Amblyopia

• History of amblyopia
  – Le Cat (1713) is credited with providing the first accurate clinical description of human amblyopia. However, credit for first describing any treatment for amblyopia is given to George Louis Leclerc, Conte De Buffon (1707-1788)
    • Buffon was the first to realize the two most important elements in amblyopia therapy: occlusion and full optical correction
In 1939, Chavasse attributed the development of amblyopia and facultative suppression to the process of “adaptive inhibition in the face of dissociation.” This is known as the theory of “amblyopia of arrest” versus “amblyopia of extinction.”
• Chavasse divided amblyopia into two types:
  – Amblyopia of arrest: there is a cessation of development of vision in the involved eye that must occur before the age of 6 years. Chavasse felt that 20/20 vision is firmly established by age 6 years and amblyopia of arrest is considered irreversible.
  – Amblyopia extinction: The amblyopia could be improved, but only up to the best vision that was obtained before the onset of the anomalous visual experience.
• Dobson and Teller (1978)
  – More recent objective methods have demonstrated 20/20 VA can be obtainable by about 6 to 12 months of age with certain testing procedures.
  – Amblyopia of arrest can only exist when the anomalous visual experience occurs before 6 months or so. Consequently, the majority of amblyopia is of the extinction type and therefore potentially reversible.
4 Months: 6/768 (20/2500, or $\frac{1}{100}$ of normal at school age)
6 Months: 6/288 (20/1000, or $\frac{1}{50}$ of normal at school age)
9 Months: 6/72 (20/240, or $\frac{1}{12}$ of normal at school age)
1 Year: 6/36 (20/166, or $\frac{1}{8}$ of normal at school age)
2 Years: 6/12 (20/40, or $\frac{1}{2}$ of normal at school age)
3 Years: 6/9 (20/30, or $\frac{3}{5}$ of normal at school age)
5 Years: 6/6 (20/20, or same as at school age)
Figure 1.5 Comparison of systematic acuity data obtained with OKN, PL, and VEP for infants between birth and 6 months of age. O—Marg et al. (1976), VEP; ■ Frantz et al. (1962), OKN; ▲—Allen (1978), PL. (Adapted from Dobson V, Teller DY. Visual acuity in human infants: A review and comparison of behavioral and electrophysiological studies. Vis. Res. 18:1469–1483, 1978.)
Example

1. Onset of abnormal visual experience is at age of 1 year
2. Best VA at age 1 year:
   - Chavasse: 20/120
   - Dobson and Teller: 20/20
3. Best VA now (after age 6 years and without previous treatment): 20/200
• Chavasse (1939)
  – 20/200 to 20/120 = deficit due to extinction and therefore fully reversible
  – 20/120 to 20/20 = deficit due to arrest and therefore nonreversible

• Dobson and Teller (1978)
  – 20/200 to 20/20 = deficit due to extinction and therefore fully reversible
  –
Definition

- Amblyopia is an unilaterally or bilaterally decrease of visual form sense for which no obvious structural or pathologic causes can be detected, and which is not overcome by correction of the refractive error.
• The problem with the definition description is the “no structural causes” is depended on the depth of the clinical investigation. Another problem is that many cases of amblyopia are cured simply by wearing spectacles, though over a period of time. This is why recent studies have changed the clause to “a visual loss resulting from an impediment or disturbance to the normal development of vision, and not directly correctable with glasses”
• Amblyopia develops in infants and very young children, beginning only during the first 6 years old. The most critical period for loss of binocularity and for the development of functional amblyopia is the first 18 months of life (Levi 1994). Once established, it can persist for life. If treated early, its effects are completely or nearly reversible.

• Different visual functions have different sensitive periods: the sensitive periods for cortical visual functions are longer than for retinal functions.
• The visual acuity of amblyopia ranges from slightly less than normal (20/25) to functional blind (less than 20/200). Light perception is always maintained. There are many criterions to define amblyopia acuity.

• Amblyopia represents a syndrome of deficits, not just decrease of visual acuity. The depressing are including other ocular functions such as ocular motility, accommodation, contrast sensitivity, and spatial judgment.
• The low spatial contrast sensitivity is close to normal but there is a marked loss at high spatial frequency. This loss increases with the severity of the amblyopia and does not result from optical factors, unsteady fixational eye movements or eccentric fixation (Flynn 1991). Intermediate spatial frequency is less affected than high contrast VA (Moseley et al 2006).
New definition of amblyopia

• Unilateral (or infrequently bilateral) condition in which the best corrected visual acuity is poorer than 20/20 in the absence of any obvious structural or pathologic anomalies but with one or more of the following conditions occurring before the age of 6 years:
Continue

• 1. Amblyogenic anisometropia
• 2. Constant uniteral esotropia or exotropia
• 3. Amblyogenic bilateral isometropia
• 4. Amblyogenic unilateral or bilateral astigmatism
• 5. Image degradation
Prevalence of amblyopia

- Amblyopia is common, but its prevalence has been difficult to assess due to:
  - Differences in criteria
  - Various populations
  - Type of visual acuity test
  - Omission of successfully treated or prevented amblyopia
  - Incomplete examination
• Preschool and school age children
  – 1% to 4.8%
• Ophthalmic patients seeking eye care
  – 1.7% to 5.6%
• Military personnel
  – 1% to 4%
Incidence of amblyopia

• A higher incidence has been associated with prematurity, low birth weight, retinopathy of prematurity, cerebral palsy, and mental retardation. Maternal smoking and use of drugs or alcohol during pregnancy are also in high risk.

• Data in various sub-populations is generally not available. No difference between males and females. The relative importance of environmental and genetic factors in the development of amblyopia is also unclear.
Etiology

• The sensory obstacles in the early life
  – Retinal image degradation
    • Cataract, lid closure, high uncorrected refractive errors
  – Binocular mis-registration
    • Strabismus
• The factors are sufficient but not necessary to produce amblyopia
• The role of visual experience in the development of visual function
  – Disruption of binocular input completely disrupts the pattern of cortical excitatory binocular interaction
  – Monocular deprivation has a dramatic effect on the anatomy, physiology, and function of the striate cortex
– The physiologic consequences of deprivation are more or less confined to the striate cortex.

– The effects of abnormal visual experience occur only during a “sensitive” period early in life.

– The physiologic consequences of deprivation can be reversed during a “critical” period early in life.
Classification

- All amblyopia was considered either organic, or functional amblyopia.
- Some contend that amblyopia should be limited to functional etiologies. Organic cannot truly be amblyopia because of its structural defects or the impairment of visual pathway, so that medical treatment can be considered.
Organic amblyopia

- Organic amblyopia occurs when the components of visual pathway fail to develop because of any subtle retinal or central nervous system lesion, or undetectable lesion because of metabolic or toxic disturbance.

- Organic amblyopia includes nutritional, toxic, retinal eye disease, and idiopathic or congenital amblyopia.
Functional amblyopia

- Reduced vision was due to physical obstacles such as corneal and lens opacities, as well as strabismus due to suppression of the retinal image in the deviated eye
- strabismic amblyopia
- anisometropic amblyopia
- isoametropic amblyopia
- image degradation amblyopia
- Psychogenic amblyopia
Psychogenic amblyopia

- The visual loss is of emotional or psychologic rather than physiologic origin. The amblyopia is characterized by reducing visual acuity for anxiety or emotional repression. The symptoms are not under voluntary control. The diagnosis is made by exclusion of organic pathology and sensory problems. Unilateral visual loss is very rare. Direct to others questions, nearly always reveals additional symptoms such as headache, periorbital pain, photophobia, and sometimes diplopia.
Strabismic amblyopia

- Strabismic amblyopia is associated with an early-onset (before age 7 years or so), constant, unilateral deviation at distance and at near. The cause is an active cortical inhibition from the fovea of the deviated eye. (diplopia and confusion)
• When mention about strabismic amblyopia, primary esotropia and not exotropia typically is associated with amblyopia.
  – Under most condition, exotropia presents as an intermittent and/or alternating deviation rather than a constant unilateral deviation
Types of Primary Strabismus and Presence or Absence of Amblyopia

- Primary esotropia
  - Intermittent → No amblyopia
  - Alternating → No amblyopia
  - Constant unilateral (common) → Amblyopia

- Primary exotropia
  - Intermittent → No amblyopia
  - Alternating → No amblyopia
  - Constant unilateral (rare) → Amblyopia
Table 1.6  Incidence of Amblyopia: Percent Esotropia versus Exotropia in Different Populations of Amblyopes with Strabismus

<table>
<thead>
<tr>
<th></th>
<th>Percent ET*</th>
<th>Percent XT*</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glover and Brewer (1944)</td>
<td>68.9</td>
<td>31.1</td>
<td></td>
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<tr>
<td>Theodore et al. (1944)</td>
<td>80.5</td>
<td>19.4</td>
<td></td>
</tr>
<tr>
<td>Downing (1945)</td>
<td>72.5</td>
<td>27.8</td>
<td></td>
</tr>
<tr>
<td>Frandsen (1960)</td>
<td>95.8</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>Helveston (1965)</td>
<td>83.3</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>Flynn and Cassady (1978)</td>
<td>79.7</td>
<td>16.1</td>
<td>4.2</td>
</tr>
</tbody>
</table>

*ET = esotropia; XT = exotropia.
• If a patient presents with an exotropia and reduced unilateral VA in the absence of anisometropia or a history of retinal image degradation, the clinician should suspect organic amblyopia. Remember, there may be a functional amblyopia superimposed over the organic amblyopia, with the cause of the functional amblyopia being the secondary exotropia.
Anisometropic amblyopia

- Anisometropia is frequently considered to be the most common cause of amblyopia. This has been found to occur twice as frequently as strabismic amblyopia. (Unfortunately, fixation status was not tested. Therefore, microtropia with anisometropia would be classified as anisometropic amblyopia.)

- Flynn and Cassady (1978) analyzed 544 amblyopes, 48% were strabismic, 32% were strabismic and anisometropic, and 20% were purely anisometropic.
Table 1.7  Incidence of Amblyopia: Strabismic versus Nonstrabismic

<table>
<thead>
<tr>
<th>Author</th>
<th>Percent Strabismic</th>
<th>Percent Nonstrabismic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glover and Brewer (1944)</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Theodore et al. (1944)</td>
<td>34</td>
<td>66</td>
</tr>
<tr>
<td>Agatston (1944)</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Sugar (1944)</td>
<td>36</td>
<td>62</td>
</tr>
<tr>
<td>Downing (1945)</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Helveston (1965)</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Flynn and Cassady (1978)</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

*Note: This table compares a more recent study (Flynn and Cassady 1978) in which fixation status was assessed with older studies in which some microtropes were probably grouped under nonstrabismic amblyopia.

Source: Adapted in part from Shapero (1971).
• A population based study (Attebo et al 1998) found that the relative prevalence of different types of amblyopia is anisometropic 50%, strabismic 19%, mixed strabismic and anisometropic 27%, and visual deprivation 4%.

• Amblyopia is more likely to be present in the left eye, and this asymmetry is exaggerated for anisometropia (Woodruff et al 1994)
Coexist of strabismic and anisometropic amblyopia

• Although anisometropia was defined as a 1-diopter or greater difference between eyes. However, significant amblyogenic anisometropia is different for myopia and hyperopia. For example:
  – OD plano 20/20
  – OS -2.00 sph. 20/100 with left esotropia

• This patient should be categorized under strabismic amblyopia, since the myopic anisometropia is probably not a significant amblyogenic factor.
There exists a controversy as to how one categorizes a patient having both significant anisometropia and unilateral constant strabismus, example:

- Patients with greater than 5 diopters of anisometropia, over two-thirds had amblyopia, a quarter of whom also had strabismus
- Patients with less than 2 diopters of anisometropia, about 20% had amblyopia and only 1% had a strabismus
• There is some evidence that emmetropization depends on normal visual experience. In amblyopia, it was found that the refractive error developed at a different rate in the amblyopic eye than in the dominant eye, with the dominant eyes becoming more myopic while the amblyopic eyes stayed the same or became more hyperopic. (Nastri et al 1984)
• Incidence and depth of amblyopia may be dependent on the degree and type of anisometropic refractive error
  – The incidence of amblyopia was lower in myopic than in hyperopia
  – Myopic anisometropia occurs more frequently in the general population than does hyperopic anisometropia
Table 1.8  Comparison of Differences in Criteria for Anisometropia versus Anisometropic Amblyopia

<table>
<thead>
<tr>
<th></th>
<th>Myopic Criteria</th>
<th>Hyperopic Criteria</th>
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</thead>
<tbody>
<tr>
<td>Anisometropia</td>
<td>&gt; 1-diopter difference</td>
<td>&gt; 1-diopter difference</td>
</tr>
<tr>
<td>Anisometropic Amblyopia</td>
<td>&gt; 6.5-diopter difference (100% incidence)</td>
<td>&gt; 3.5-diopter difference (100% incidence)</td>
</tr>
<tr>
<td>Anisometropic Amblyopia</td>
<td>≥ 5-diopter difference (50% incidence)</td>
<td>≥ 2-diopter difference (50% incidence)</td>
</tr>
</tbody>
</table>
Strabismic amblyopia v.s. anisometropic amblyopia

- The pupillary function of the eye with strabismic amblyopia is subtly different from that of eyes with anisometropic amblyopia.

- In anisometropic amblyopia, there is either a difference in retinal image clarity (and contrast) or a difference in retinal image size. In strabismic amblyopia, there is a form dissimilarity of retinal images. Therefore, the suppression mechanism may be very different.
• Anisometropic amblyopia reduces sensitivity centrally and peripherally, whereas, strabismic amblyopia losses acuity is predominantly restricted to the foveal region.
Isometropic Amblyopia

• Secondary to a significant bilateral refractive error
  – Even when properly corrected, does not immediately result in normal vision
  – Visual acuity usually improves once the corrective lenses have been worn for a period of time
  – A relatively mild vision loss that is amenable to vision therapy
• Strabismus secondary to the amblyopia is much less likely to occur
  – Esotropia is more likely to occur in lower amounts of bilateral hyperopia and unilateral amblyopia secondary to an accommodative esotropia
    • Strabismus will result if the AC/A ratio is high, the fusional system cannot handle the excessive vergence demand
• Clinically, isometropic amblyopes typically exhibit VA in the range of 20/30 to 20/70 in each eye when first corrected
  – If VA is not normalized once the proper corrective lenses are worn for a period of time, then VT is indicated
– Myopes and astigmats show their best acuities through full correction, whereas hyperopes show better acuities when slightly undercorrected
  • For hyperopes, a large exophoric or tropic deviation may become manifest as the full correction is gradually accepted
• Isometropic amblyopia is generally detected and treated earlier than anisometropic amblyopia
  – The prevalence of isometropic amblyopia is decreasing in countries where early vision care is emphasized
• The meridional amblyopia does not develop during the first year of life, despite the high incidence of significant astigmatism during the first year of life
  – May have dissimilar “critical period” timetables
• It is difficult to determine precisely the prevalence of isometropic amblyopia
  – It appears to be about 0.03%
    • The effects of bilateral loss of clear form vision are not as damaging as asymmetrical visual inputs
    • The depth of isometropic amblyopia and its resistance to therapy is less
    • High degrees of myopia are frequently associated with retinal thinning and macular pigment abnormalities
Image degradation

- Secondary to the obstruction of sight that prevents the formation of a well focused, high contrast image on the retina
  - Either one or both eyes take place before the 7 year of life for amblyopia to develop
    - Time of onset
    - The extent of the degradation
    - Cataract, corneal opacities, congenital ptosis, and early total occlusion
Treatment

• Early surgery
  – Before 8 weeks of age
• Total bilateral occlusion between operations on the fellow eye
  – 48 hours or less
• Early correction of aphakia with extended wear contact lenses
  – Within one week of surgery
• The importance of early treatment and optical correction
  – The effect of deprivation begins at about 4 months of age, increases rapidly up to 8 months, and the declines gradually over the first decade of life
• Congenital cataract are often associated with organic ocular diseases:
  – Microphthalmia, coloboma, and optic atrophy
  – The vision is bad
  – Rule out the possibility of functional amblyopia
• The concept of occlusion amblyopia in human infants is well established
  – Even short periods (less than 1 week) of direct occlusion can result in dramatic changes in monocular acuity and a tradeoff between the two eyes
Clinical diagnosis and prognosis of amblyopia

• The clinician’s task:
  – Determine the etiology of the amblyopia
  – Rule out any organic contributions to the VA loss
  – Determine the prognosis and probability for success
  – Organize a comprehensive monocular and binocular treatment strategy
<table>
<thead>
<tr>
<th>Test Category</th>
<th>Procedures</th>
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<tr>
<td><strong>Tests to determine etiology:</strong></td>
<td>History</td>
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<td></td>
<td>Cover test</td>
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<td></td>
<td>Objective refraction</td>
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<td></td>
<td>Visuoscropy</td>
</tr>
<tr>
<td><strong>Tests to rule out organic amblyopia:</strong></td>
<td>History</td>
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<td></td>
<td>Anterior and posterior segment evaluation</td>
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<td>Pupils</td>
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<td>Color vision</td>
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<td>Neutral-density test</td>
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<td>Threshold visual fields</td>
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<td>Visual-evoked potentials</td>
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<tr>
<td><strong>Tests to determine prognosis:</strong></td>
<td>History</td>
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<td></td>
<td>Visual acuity</td>
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<td></td>
<td>Laser interferometry</td>
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<tr>
<td></td>
<td>Visuoscropy</td>
</tr>
<tr>
<td><strong>Tests to determine treatment plan:</strong></td>
<td>Visual acuity</td>
</tr>
<tr>
<td></td>
<td>Accommodation</td>
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<tr>
<td></td>
<td>Fixation and eye movements</td>
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<td></td>
<td>Monocular sensory perception</td>
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<td></td>
<td>Binocular evaluation</td>
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History taking

- When did the amblyogenic anomaly begin?
  - The later the onset, the better is the prognosis
    - Parents are more likely to recall strabismus rather than anisometropia
    - The anisometropia amblyope is typically first detected during a vision screen
    - If the vision anomaly occurred after age 4 years, the prognosis is excellent
    - Obtaining the results of the earliest vision examination
• When was treatment initiated?
  – If the uncorrected anomaly has existed for less than 1 year, the prognosis for success is much better
  – There is no drastic difference in prognosis once the non-treated amblyogenic anomaly has existed for greater than 5 years
• What did the treatment consist of and how successful was it?
  – An amblyope left without either stereopsis or alternation of fixation after treatment is to demonstrate some regression in visual function, especially VA
• What was the extent of compliance?
  – Need to fully complied and monitored
• Any history of trauma?
• Is there a family history?
• Any diplopia?
  – If yes, suggests recent onset or not very severe
• Is patient or parent motivated?
  – Without motivation, there will be little or no success
<table>
<thead>
<tr>
<th></th>
<th>Poor to Fair</th>
<th>Fair to Good</th>
<th>Good to Excellent</th>
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<tbody>
<tr>
<td><strong>Onset of amblyogenic anomaly</strong></td>
<td>Birth to age 2 years</td>
<td>2 to 4 years</td>
<td>4 to 7 years</td>
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<tr>
<td><strong>Treatment onset minus anomaly onset</strong></td>
<td>&gt;3 years</td>
<td>1 to 3 years</td>
<td>≤1 year</td>
</tr>
<tr>
<td><strong>Extent and success of initial treatment</strong></td>
<td>Optical correction Minimum VA improvement</td>
<td>Optical correction and patching Moderate VA improvement</td>
<td>Full optical correction Proper patching Significant VA improvement Accommodation, eye-hand coordination, and fixation training Stereopsis or alternation established Good to excellent</td>
</tr>
<tr>
<td><strong>Compliance</strong></td>
<td>None to poor</td>
<td>Fair to good</td>
<td>Good to excellent</td>
</tr>
</tbody>
</table>
Visual acuity

• Contour interaction (Crowding phenomenon)
  – Contour interaction does not begin at greater than one letter diameter separation
  – The effect is approximately equal at threshold visual acuity levels for both normal and amblyopic eyes
• The amblyopic eye resolve a few letters per line with no clear cutoff point to define threshold (a sigmoid, or S-shaped, curve of acuity value)
  – It is similar either use snellen chart or a visual acuity chart with contour interaction control
• The normal eye will generate a curve with a steep slop, demonstrate a sharp drop-off VA
Snellen chart versus S-chart

- The inter-letter separations
- Control for contour interaction
- The VA levels have large gap at the low end
- Letters with different degrees of difficulty
- Frequent re-testing of the VA can result in contamination by memorization
Flom’s visual acuity test slide
<table>
<thead>
<tr>
<th>Card No.</th>
<th>Foot-Letter Size</th>
<th>20-foot Snellen Equivalent</th>
<th>Snell-Sterling</th>
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<tbody>
<tr>
<td>1</td>
<td>4.5</td>
<td>20/9</td>
<td>110</td>
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<tr>
<td>2</td>
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<td>21</td>
<td>138.5</td>
<td>20/277</td>
<td>10</td>
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</tbody>
</table>
Flom designed a VA test specially for the evaluation of amblyopic eyes.

- Consists of a series of 21 slides.
- Range of VA values from 20/277 to 20/9.
- Each slide contains a series of eight Landolt C.
- The interletter spacing is equal to the letter diameter, and is surrounded by an equal number of contours.
- The determination of VA use psychometric analysis.
  - The number of correct responses is plotted against letter size.
<table>
<thead>
<tr>
<th>“Easy” Chart</th>
<th>“Difficult” Chart</th>
</tr>
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<tbody>
<tr>
<td>20/300 TOL</td>
<td>FHB</td>
</tr>
<tr>
<td>20/300 UZT</td>
<td>MRX</td>
</tr>
<tr>
<td>20/200 IAOCZ</td>
<td>YSNBM</td>
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<tr>
<td>20/100 IULTA</td>
<td>XHYNF</td>
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<tr>
<td>20/80 IDVLIC</td>
<td>RMYSQ</td>
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<tr>
<td>20/60 ZTVIU</td>
<td>BSXFRC</td>
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<tr>
<td>20/40 DOLCV</td>
<td>HQFBM</td>
</tr>
<tr>
<td>20/30 AUTZI</td>
<td>XRNXYQ</td>
</tr>
<tr>
<td>20/25 DLCVU</td>
<td>BMHSX</td>
</tr>
<tr>
<td>20/20 TOCZA</td>
<td>NRYFH</td>
</tr>
<tr>
<td>20/15 LADUV</td>
<td>BFQNS</td>
</tr>
</tbody>
</table>

Eye chart with letters and numbers for vision testing.
• A modification of the S-chart
  – Increases contour interaction by reducing interletter spacing to half of the letter size
    • This chart is easier and less confusing to use with children
Figure 8.9  E-chart with interletter spacing of one-half test-letter size. (Reprinted, with permission of the publisher, from Davidson and Eskridge 1977.)
Telescopic acuity

• Differential diagnosis between organic and functional amblyopia
  – Any improvement in acuity through a telescope indicates a functional amblyopia
  – That telescopic acuity greater than predicted by the magnification of the telescope indicates a functional amblyopia with good prognosis
  – The pretherapy acuity through the telescope is the predicted acuity following successful therapy
Neutral density filter

- Preadapt the good eye for 5 minutes with the polarized filters
- Expose an S-chart of 20/42. Slowly rotate the polarizers until the patient can just begin to resolve at least five of the eight LandoltC
- Similarly preadapt the amblyopic eye for 5 minutes, and then quickly introduce the filter that allow the good eye to resolve
- Measure VA of the amblyopic eye through the filter, and compare this without the filter VA
- If VA is reduced considerably more in the amblyopic eye than in the good eye, then organic amblyopia should be suspected
Other abnormal aspects of amblyopic eye

• Accommodation
  – Reduced amplitude
    • Reduce threshold and contrast sensitivity, target fading
  – Accommodative stimulus response
    • Eccentric fixation
  – Increased depth of focus
  – Increased variability of accommodative response
    • Abnormal fixational eye movements, increase drift and jerk nystagmus
Other abnormal aspects of amblyopic eye

- Eccentric fixation
- Binocularity
  - Motor
    - Cover test at distance and near
  - Sensory
    - Stereopsis, anomalous retinal correspondence
Visual acuity, fixation, and direction sense

• MAR = E + 1
  – MAR is minimum angular resolution
  – E is eccentricity

• In 1961, Flom and Weymouth studied the eccentricity of Maxwell’s spot in both normal and amblyopic eyes
  – Monocular VA in the amblyopic eye at the point of eccentric fixation was the same as that found in the normal eye at the same eccentricity
<table>
<thead>
<tr>
<th>Eccentricity (degrees)</th>
<th>Schapero</th>
<th>Flom and Weymouth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20/30</td>
<td>20/55</td>
</tr>
<tr>
<td>2</td>
<td>20/40 to 20/50</td>
<td>20/90</td>
</tr>
<tr>
<td>3</td>
<td>20/50 to 20/60</td>
<td>20/125</td>
</tr>
<tr>
<td>4</td>
<td>20/60 to 20/70</td>
<td>20/160</td>
</tr>
<tr>
<td>5</td>
<td>20/70 to 20/100</td>
<td>20/195</td>
</tr>
<tr>
<td>10</td>
<td>20/100 to 20/160</td>
<td>20/370</td>
</tr>
<tr>
<td>20</td>
<td>20/180 to 20/300</td>
<td>20/720</td>
</tr>
</tbody>
</table>
Treatment

• Early detection
• Correction of any significant refractive error
• Constant Occlusion
• Additional active training
  – The effects of occlusion can be enhanced or facilitated by addition of active training
Home and office therapy

- Weekly office session of approximately 45 minutes
- Daily home therapy lasting from 20 minutes to 2 hours
- The amblyopic visual system responds best to short regular periods of intense therapy
Patching

- Anywhere from $\frac{1}{2}$ to 6 hours daily
- Most of the patching done at home
  - Cosmetic is not a major factor
Length of treatment

• Last from 4 to 6 months
• Afterward, daily treatment duration will be gradually reduced
  – To prevent regression of vision function
  – Take another 2 months or so
Progress evaluation

• Perform every 8 weeks during the therapy course
  – The goal of amblyopia treatment is to improve vision and sensorimotor function (eye-hand coordination, focusing, navigation ability, etc.)
  – Monitor improvement in vision function
  – Determine when treatment should be discontinued
Motivation

• The single most important factor contributing toward a successful case
  – Explain to the patient and encourage the patient by setting up situation that will allow the patient to be aware of progress
  – Show the progress of evaluation to patient, have them become actively involved in the therapy process
  – May experience headaches, eyestrain, fatigue, or diplopia during treatment
Figure 10.1 Improvement in S-chart visual acuity over time in the amblyopic eye (AMB). 
(○ = pretherapy curve (20/122); ● = midtherapy curve (20/32)). Also shown is the normal (NOR) or dominant eye response (△).
Training sequences

• Accommodation
  – Stimulus, monocular to bi-ocular accommodation

• Eye movements
  – Hart-chart saccades, eye-hand coordination

• Form recognition
  – Recognize the simple and complex forms with either being hidden, or slightly different from a similar comparison form
Figure 10.15  Use of Marsden ball for pursuit training of large object.

Figure 10.24  Wayne saccadic fixator. Patient’s goal is to press the button corresponding to the appropriate light. Center display presents the number of correct responses per programmed time. Auditory feedback and predictability of presentation can be varied.
Compare these two theoretically identical tables. Correct the errors in the lower table.

\[
\begin{array}{ccccccc}
37 & 43 & 623 & 634 & 127 & 289 \\
42 & 438 & 537 & 728 & 183 & 148 \\
327 & 211 & 248 & 231 & 129 & 537 \\
499 & 528 & 633 & 227 & 148 & 321 \\
328 & 433 & 221 & 130 & 127 & 643 \\
566 & 633 & 399 & 722 & 472 & 946 \\
355 & 444 & 376 & 588 & 832 & 946 \\
\end{array}
\]

\[
\begin{array}{ccccccc}
37 & 43 & 623 & 634 & 127 & 289 \\
42 & 438 & 539 & 728 & 183 & 148 \\
327 & 211 & 248 & 231 & 129 & 537 \\
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328 & 433 & 221 & 130 & 127 & 643 \\
566 & 633 & 399 & 722 & 472 & 946 \\
355 & 444 & 376 & 588 & 832 & 946 \\
\end{array}
\]

**Figure 10.28** Goal is to compare the two theoretically identical tables and to correct the errors in the lower table. (Reprinted, with permission of the publisher, from Lyle et al. 1960.)
Figure 10.34  Scene (A) is different from scene (B) in 10 ways. What are they? (Reprinted, with permission of the publisher, from Lyle et al. 1960.)

Figure 10.34  (continued)
Strabismus

- Strabismus most often develops within the first 6 ~ 7 years of life. Approximately 7% of children aged 6~7 years had strabismus. Strabismus affected approximately 1% of infants ( < 12 months).
Risk factors for strabismus

- Maternal cigarette smoking
- Neurologic disorders
- Use of other drugs during pregnancy
- Heredity
- Refractive errors
- Low birth weight (prematurity)
- Anatomic factors (craniofacial anomalies)
Classification of Heterotropia

• Squint or Strabismus
  – In term of the direction and magnitude of the deviation, heterotropia is classified as either comitant or incomitant.
  – More information are also required to have more detailed classification regarding its frequency, laterality, age of onset, influence of accommodation and cosmesis.
Comitant and Incomitant heterotropia

• The angle of deviation is constant in all direction of gaze called comitant strabismus

• The incomitant deviation is varies with direction of gaze. The deviation is largest when the eyes are turned in the direction of maximum action of the affected muscle.

• The term **paralysis** is used if the action of one or a group of extra-ocular muscles is completely abolished. If the action of muscle is impaired the term **paresis** is used.
• Frequency
  – Constant or intermittent
• Laterality
  – Unilateral or alternating
• Location
  – Patient may have a phoria at distance and have a tropia at near.
• Direction
  – Depend on the visual axes deviate from alignment.
  – The tropia is noted by the non-fixating eye.
  – Esotropia, Exotropia, Hypertropia, Hypotropia
  – Deviation of the upper pole of the cornea result in Excyclotropia (outward) or Incyclotropia (inward)
• **Age of onset**
  – Congenital is the deviation that are present at birth or develop during the first few months of life. Acquired is arisen during childhood or later in life.

• **Presence of nystagmus**
  – Should be described in terms of congenital, latent or acquired and whether pendular or jerky.
Refractive errors in children

- The management of refractive errors is of the utmost importance in children with strabismus. Hyperopia was more common in esotropia at the time of diagnosis. A few exopropic children were myopic. The strabismic eye had a greater chance of becoming anisometropic in esotropia.
• In every child with strabismus, VA should be measured as early as possible to detect amblyopia. The vision in one eye is compared with the fellow eye. VA of 20/200 or less should raise the suspicion of anisometropic amblyopia or other ocular disease.
Differential diagnosis

• Not all monocular vision loss with a strabismic patient is secondary to amblyopia. Only after an extensive examination has been performed otherwise. Careful refraction must be performed and any refractive error corrected before it is assumed. Mild congenital optic nerve pathology as well as small lens opacities can be overlooked.
  – The amblyopic patient has normal color vision, in contrast to the patient with optic neuropathy.
  – Marcus Gunn pupil is rare in strabismic amblyopia.
| **Table 15.1** Differential diagnosis of pathological cause in acquired comitant strabismus |
|-----------------------------------------------|-----------------------------------------------|
| **Sign associated with acquired comitant strabismus** | **Risk of pathology** |
| Is there a refractive error that might account for the deviation? | Latent hypermetropia is very likely to be the cause of esotropia. The onset of myopia can trigger a small exotropia. |
| If new comitant strabismus, is there a history of previous large phoria or microphoria that may be decompensating? | If so, a pathological cause is less likely. |
| Is nystagmus present (maybe only in abduction)? | If so, strongly suggests pathology if onset at over age 6 months. |
| Are there pupil, field, disc or fundus abnormalities? | Indicates pathology. |
| Are there systemic neurological signs (seizures, headaches, mood changes, impaired coordination)? | Indicates pathology. |
| Is the angle increasing? | Suggests pathology. |
| Can motor and sensory fusion be demonstrated with prisms? | If not, pathology more likely. |
| If comitant esotropia, is there an A pattern? | If so, may indicate hydrocephalus or Chiari type I. |
| Is the strabismus responding to treatment? | If responding to treatment (e.g. refractive or exercises), pathology unlikely. |

Source: based on Hoyt & Fredrick 1999.
When to treat comitant strabismus

• There are three good reasons for treating:
  – If they are causing problems
  – If they are likely to deteriorate if left untreated
  – If treatment may be required but less effective when the patient is older.
Clinical Key Points

- Most cases of long-standing strabismus have good sensory adaptations and do not require treatment
- When treatment is sought many cases of strabismus can be treated in community eyecare practices
- Attention needs to be paid to sensory and motor factors and neither of these should be treated unless both can be corrected
- Strabismic patients will either have diplopia, suppression or HARC
- Patients with intractable diplopia can benefit from monovision, occlusion or hypnosis
- If patients are adapted to their sensory status, even if this is diplopia, then they may be unhappy if their deviation is changed with new spectacles
- The best methods for assessing binocular sensory adaptations (HARC or suppression) are Bagolini lenses or the modified OXO test. A neutral density filter bar can be used to assess the depth of adaptation
- Shallow HARC or suppression is often eliminated when the motor deviation is corrected
- The motor deviation can be treated by eye exercises, refractive modification, prisms, pharmacological management, botulinum toxin, or surgery
兒童驗光學

- 目前台灣驗光師法擬訂有關兒童視光的檢查限制於三歲以下兒童由眼科醫師執行
  - 第十二條 驗光師之業務範圍如下：
    - 眼球屈光狀態之非侵入性測量及相關驗光。但未滿三歲兒童之驗光，不得為之。
    - 驗光師執行情務，發現視力不能矯正至正常者或三歲以上六歲以下視力異常之兒童時，應轉介至眼科專科醫師診治。
兒童驗光的重要性

• 幼兒若有嚴重的屈光或眼睛健康問題，對於他們日後的生活可能形成障礙，無論學習、與其他小孩的互動、及個自的活動都有重大的影響，是以從小就需留意他們的眼睛健康，以發揮他們最大的發展潛能。

- 我們常說眼睛是最主要的學習器官( see to learn)，大部分的學習皆透過視覺最為迅速，但是不要忘忽略「如何看」也是需要學習 ( learn to see)。
在近代的趨勢，眼視光已漸漸成為眼睛檢查的基礎，視光師可能成為一般民眾最先接觸的健康照顧檢查者，這意味著視光師需注意到患者各種身體狀況，包括兒童的視力、學習、以及身心的發展等以備做適當之轉介。
學齡前 (3~5 歲) 是兒童整體身心發育的重要階段，這時期影響兒童的語言、字彙、行為等身心表現，尤其在行為動作上有些兒童似乎表現得與正常發展的速度不一樣，這些的表現有的是非常明顯（如有聽、視或身障情形），有的可能看來比較輕微，然而這些將給予學齡的兒童學習上的障礙，造成將來的學習困難。及早發現兒童是否處於這樣的不利狀況是相當重要，必要時做轉介以確定真正的問題所在。
At what ages should children be examined?

- All children should be seen at before the end of the first year of life.
  - If there is a family history of strabismus, amblyopia, high refractive error, or early vision loss, the infant should be examined by 6 months of age.
  - If the parents observe any unusual appearance of the child’s eyes or visual behavior, they should be evaluated as soon as possible.
• The child should routinely be seen again between the ages of 2.5 ~ 3.5 years, just before kindergarten, and then yearly through elementary school. This is to ensure early detection of major visual anomalies that might affect the child’s general performance.
Practice Management

• Many clinical examination techniques on the young children are quite the same with older children and adults. These may require only few modification of instruction and targets to be effective with young children.
• Environment
  – Comfort and welcome designed office or reception area reduce the fear and anxiety
  – Select the optimal appointment time
  – Removing the doctor’s white coat
• Observation
  – Hyperactive vs. shy or cautious child
• Communication with parents
  – Convey clear expression and clearly outline the parent’s involvement. The parents will follow the optometrist’s lead and will interact with the child at the level of permitted.
The Problem Oriented Record

• The data base
  – A problem solving approach requires the optometrist to think in terms of ensuring the major visual system or function.
  – The data base can be subdivided into the diagnostic areas as following:
Examination strategy

- Case history
- Refractive status
- Visual acuity status
- Binocular status
  - Motor
  - Sensory
- Accommodative status
- Ocular health status
- Developmental perceptual motor status
• Problem list
  – From the results of data base evaluation the optometrist construct a problem list, which provides an overview of the patient’s problems and eliminates the extensive file review prior to future visits.
• Initial plan
  – This serves as the basis for the plan list, consisting of the therapy and education recommendations.

• Progress note
  – Used to follow up on the initial management plans and is outlined in SOAP notation
• **S (subjective):** information about course of signs and symptoms, compliance with the management plan, and new concerns.
• **O (objective):** examination findings.
• **A (assessment):** the doctor’s interpretation.
• **P (plan):** any modification of the initial plan.
Primary reason for eye examination

- Routine check-up
- Family Hx of visual problems
- Failed vision screening
- Referred by GP or teacher
- Signs noticed by parents
- Symptoms reported by child
- Further opinion sought
History

• 關於幼童的病歷問診比較偏重於下列方面：
  – 出生病歷：是否早產、正常體重
  – 發育病歷：是否有任何生長遲緩
  – 一般健康：是否有任何疾病、服藥
  – 學校學習進度：功課是否正常
  – 家族病歷：是否有斜弱視家人
一般幼童到了約5~6歲已會做一些清楚的表達，譬如相關的痛覺、模糊、不舒服等，頭疼與模糊是最多呈報的現象，在做問診時需注意的是這些問題的抱怨已存在多久，這對判斷患者問題影響的嚴重度關係很大。
常見問題之抱怨

• 頭疼：雖然是最常見的幼兒抱怨的症狀，但由視覺或動眼所引起的原因則少見，成年人或許有時因未矯正的屈光或動眼問題引起頭痛，幼童則是在尚未發生不舒服時就已停止用眼的活動，幼兒對於頭疼的描述通常是不清楚的，伴隨的家長應可提供較明白的情況，如果幼兒陳述頭痛現象，檢查沒有任何明顯視覺或動眼原因，應推介給一般小兒科醫師檢查。
• 視力模糊：一般幼兒很少明白他們的視力模糊，尤其當幼兒只有一眼視力不好，除了在做特別需要兩眼協調的活動時，將表現笨拙情形。視力不好通常是在學校視力檢查時發現，若幼兒雙眼視力不好會給家長一些現象，如看電視特別往前、學校抄黑板時作業不好，當然屈光差及雙眼視異常的問題可在視光檢查部分排除，但眼睛健康的部份需做眼科的檢查確定。視力模糊有伴隨著任何眼痛、眼睛紅等都應立即轉介眼科做確定的檢查。
• 複視：注意辨別是單眼或雙眼下的複視，單眼的複視顯示著眼睛介質或視網膜的病理現象，有時也有些人的心理感覺或嚴重的弱視。雙眼視左右的複視排除對生理性複視的感覺，同時是否有偶發性的斜視，幼兒具有高眼位無法補償，或疲倦偶爾斜視，常自覺要蓋上一眼，或頭斜趴在書桌寫字以利單眼運用。
Visual Acuity

• There are several tests available for children.
  – Response to occluding
  – Forced-choice preferential looking (FPL) is suitable for toddlers from 12 months of age up to 3.5 years old, and for older children with either poor communication skills or delayed development
• Children of three years to five years old
  – The Kay picture test
    • Recognition test, pictures of familiar objects are presented to the child
– The Sheridan-Gardiner test
  • Seven Snellen letters are used in this matching test
屈光檢查

• 準確的屈光檢查無疑是相當重要的，不論是在矯正其屈光差方面，對於處置許多的雙眼發異常，屈光檢查是一個重要的起點。

• 檢影鏡方法是在檢查幼兒屈光時最重要的一種技術，雖然4~5歲以上幼兒可些許做自覺上的表達，屈光的準確度仍需靠檢查者熟練的檢影鏡技術確定。
幼兒的檢影鏡檢查時，若phoropter的高度與大小不適，應使用試鏡架來做，需讓患者能注視遠處的視標，注意能有效的控制保持幼兒注視遠方事物，或許呈現有趣動畫及不斷提示視標內容以確定幼兒眼睛正在看著遠處，檢查者的速度也是一相當重要的訓練。
Cycloplegia的使用

- 事實上並非幼兒的屈光檢查都需要使用 Cycloplegia，然而是有些情況使用 cycloplegia 是對檢查正確性有很大幫助，如
  - 幼兒注視情況不好，檢影鏡不易檢查
  - 幼兒有明顯內聚或內斜現象
  - 檢影鏡檢查中發現調節狀態不穩
  - 較大兒童的自覺驗光與檢影鏡值差異太大
  - 初次確診近視，或近視增加速度超出預期太多
Near fixation retinoscopy

• The Mohindra technique
  – 最先由Mohindra (1975)使用近點注視檢查幼兒屈光，是最常用做檢查嬰幼兒屈光的方法之一
  – 檢查室內光線全暗，檢影鏡於50公分處的工作距離，讓幼兒注視著檢影鏡光源快速地檢查，置trial lens or lens racks在幼兒眼前直到光影動作逆轉出現
  – 再加-1.25D於所得鏡片的結果，是此法所建議的幼兒屈光檢影值
一些研究對年幼患者比較Mohindra technique 與 subjective refraction 和 cycloplegic refraction發現有高度的相關性，雖然對於大量的18 ~ 48個月大的幼兒尚存有一些一致的差異性，然而對於非遠視型及一般表現差的兒童都可得到合理的結果。
Dynamic retinoscopy

- Dynamic retinoscopy's purpose is to assess the patient's accommodation status at near distance.
- So-called accommodation lag is when the patient's eyes are looking at the retinoscopy position, the retinoscopy光影呈順動情 形, 若此時中和以正鏡片達到中和點時, 此時稱作low neutral point, 若維持一定量的正度數維持到某一度數, 轉呈檢影鏡光影逆動現象, 此時稱high neutral point, 實際上這兩者間的差異是患者的NRA.
視光師在決定幼兒屈光處方時需要考量各種檢查結果，包括 static retinoscopy, other objective refractive and subjective refractive findings 以決定眼鏡度數，一般檢影鏡的光影反射位置所獲得的屈光差會大約造成達 0.50D 的遠視假象，這可由準確的自覺驗光獲得調整，對於表達力不好的幼兒當可做為調整的空間。
Subjective refraction

- 一般來說幼兒的自覺驗光可靠度不佳，可做的檢查甚是有限，在做自覺檢查時注意檢查的說明，清楚簡單，動作要快因為幼兒的注意力耐性差，在檢查時皆需考量數據的意義與可靠性。
認識學齡兒童學習能力的潛在危機

• 學齡期的幼童正是所有方面發育的重要階段，幼兒各方面的行為表現包括語言、動作舉止等都將顯現這幼兒是否處於不利學習的狀態下，幼兒發生學習上的困難是許多複雜的因素導致的，包括生理、社會環境、心理等，視光師也只就視覺上的影響做評估，重要的是注意區分幼兒最近出現的表現與幼兒處身於不利狀態下的辨別，身為視光師必須知道隨時與其他專業做鑑別轉介，遇到需要其他專業協助，需清楚正確地轉告其家長做正確的鑑別。
認識受傷與受虐兒童

• 幼兒呈現傷害無論在眼部或臉上及其他部位，都需小心注意，一般從問診上得知傷害的原因，小孩與家長的反應也應小心辨別，做必要的轉介與呈報是必需的。