyperopiaa voidaan alikorjata 0.50–1.50 dioptriaa.
- Yhden vuoden ikäisillä lapsilla, joilla on vähintään +3.50 dioptriaa, ja neljän vuoden ikäisillä lapsilla, joilla on vähintään +2.00 dioptriaa, on lisääntynyt riski amblyopian kehittymiselle. Vauvojen yli ikätasoisen hyperopian osittainen korjaaminen voi parantaa näöntarkkuutta ja vähentää esotropian riskiä. Korjaamaton astigmatia, erityisesti vinosuuntainen astigmatia, voi johtaa amblyopiaan jo yhden vuoden iästä lähtien.
- Silmälasi- ja piilolinssikorjaus tulee aina räätälöidä yksilöllisesti huomioiden tutkimustulokset, mahdolliset karsastukset, näköoireet, sekä potilaan ikä ja tausta.

Peittohoito

- Peittohoito on tehokas hoitomuoto, jota voidaan käyttää ainoana hoitomuotona tai esimerkiksi lasikorjauksen kanssa amblyopian tai karsastuksen hoitoon. Peittohoidossa peitetään parempi silmä liimapintaisella lapulla tai joskus linsseihin kiinnitettävällä sumukalvolla tai kangaslapulla. Hoidon tarkoitus on aktivoida huonommin näkevää silmää.
- Peittohoidon kesto riippuu potilaan iästä ja amblyopian syvyydestä. Tyypillisesti hoito kestää 2–6 tuntia päivässä. Säännölliset näöntarkkuustutkimukset kummankin silmän osalta hoidon aikana ovat tärkeitä.
- Peittohoidon toteuttaminen voi olla haastavaa koko perheelle. Ohjeiden tarkka noudattaminen on ratkaisevaa onnistuneen hoidon kannalta. Pienet palkinnot kuten tarrat voivat motivoida lasta noudattamaan hoitoa paremmin.
- Inverssipeittohoitoa käytetään vain erikoistapauksissa, joissa havaitaan fovean ulkopuolinen pysyvä fiksaatio. Alkuun amblyooppisilmää peitetään yhtäjaksoisesti viikon tai viikkojen ajan ja tämän jälkeen aloitetaan tiukka vuorottainen peittäminen. Tavoitteena on saavuttaa foveafiksaatio ja tämän myötä edellytys näöntarkkuuden paranemiselle.

Atropiini

- Atropiinia voidaan käyttää penalisaatiohoitona vaihtoehtona perinteiselle peittohoidolle. Atropiinitippa 1 % laitetaan paremmin näkevään silmään, jolloin atropiini laajentaa pupillia ja rajoittaa akkommodaatiota, pakottaen amblyooppisilmän aktivoitumaan.
- Atropiinipenalisaatio on erityisen tehokas lievästä keskivaikeaan amblyopiaan, erityisesti anisometrooppisessa amblyopiassa (jossa näöntarkkuus on 0.25 tai parempi). Tippaa käytetään yleensä kahdesti viikossa, kun peittohoito ei onnistu tarkoituksen mukaisesti.
- Atropiinihoito tuo etuja peittohoitoon verrattuna, koska sitä on vaikeampi välttää ja se aiheuttaa vähemmän psykososiaalisia haasteita, erityisesti kouluikäisille lapsille. Lieviä sivuvaikutuksia voivat olla valoherkkyys ja punoitus.

Uudet hoidot

- Viimeisten 20 vuoden aikana amblyopian ja sen hermostollisten mekanismien ymmärtämisessä on edistytty merkittävästi. Tutkimukset osoittavat, että hermostollinen plastisuus säilyy aiemmin oletettua pidempään.
- Nykyiset hoidot keskittyvät pääasiassa näöntarkkuuden parantamiseen ja joskus toissijaisiin binokulaarisiin haasteisiin. Terveydenhuollon kokonaisvaltaisempi lähestymistapa on kuitenkin välttämätöntä, ottaen huomioon useita osa-alueita, kuten lukutaito, itsearvostus, elämänlaatu ja hoidon taakka lapsen näkökulmasta.
- Uudet lähestymistavat amblyopian hoitoon, kuten havaintopohjainen oppiminen, videopelit ja binokulaariset menetelmät, tarjoavat lupaavia vaihtoehtoja. Binokulaariset hoidot pyrkivät vähentämään amblyooppisilmän rajoituksia ja parantamaan binokulaarista fuusiota ja stereonäköä, mahdollisesti parantaen kokonaisvaikutusta verrattuna perinteiseen peittohoitoon. Lisätutkimuksia tarvitaan uusien menetelmien turvallisuuden ja pitkäaikaisen tehon selvittämiseksi.

Seuranta ja hoitomyöntyvyys

- Amblyopian hoidon tehoa arvioidaan mittaamalla näöntarkkuuden muutoksia kontrollikäynneillä. Hoidon onnistuessa amblyooppisilmän näöntarkkuus paranee ja potilas näkee yhä pienempiä kohteita.
- Jos näöntarkkuus ei parane, hoitoa lisätään tai vaihdetaan toiseen. Jos amblyooppisilmän näöntarkkuus laskee, tulee refraktio, näöntarkkuus ja hoidon noudattaminen uudelleenarvioida.

- Amblyopian hoito on tehokkainta varhaislapsuudessa, mutta onnistunut hoito on mahdollista lapsille jopa 12-vuotiaiksi saakka, ja joissakin tapauksissa jopa 13–17-vuotiailla voi hoidosta olla jonkin verran hyötyä. Kuitenkaan kaikki yksilöt eivät saavuta normaalia näöntarkkuutta, vaikka hoitoa jatketaan pitkään. Epäonnistumisasteet vaihtelevat eri tekijöiden, kuten hoidon aloittamisen viivästymisen, huonon toteuttamisen ja yksilöllisten hoitovasteiden takia. Taustalla olevat rakennepoikkeavuudet tai silmäsairaudet voivat joissakin tapauksissa rajoittaa näöntarkkuuden nousemista.

Vuorovaikutus lapsipotilaiden kanssa

- Tehokas viestintä ja hyvän suhteen rakentaminen on olennaista lapsipotilaiden kanssa. Lapsen ja vanhempien huomioiminen, nuorten lasten kiinnostuksen kohteiden kehuminen ja leikinomainen tutkiminen auttavat luomaan yhteyden tutkimuksen aikana.
- Lasten silmätutkimukset edellyttävät ripeää anamneesia ja kliinistä arviointia ilman kiireen tunnetta. Vastavuoroinen ymmärrys ja aktiivinen kommunikaatio potilaiden, vanhempien ja terveydenhuollon ammattilaisten välillä ovat tärkeitä luottamuksen luomisessa ja huolenaiheiden käsittelemisessä. Vaikeasti käyttäytyvien lasten kanssa toimiminen vaatii lempeää päättäväisyyttä ja rauhallista käytöstä, ja ammattilaisten on oltava rehellisiä tietämyksestään ja rajoituksistaan.
- Vanhemmat ovat keskeisessä asemassa tiedon prosessoinnissa ja hoito-ohjeiden sisäistämisessä. Heidän tulisi olla hyvin perillä amblyopian hoidosta, erityisesti sen merkityksestä varhaislapsuudessa. Sekä suullisen että kirjallisen tiedon antaminen stressaavissa tilanteissa ja viestinnän sovittaminen lapsen ymmärrystasolle ovat hyödyllistä. Kattava informointi tulisi käsitellä amblyopian vaikutuksia lapsen kehitykseen, mukaan lukien haasteet lukutaidossa ja visuomotorisissa taidoissa, parantaakseen kokonaisvaltaista hyvinvointia.