Nonsurgical Treatment of Strabismus

6

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6.1 Introduction

Previous chapters have highlighted various altered sensory and motor ocular mechanisms associated with strabismus either as cause or effect. The goal of strabismus management is not only to restore motor alignment of the eyes but also to correct any underlying sensory abnormality. While most of the sensory abnormalities are managed conservatively, surgery is often indicated for correcting the static component of the motor misalignment. This chapter will discuss the nonsurgical approach in strabismus management which includes appropriate correction of the refractive error, treatment of associated sensory abnormalities including amblyopia, and treatment of the dynamic component of the deviation.

6.2 Refraction

Cycloplegic refraction should be carried out in all patients having or suspected of having strabismus. Identification and appropriate correction of refractive error is the first essential step before considering any further treatment of strabismus. Prescription of proper glasses provides a sharp retinal image for fusion and creates a balance between accommodation and convergence. It also takes care of the dynamic component of the strabismus and in patients with fully accommodative esotropia may be the only treatment required. Our choice of cycloplegic agent has been discussed in Chap. 1. Here we elaborate the guidelines for prescription of glasses.

Children are most comfortable in their parent's lap and can be made to look straight with the other parent or sibling standing behind the examiner. They may be made to look at distance with screen (even a phone) playing something of their

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Table 6.1 The American Academy of Ophthalmology Preferred Practice Pattern guidelines for prescribing spectacles in preverbal children

	Refractive error (diopter) threshold for correction at different ages		
Refractive status	≤1 year	1–2 years	2–3 years
Isoametropia (equal or nearly equal refractive error in both eyes)			
Myopia	≥−5.00	≥−4.00	≥−3.00
Hyperopia (no manifest deviation)	≥+6.00	≥+5.00	≥+4.50
Hyperopia with esotropia	≥+2.50	≥+2.00	≥+1.50
Astigmatism	≥3.00	≥2.50	≥2.00
Anisometropia (without deviation)[a]			
Myopia	≥−4.00	≥−3.00	≥−3.00
Hyperopia	≥+2.50	≥+2.00	≥+1.50
Astigmatism	≥2.50	≥2.00	≥2.00

American Academy of Ophthalmology Pediatric Ophthalmology/Strabismus Panel. Preferred Practise Pattern Guidelines. Amblyopia. San Francisco, CA: American Academy of Ophthalmology; 2007. Available from: http://www.aao.org/ppp

Note that in isoametropia, the threshold for correction of hyperopia is higher than myopia in children without strabismus. In presence of esotropia, threshold for hyperopia correction is much lesser.

≤ lesser than or equal to, ≥ more than or equal to

[a]Threshold for anisometropia correction should be lower in presence of deviation

interest. With a little bit of patience, we seldom need to sedate children for retinoscopy and retina examination.

In absence of symptoms or ocular deviation, a hypermetropia of up to + 4 D, myopia up to −3 D, and astigmatism of up to 2 D may be left uncorrected in small children. The American Academy of Ophthalmology Paediatric Eye Evaluations Preferred Practice Pattern summarizes guidelines for prescribing spectacles in children (Table 6.1).

The reader must understand that hypermetropes are overexerting their accommodation to see clear. Accommodation has three components, change in refractive power of crystalline lens, convergence, and miosis, which occur together. The undesired convergence that occurs along with increased accommodative effort to see clear is believed to play a role in certain types of ET [1]. An opposite mechanism would work in myopes who would try to relax their accommodation; however this has a much smaller role in development of XT [2]. Once this is clear, it would also be easy to understand that if abnormally increased convergence occurs with a normal accommodative effort, the eyes would become esotropic on attempts to focus near. This is the etiology of accommodative ET associated with increased AC/A (accommodative convergence/accommodation) ratio.

The unit for AC/A ratio is prism diopter (Δ/diopter (D). Formulae for measuring the AC/A ratio have been listed in Chap. 3.

Clinical Tip: In presence of ET, hyperopia should be maximally corrected to relax any accommodative effort, and in XT, full myopic prescription should be prescribed to induce accommodation.

Fig. 6.1 Correction of refractive accommodative esotropia with glasses

In presence of XT, a full or slight overcorrection of myopia and a slight undercorrection of hypermetropia may be desirable. Similarly, in ET, a full correction of hypermetropia should be given [2] (Fig. 6.1). However, an undercorrection of myopia in an attempt to reduce the ET is not desirable [3, 4]. A note should be made of the change in ocular deviation with glasses after allowing suitable time (refractive adaptive time varying from few hours in myopia to few days or weeks in hypermetropia). Where glasses have been deliberately under- or overcorrected and the child complains of asthenopia, a shift toward full correction should be considered. Hypermetropic children may require initial cycloplegia for a few days to adjust to the new glasses [2].

Contact lenses may be prescribed for myopia in older children as placing the refractive correction closer to the nodal point has several advantages in a patient with strabismus [5]. We have reported that strabismus associated with significant anisometropia in young adults may also improve with refractive correction in phakic plane [6, 7].

Bifocals whenever prescribed (in pseudophakes and in ET with high AC/A ratio) should be of pupil bisecting (executive) type only (Fig. 6.2). Progressive lenses should be avoided in children below 12 years of age.

Clinical classification of hypermetropia is depicted in Fig. 6.3, and indications for nonsurgical management of strabismus are listed in Table 6.2.

6.3 Amblyopia

von Noorden defines amblyopia as "*decrease of visual acuity in one eye when caused by abnormal binocular interaction or occurring in one or both eyes as a result of pattern vision deprivation during visual immaturity, for which no cause*

Fig. 6.2 Non refractive accommodative esotropia (with high AC/A ratio). The eyes are orthotropic for distance (top). The ET present for near (middle) is corrected when the patient looks through the lower segment of the bifocal lenses (bottom) having just enough addition to convert ET to esophoria

Spherical Error (in Dioptres)	< 2.0	2.25 to 5.0	>5.0
Degree*	Mild	Moderate	High
Clinical Presentation	Latent (detected only after cycloplegia)	Manifest (may be detected without cycloplegia)	
		Facultative (Overcome by accommodation)	Absolute (Always present)
Management	Usually not corrected	Corrected in specific conditions (e.g. symptomatic patient, strabismus, amblyopia)	Corrected

* American Optometric Association. Optometric Clinical Practise Guideline. St.Louis, MO. 2008. Available from https://www.aoa.org/documents/optometrists

Fig. 6.3 Clinical classification of hypermetropia

can be detected during physical examination of the eye(s) and which in appropriate cases is reversible by therapeutic measures." [8]

Simply put (a) an interocular difference of two or more lines or (b) Snellen's single eye best corrected visual acuity lesser than 20/40 or 6/12 (<0.3 logMAR) in the absence of any detectable cause can be termed as amblyopia.

Table 6.2 Indications of nonsurgical treatment of strabismus

1. Refractive errors
2. Sensory abnormalities
(a) Amblyopia
(b) Suppression
(c) Abnormal retinal correspondence
(d) Eccentric fixation
3. Motor abnormalities
(a) Convergence insufficiency
(b) Low fusional amplitude
4. Deviations
(a) Dynamic component, e.g., accommodative ET
(b) Static component, e.g., small-angle deviations, recovering incomitant deviations

Table 6.3 Classification of amblyopia

Based on etiology		
	Abnormal binocular interaction	Vision deprivation
I. Strabismic	Yes	
II. Refractive		
(a) Anisometropic	Yes	Yes
(b) Ametropic	Yes	Yes
III. Stimulus deprivation		
(a) Unilateral	Yes	Yes
(b) Bilateral		Yes
Based on severity	Snellen Acuity (Log MAR)	
I. Mild	>20/40 (<0.3)	
II. Moderate	20/40 to 20/100 (0.3 to 0.7)	
III. Severe	<20/100 (>0.7)	

Amblyopia is caused either by an abnormal binocular interaction or stimulus deprivation during the first 7 years of life (the sensitive period). After this sensitive period, the visual maturation is complete, and the retinocortical pathways become resistant to abnormal visual input [9]. Common causes of amblyopia are strabismus, anisometropia (commoner in anisohypermetropia than anisomyopia), cataract, corneal opacity, or severe ptosis occurring in early childhood. Earlier, longer and denser visual deprivation increases the severity of amblyopia. The classification of amblyopia according to etiology and severity is presented in Table 6.3, and its salient features are listed in Text Box 6.1.

Text Box 6.1: Amblyopia Features

- Caused by abnormal binocular interaction (as in strabismus) or pattern vision deprivation (as in bilateral congenital cataract) or both (as in unilateral congenital cataract).
- Fixation preference for non-amblyopic eye.

- Subnormal near and distance vision.
- Subnormal color vision, contrast, and accommodation.
- Vision improves in mesopic (dim light) conditions.
- Crowding phenomenon (characters appear to run into one another).
- Visual acuity does not improve when tested binocularly (no binocular summation).
- Eccentric fixation.
- Slow and jerky pursuits.
- Larger pupil with increased latency of reaction.

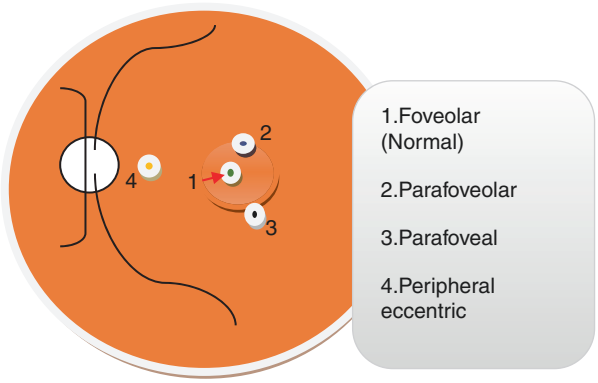


Fig. 6.4 Central (foveolar) and non-foveolar fixation patterns seen in amblyopia [8]

It is the responsibility of each ophthalmologist to diagnose and treat this condition as early as possible. The diagnosis should be one of exclusion when all other organic causes have been ruled out. Once diagnosed, corrected and uncorrected visual acuity for distance and near should be documented. We have seen that if near vision is subnormal and improves with addition of +3.0 D sphere, it implies a weak accommodative effort. This indicates a better prognosis to amblyopia treatment [9]. Effort should also be made to note the fixation with the visuscope attachment of the direct ophthalmoscope (Fig. 6.4).

Anatomical changes in amblyopia have been demonstrated in the lateral geniculate nucleus by von Noorden and in the macular thickness on Optical Coherence Tomography (OCT) by other researchers and us [10, 11]. It would be logical to assume that reversal of these changes would be difficult as the age advances, highlighting the importance of early management.

6.3.1 Principles of Amblyopia Management

After correcting the causative factor, conventional occlusion of the non-amblyopic eye remains the gold standard treatment. Few points to be remembered while treating amblyopia are:

Fig. 6.5 Amblyopia treatment. While occlusion of the non-amblyopic eye remains the gold standard, newer options like digital amblyopia goggles are emerging

1. Occlusion or atropine penalization may not be started immediately with the prescription of glasses for the first time. It would come as a shock to the child and the parents who would tend to become non-compliant. Moreover, it has been shown that large percentage of children with mild to moderate anisometropic amblyopia improve two or more lines of vision within 15 weeks of wearing glasses alone [12]. Subsequently, occlusion or penalization should be started in children who do not show full improvement.
2. Occlusion should be done directly with a patch so that the child does not peek through the side of glasses (Fig. 6.5).
3. Initially full-time occlusion was prescribed in all children. This had poor compliance, dissatisfied parents, and also the risk of occlusion amblyopia of the sound eye.

   The recommendations of Pediatric Eye Disease Investigator Group (PEDIG) are that moderate amblyopia (20/40–20/100) responds well to 2 h/day patching and severe amblyopia (20/100–20/400) responds to 6 h/day patching of the sound eye [13, 14]. It should be kept in mind that these regimens are effective when initiated below 5 years of age, with proper compliance and the children actively using the amblyopic eye during the period of occlusion [15–17].
4. Suitable correction should be worn over the amblyopic eye, and the child should be encouraged to perform near work like coloring or playing video games when the better eye is occluded.
5. Follow-ups should occur every 4 weeks to monitor change in visual acuity and fixation preference. No improvement should raise the suspicion of improper technique. We believe that pleoptics or office exercises to stimulate the amblyopic macula only serve to reduce missed appointments by patients.
6. Weekend atropine penalization of the sound eye was initially suggested as an option in children non-compliant to occlusion or in maintenance phase but is now recommended as an alternative to occlusion in primary amblyopia management [18–21]. *Penalization* of the sound eye combined with overcorrection of the amblyopic eye by +1.0 to +3.0 D sphere forces the child to use the amblyopic eye for near work [4].

7. Miotics may be used as an alternative to hypermetropic glasses in the amblyopic eye, to facilitate accommodation without effort in children non-compliant to glasses. The same principle is followed in prescription of miotics as an alternative to bifocals in accommodative ET.
8. Although best response is seen in children below 6 years of age, a sincere attempt to improve vision in the amblyopic eye must be made in older children and even adults. We have seen vision improve in adults over 20 years of age.
9. As the vision starts to improve, attempts must be made to assess and improve the binocular functions. Ocular alignment may be considered as the improvement begins, as alignment itself enhances the response to treatment, provided amblyopia therapy is continued after surgery [22]. If parents are non-compliant, it may be prudent to wait for surgery till complete recovery of vision in the amblyopic eye.
10. Several newer options like digital amblyopia goggles are available, but we have a limited experience with these (Fig. 6.5). A randomized trial addressing this issue is lacking. Considering the initial cost and recurring cost of maintenance in an active child, they are unlikely to become very popular. Binocular visual stimulation through the use of dichoptic glasses while playing video games is the newest treatment regimen which appears promising [23].
11. Drugs like levodopa should not be used [24, 25]. Citicoline appears to be promising and may be given in selected patients [26].
12. After complete resolution gradual tapering of the treatment should be continued till 8–10 years of age. Recurrence is common if the treatment is stopped abruptly [27].

In presence of nystagmus which increases on occlusion, overcorrecting the hyperopia or using lightly frosted glasses (achievable by applying neutral colored nail paint on glass) in the sound eye to reduce its vision to one line below the amblyopic eye may be advisable. We have found this to serve the purpose of occlusion without increasing the nystagmus. However, some researchers advocate full-time occlusion and believe that the oscillopsia improves gradually [4]. Penalization is also effective.

Clinical Tip: In presence of strabismic amblyopia, amblyopia therapy should be rigorously initiated prior to surgical alignment and be continued thereafter [22].

6.4 Orthoptics

Once amblyopia has been overcome, subsequent efforts are directed at strengthening of binocular fusion as achieving normal binocular single vision (BSV) is the ultimate aim of strabismus management. Binocular vision better than uniocular

Fig. 6.6 Quantification of stereopsis. Left to Right. Random Dot, Titmus fly, and TNO test. These tests are performed after dissociating the two eyes with polaroid or red green glasses

Table 6.4 Grades of Binocular Single Vision (BSV)

Simultaneous Macular Perception (SMP): ability to perceive separate stimuli at the same time			
Fusion: unification of visual impulses from the corresponding retinal images into a single visual percept. To simplify, the ability to fuse (as 1) slightly dissimilar images falling on *corresponding retinal points* of two eyes			
Average fusional amplitudes (vergence in prism diopters)			
	Convergence	Divergence	Vertical
Distance	14	6	2.5
Near	38	16	2.6
Stereopsis: is binocular appreciation of an object in *depth* due to fusion of images that stimulate *horizontally disparate retinal points*			
Normal range of stereopsis			
Distance	200–450 s of arc		
Near	20–40 s of arc		

vision (binocular summation), ability to appreciate physiological diplopia, and correct response on Worth Four Dot Test (WFDT) confirm the presence of binocular single vision (BSV). These tests can be performed in the office of each ophthalmologist without the need of any special equipment.

Grading binocular vision requires a synoptophore, and quantification of stereopsis is done by tests like Titmus Stereo, TNO, or Random Dot (Fig. 6.6 and Table 6.4) [28]. Assessment of binocular functions has been dealt in Chap. 2.

Satisfactory motor alignment and good vision in each eye are primary requirements for BSV. Motor alignment enables the images to fall within the Panum's area which itself provides a stimulus for binocular fusion and stereopsis. This may be further reinforced by orthoptic exercises.

Literal meaning of the word "orthoptics" is "straight sight." Truly speaking, entire strabismus examination and all nonsurgical treatment including amblyopia management is orthoptics, which is carried out by the treating physician or under his direct supervision.

The role of the orthoptist and the synoptophore is limited to the following in current scenario:

1. Confirming the deviation preoperatively

This is more relevant in vertical and torsional deviations measurements of which are better performed on the synoptophore.

2. Convergence and fusion exercises

An individual with normal convergence should be able to converge his eyes and see an object like pencil tip clearly at about 10 cm for 30 s. Those unable to do this may be symptomatic because of convergence insufficiency.

Convergence exercises prescribed in presence of convergence insufficiency are effective. The patient is taught to converge on an object like a pen at the closest distance that he can see clearly. At the same time, he is made aware of physiological diplopia for distance objects. The patient is then asked to remove the near object, while continuing to voluntarily converge and have diplopia for distance. In subsequent attempts the distance at which the pen is initially held is gradually reduced. This exercise should be performed for not more than 5 min and never when the patient is tired or sleepy.

Fusion exercises are performed on the synoptophore or with prisms by an orthoptist. They are useful to increase the fusional range in patients with subnormal fusional amplitude.

3. Pleoptics

Several exercises and equipment have been described to actively stimulate the macula, like the CAM stimulator and the Haidinger's brushes. They have a limited utility except to encourage the patients to regularly attend the follow-up visits.

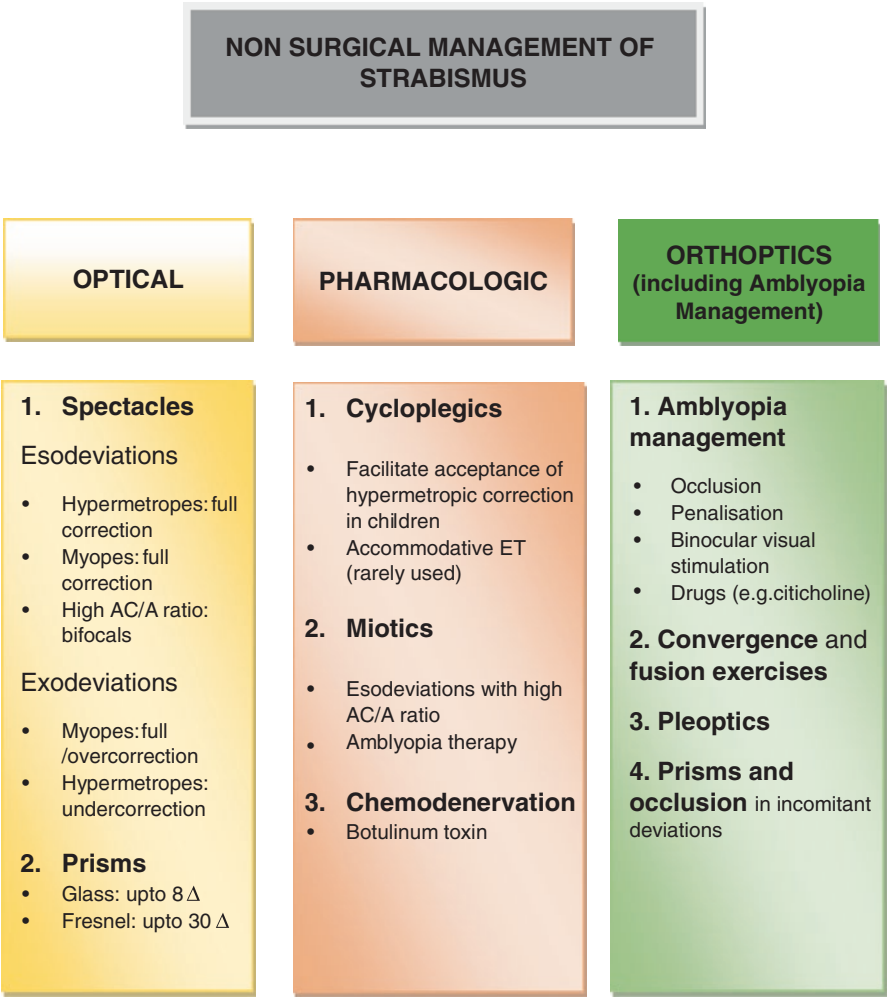
6.5 Prisms

Prisms have a therapeutic utility in facilitation of binocular vision in small-angle deviations, especially in residual or consecutive deviations postsurgery. Prisms can be incorporated in lenses with prescription or may be stuck on their back surface (Fresnel prisms). While prescribing, the base of the prism should point away from the deviation, for example, base in prisms would be prescribed in XT. Also, the total amount of prisms to be prescribed in prism diopters (Δ) should be divided between the two eyes. Prescription of prisms is best left to the specialist.

6.6 Chemodenervation

Chemodenervation with botulinum toxin has been discussed in detail in Chap. 9.

6.7 Summary



6.8 Multiple Choice Questions

1. Amblyopia is decreased visual acuity in the absence of any obvious cause. True statement with regard to it is:
   (a) It is almost always unilateral.
   (b) Anisometropia would cause it to be denser compared to total congenital cataract.
   (c) Strabismus would cause it to be denser compared to total congenital cataract.
   (d) Unilateral congenital cataract would cause it to be denser compared to bilateral.

Answer (d) Amblyopia is frequently bilateral. Congenital cataract causes form vision deprivation unlike strabismus and anisometropia which cause abnormal binocular interaction. Amblyopia due to vision deprivation is denser. Unilateral congenital cataract causes both form vision deprivation and abnormal binocular interaction; as a result it causes one of the densest amblyopia.

2. Amblyopia is reversible if treated in time and appropriately. A good prognostic sign for amblyopia is:
   (a) Established eccentric fixation
   (b) Visual deprivation occurring at an early age
   (c) Near vision improves with +3.0 D sphere
   (d) Detection during college entrance medical examination

Answer (c) Established eccentric fixation, early visual deprivation, and late detection are all poor prognostic. Improved near vision is suggestive of impaired accommodation and carries good prognosis [9].

3. Orthoptic exercises should be best considered in management of:
   (a) Convergence insufficiency
   (b) Infantile esotropia
   (c) Dissociated vertical deviation
   (d) Sixth nerve paralysis

Answer (a) Orthoptic exercises are treatment of choice for symptomatic convergence insufficiency. They are not indicated in other three conditions.

4. Accommodative esotropia with high AC/A ratio is best managed by:
   (a) Progressive glasses
   (b) Executive type bifocals
   (c) Full hypermetropic correction
   (d) Surgery

Answer (b) In patients of accommodative esotropia with convergence excess (high AC/A), a full correction for distance will leave residual esotropia for near which should be corrected with near addition. Executive type bifocals (large lower segment bisecting the pupil) are preferred in children.

5. A 4-year-old child presents with left esotropia and amblyopia. What is the correct sequence of management?
   (a) Cycloplegic refraction → amblyopia therapy → Squint surgery
   (b) Cycloplegic refraction → squint surgery → amblyopia therapy
   (c) Cycloplegic refraction → amblyopia therapy only
   (d) None of the above

Answer (a) Cycloplegic refraction is always the initial step in management of comitant strabismus. Ocular alignment should be considered only after completion of amblyopia management.

6. Correct statement regarding prescription of glasses in intermittent exotropia:
   (a) Hypermetropia may be overcorrected to control deviation.
   (b) Myopia should always be fully corrected.
   (c) Undercorrection of hypermetropia and overcorrection of myopia may help to control deviation.
   (d) Both (b) and (c)

Answer (d) Myopia should always be fully corrected in exotropia to help in fusion. A slight overcorrection of myopia and a slight undercorrection of hypermetropia may be desirable to increase accommodative effort which would subsequently increase convergence and help in controlling the deviation.

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