The Functional Impact of Amblyopia on Visual Skills In Children

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Purpose: To assess the efficiency of visual functions and visual skills in strabismic & anisometropic amblyopes and to assess visual acuity and contrast sensitivity in anisometropic amblyopes with spectacles & contact lenses.

Methods: In a prospective clinical study, 32 children aged 5 to 15 years presenting with amblyopia in the pediatric department of Shri Ganapati Netralaya Jalna, India, were assessed. Visual acuity was measured with Snellen’s and Bailey-lovie log MAR charts and contrast sensitivity was measured with Pelli-Robson chart with spectacles and contact lenses. Saccadic movements were assessed with SCCO scoring criteria and accommodative facility was checked with ±1.50 DS flippers. Stereopsis was assessed with TNO test.

Results: By using Wilcoxon sign rank test p-value < 0.05 (<0.001), the mean linear visual acuity was 0.29 (‘6/21) and mean single optotype visual acuity was found to be 0.36 (‘6/18). Mean visual acuity of 0.27 (‘6/21) with spectacles improved to 0.33 (‘6/18) with contact lenses in amblyopic eyes. The mean log MAR visual acuity with spectacles and contact lens was found to be 0.602(‘6/24) and 0.531(‘6/21) respectively. The contrast threshold of 20 amblyopic eyes showed that the mean contrast threshold changed in 9 patients from 0.27 (spectacles) to 0.19 (contact lens). The mean accommodative facility was 5.31 (22.37). 24 subjects (75%) revealed marked saccadic defects on the test applied. 76% subjects didn’t show even gross stereoscopic ability on TNO test.

Conclusion: This study supports the facts about amblyopia and associated deficits in visual skills which were claimed in previous studies. In addition, anisometropic amblyopia can be managed better with contact lenses than spectacles.

Abstract

Introduction

“When doctor sees nothing and patient sees very little, the diagnosis is amblyopia”

One of the most dramatic sensory anomaly commonly seen in patients with strabismus is reduced visual acuity of one eye or both the eyes, known by the term amblyopia. This term literally means “dullness of vision” (G.ambly dull, + ops, vision, sight). Amblyopia is appropriately defined as a decrease of visual acuity in one eye when caused by abnormal binocular interaction occurring in one or both eyes as a result of pattern vision deprivation during visual immaturity, for which no cause can be detected during the physical examination of the eye(s). Amblyopia in appropriate cases is reversible by therapeutic measures.

Controversy about visual acuity criteria to be adopted as the clinical definition of amblyopia has caused confusion regarding the prevalence of amblyopia. Estimates of the prevalence can vary substantially depending on which criteria and population are selected (e.g., 3.5% for patients whose visual acuity is 20/30; 1.4% for 20/40). Amblyopia affects approximately 3% of the population. In a study conducted in India, amblyopia was found in 0.8% of children in urban schools and 0.23% children in rural schools. With the increasing visual demands of a never more mechanized society, amblyopia, as defined above, is a growing socioeconomic problem.

Functional amblyopia occurs before 6-8 years of age and is attributable to form deprivation, strabismus, or anisometropia. Age of onset of amblyopia in humans is a matter of some debate. But it is commonly thought to include the first 8 years after birth (Von Noorden, 1980). If present during the critical period of visual development (up to 7 years of age), the optical or oculomotor deficits lead to abnormal neurodevelopment of the visual system, with a loss or rearrangement of neural connections within the visual cortex. An extensive review of literature describes the adaptations in spatial vision that occur in the amblyopic eye, including reduction in optotype VA, grating acuity, contrast sensitivity and visual skills. Although amblyopia is primarily a deficit in spatial visual acuity, its defects are also evident in spatial localization, fixation, ocular motility, accommodation, crowding effects, attention behaviour and motion. Amblyopia needs to be treated in childhood as patients with uniconular amblyopia are debarred from a wide variety of jobs increasing with the severity of amblyopia. In addition, there is a risk of future blindness when the good eye is damaged either by trauma or by conditions associated with the ageing process in later life.

Role of Contact Lenses In Amblyopia

We, as eye care providers know that an amblyopic eye must wear optical correction but children are notorious, may tend to look from the sides, up & down and are often reluctant
to wear correction in the form of spectacles either because of fear or psychological issues like teasing by others. In addition, in children having amblyopia associated with high refractive errors, glasses should be fitted very carefully as there are common potential problems like aberrations, distortions and experiencing unwanted prismatic effects when viewing off-axis or away from the optical centre of high powered spectacle lens. Limitation of peripheral field remains an unsolved problem. The quality of image forming on retina of amblyopic eye degrades further due to above problems which can be a reason of reduced contrast. The only available option in such realistic issues is use of contact lenses as they remain stable on the eye.

**AIM**

To investigate the functional impact of amblyopia on the visual skills in children

**Objectives**

- To assess the efficiency of following
  1. Visual acuity
  2. Contrast sensitivity
  3. Saccadic movements
  4. Accommodative facility
  5. Stereopsis

  In strabismic & anisometropic amblyopes

- To assess visual acuity and contrast sensitivity in anisometric amblyopes with spectacles & contact lenses.

**Materials and Methodology**

This is a prospective clinical study. A total of 64 eyes of 32 subjects with age group between 5 to 15 years or age were included in this study, with a mean age of 10.5 (± 3.22) years. There were 15 (46.88%) males and 17 (53.13%) females. All the eligible subjects underwent routine preliminary investigation for amblyopia at Shri Ganapati Nethralaya, Jalna, Maharashtra. Subjects between age range of 5 to 15 years, diagnosed with strabismic amblyopia &/or anisometropic amblyopia & having no other ocular abnormality found on slit lamp examination were included in the study. Subjects having any systemic illness, mental disability or having undergone any ocular surgery in the past were excluded.

**Selection Criteria for the study:**

**Definition of Amblyopia considered**

"Two line interocular acuity difference (IAD) on Snellen’s acuity between eyes even after optical correction for practical purpose."

**Types of amblyopia**

Anisometropic amblyopia (AA) is caused by an uncorrected refractive error in which difference between the corresponding major meridians of the two eyes is at least 1 D.19 For hyperopic, as little as +1.00DS difference or more, for myopic, a difference of at least -2.00DS or more, whereas for astigmatic, a difference of at least 1.00DC or more in the most anisometric meridian in two eyes was selected. Strabismic amblyopia (SA) is most commonly associated with an early onset (<6-8 years of age) of constant unilateral strabismus.

**Assessment of Visual Skills as follows**

**Visual acuity**

Log MAR Chart (image1) Single Optotype E letter acuity as well as Snellen’s linear acuity were assessed on projector chart & converted into decimal equivalent for simplification in statistical analysis. Log MAR visual acuity was measured on Bailey-Lovie chart at a distance of 3 meters with spectacles and contact lenses. The trial soft contact lens of different companies was applied on amblyopic eye and assessment was carried out after 3-4 (mean 3.5) hours of wear.

**Contrast sensitivity**

Contrast sensitivity was measured with Pelli-Robson chart because of its availability and ease to use in patients. Assessment was done uniocularly with undilated pupil in normal room illumination with spectacle and was repeated with contact lenses. (Pelli–Robson chart, image 2)

**Accommodative facility**

The test is usually done binocularly and uniocularly. We performed the test uniocularly in this study.

Flipper: It comprises of holder with binocular spherical plus and minus lenses that can quickly be flipped from plus
to minus during testing. Sphere powers commonly used are ± 1.50 D. The recommended near vision optotype is equivalent to 6/9 or 20/30 of Snellen’s chart or the letter size of best corrected visual acuity at 40 cm. The results were recorded as cycles per min for each eye. e.g. RE__cpm. The range is normally 8 to 11 cpm for children with a mean of 9.5 cpm. Accommodative Flippers (Image 3)

Accommodative Flippers (Image 3)

Saccades
Saccades were assessed objectively according to criteria suggested by SCCO (Southern California College of Optometry).
Scoring the results of observation is on a 4+ scale basis as follows:
4+ if eye movements are accurate, 3+ indicates some undershooting, 2+ indicates gross undershooting or any overshooting and 1+ either the inability to do task or child moved his/her head while testing.\(^\text{12}\)

Stereopsis - TNO Test
It has the advantage of eliciting quantitative responses without changing the testing distance. The TNO test provides much accurate measurement of stereopsis than Titmus test as there are no monocular clues. The TNO test is graded to provide retinal disparities ranging from 15 to 480 seconds of arc.\(^\text{13}\)

(TNO image 4)

Results
1. Comparison of linear visual acuity and single optotype visual acuity with spectacles. (Table 1) & (Graph 1)
\(=\) Single optotype < linear acuity with spectacles
\(>\) Single optotype > linear acuity with spectacles
\(=\) Single optotype = linear acuity with spectacles
The linear visual acuity and single optotype visual acuity of total of 32 amblyopic eyes were successfully assessed with spectacles and recorded. The mean linear visual acuity was 0.29 (=6/21) and mean single optotype visual acuity was found to be 0.36 (=6/18). By using Wilcoxon sign rank test \(p\)-value < 0.05 (<0.001), there was a significant difference between the linear visual acuity and single optotype visual acuity. i.e single optotype visual acuity is significantly more than linear visual acuity with spectacles.

Out of 32 amblyopic eyes, 20 eyes were applied trial soft contact lens of required power. The single optotype visual acuity was assessed with contact lens in amblyopic (worse eye) eye.

2. The comparison of single optotype visual acuity with spectacles and with contact lens is compared in following table & graph. (Table2) & (Graph2)
The graph shows mean visual acuity of 0.27(= 6/21) with spectacles and 0.33 (=6/18) with contact lenses in amblyopic eyes. By using Wilcoxon sign rank test \(p\)-value < 0.05 (<0.001), there was a significant difference between the single optotype visual acuity with spectacle and single optotype visual acuity with CL. i.e single optotype visual acuity with CL was significantly more than linear visual acuity with spectacles.

3. Comparisons of log MAR visual acuity with spectacles and with contact lens (CL) (Table3) & (Graph 3) The graph shows the comparison of Log MA R visual acuity of amblyopic eyes with spectacles a ndLog MAR visual acuity with contact lenses. The mean Log MAR visual acuity with spectacles was found to be 0.602(=6/24) and mean Log MAR visual acuity with contact lenses was found to be 0.531(=6/21).
By using paired t-test p-value < 0.05, there was significant difference between the log MAR visual acuity with spectacles and with CL, i.e., visual acuity was significantly more with CL than with spectacles.

4. Comparison of contrast threshold with spectacles and with contact lens (CL). The contrast threshold of 20 amblyopic eyes assessed with spectacles and contact lenses showed that mean contrast threshold changed in 9 patients from 0.27 (spectacles) to 0.19 (after wearing contact lens). (Table 4) & (Graph 4)

By using Wilcoxon sign rank test p-value < 0.05, there was significant difference between the contrast threshold with spectacles and with CL. i.e., contrast threshold with CL was significantly less than contrast threshold with spectacles. Therefore, contrast sensitivity with contact lens was better than contrast sensitivity with spectacles. Assessment of accommodative facility in all amblyopic subjects is shown as a range in the following table. The mean accommodative facility was found to be 5.31±2.37 (Table 5).

By using one sample t-test, p-value < 0.05(<0.001), there was significant difference between measured accommodative facility and expected accommodative facility i.e., measured accommodative facility is significantly less than expected accommodative facility.
saccadic defects whereas 7 (21.88%) subjects showed accurate saccadic response on the test applied.

b. Stereopsis
(Table 7) & (Graph 6)
Stereopsis was not elicited in 25 subjects. This indicates marked deficit in binocular function. 78% subjects didn’t show gross stereoscopic ability whereas 22% subjects showed presence of gross stereopsis on TNO test.

| Saccades | Number of subjects | Percentage (%) |
|----------|--------------------|----------------|
| 1+       | 24                 | 75.00          |
| 2+       | 1                  | 3.13           |
| 3+       | 0                  | 0.00           |
| 4+       | 7                  | 21.88          |

| Stereopsis | Number of subjects | Percentage (%) |
|------------|--------------------|----------------|
| Elicited   | 7                  | 21.88          |
| Non-elicited | 25                | 78.13          |

Discussion
This study provides evidence that, in addition to reduced visual acuity and binocular function that define the condition, amblyopes have functional impairments in childhood development skills that underlie proficiency everyday activities. The study provides information about status of visual performance in amblyopia and identification of co-existing deficits in the development of visually directed skills that may arise from various causes of amblyopia. Learning to read and reading for information require efficient visual abilities. The eyes must team precisely, focus clearly, and track quickly and accurately across the page. These processes must be coordinated with the perceptual and memory aspects of vision, which in turn must combine with linguistic processing for comprehension. To provide reliable information, this must occur with precise timing. Inefficient or poorly developed vision requires individuals to divide their attention between the task and the involved visual abilities. Some individuals have symptoms such as headaches, fatigue, eyestrain, errors, loss of place, and difficulty sustaining attention. Others may have an absence of symptoms due to the avoidance of visually demanding tasks. High anisometropia is uncommon and difficult to treat. Because these children are asymptomatic they are often diagnosed late although in this study, age of presentation did not appear to influence outcome. In such cases we believe treatment is worthwhile. C J Roberts and G G W Adams did a study namely “contact lenses in anisometropic amblyopia” where they found that anisometropic amblyopia of as high as -9.00DS improved well by two or more lines with contact lens use. In their study, contact lens was worn for one whole year. In summary, good binocular function benefits from clear images, equal image sizes and a full field of view. Contact lenses are therefore the preferred mode of refractive correction for many binocular problems. Perhaps the most common orthoptic problem that may benefit from contact lens wear is anisometropic amblyopia. The benefit here is more long term than short term. Silicone hydrogel continuous wear has opened up new opportunities for these patients, when the patients meet the usual clinical requirements for safe contact lens wear.

Conclusion
This study supports the facts about amblyopia and its associated deficits in visual skills. Visual acuity of amblyopic eye when measured with single optotype shows significant improvement as compared to Snellen linear or log MAR line visual acuity. Facility of accommodation was found to be significantly less than expected range for that age. Saccadic movements also showed marked defect. Level of binocularity in the form of stereopsis or perception of depth was significantly affected. Apart from above skills, this study has also thrown focus on influence of optical correction on visual functions, namely visual acuity and contrast sensitivity. These visual functions are found to be greatly influenced by type of optical correction worn—either spectacle or contact lens. The visual acuity improved when contact lens was applied on amblyopic eye after a specific time interval. Contrast sensitivity has also shown improvement in some subjects.
Further Research

A randomised controlled trial of contact lens treatment in high anisometropic amblyopia would be helpful. However since it is a rare condition it may take a long time to recruit sufficient patients. The long term effects of contact lens wear for certain weeks, months or years on visual function becomes a topic of research.

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