Introduction

Screening for ocular disease and visual dysfunction in children has been conducted at different levels and to varying extent in different countries of the world. There are two main periods in a child’s life that are of special interest. In the neonatal period detection of organic disease such as congenital cataract and retinopathy of prematurity (ROP) is important. Screening for congenital cataract is a type of mass screening, where every child is examined, while examination for ROP is a selective screening of a special high-risk group of premature babies. For many of the congenital ocular conditions there may be no treatment available as such, but an early detection is nonetheless essential since early visual rehabilitation plays an important role in the child’s visual development. In the developed countries the incidence of severe visual handicap has been quite constant at about 3 in 10 000 inhabitants for several decades (Riise 1993). For other conditions such as cataract and ROP there are successful treatments and for the individual this could mean the difference of being socially blind or seeing as an adult.

The other period in a child’s life at the age of 2-4 years involves finding less serious conditions, mainly amblyopia. Amblyopia is preferably diagnosed by testing monocular visual acuity.

Amblyopia

Amblyopia is defined as a reduction in visual acuity due to abnormal visual development, usually caused by a defocused retinal image where a refractive error leads to under-stimulated
neurons in the visual cortex or by inhibition of the connections to the neurons in the visual cortex of one eye caused by anisometropia or strabismus. It is the most common cause of reduced vision in the population below the age of 50 years and the prevalence is about 3% (Hauffman 1974). Amblyopia can be treated successfully if detected at an early age, i.e. in the preschool years. Strabismus is usually detected and diagnosed in the first years of life at home or at the Child Health Care Centers, while amblyopia caused by refractive errors and anisometropia more commonly is detected with testing of monocular visual acuity at the Child Health Care Centers.

The disability caused by having amblyopia in one eye has been disputed (Snowdon & Stewart-Brown 1997). In a study by Packwood et al. (1999) a significant number of amblyopic patients complained that the amblyopia interfered with school (52%) and work (48%). Although there is argument about the significance of having amblyopia in one eye there is little argument about the fact that a patient is seriously handicapped when losing vision in the non-amblyopic eye. Amblyopia was the main cause of decreased visual acuity in one eye in at least 1.72% of the patients at visual rehabilitations centres (Jakobsson et al. 2002). This means that approximately 1.2% of the people with amblyopia ≤0.3 will eventually become visually handicapped due to lesions in the better eye. This visual handicap could have been avoided by screening and treatment in childhood.

**Screening in the world**

The most extensive programs of ocular and visual surveillance and with good attendance from the parents and children seem to be those performed in Scandinavia and Holland and in some provinces in Canada (Köhler & Stigmar 1973, 1978; Nörskov 1984; Lantau et al. 1991; Lantau 1992; MacPherson et al. 1991). The attendance rate at the Child Health Care Centres is reported to be 95% or more in Sweden and Holland for the children below 1 year of age, but lower in the other countries. In the studies from Denmark, where population studies have been performed before and after the introduction of screening programs for children, the prevalence particularly of deep amblyopia (visual acuity ≤0.1) has been reduced markedly, from 1.5% before screening to <0.01% when screening was introduced and amblyopia treatment was started at an early age (Vinding et al. 1991, Jensen & Goldschmidt, 1986).
Screening in Sweden

Screening for visual disorders was introduced in Sweden in the 1960-ies and a national program was established in the 1970-ies. Nordlöw and Joachimson (1966) and Köhler and Stigmar (1973, 1978) showed convincingly that amblyopia and other types of visual disorders could be efficiently detected by monocular testing of visual acuity, performed by the nurses at the Child Health Care Centers in all children when they were 4 years of age. This system has now been in use for almost 40 years.

All children are examined within the Child Health Care system at the age of 1–3 days, 6–12 weeks, 6, 18 and 36 months. These examinations are done by visual inspection and behavioural testing. The children with clear or suspected visual and ocular abnormalities are referred to (paediatric) ophthalmologists. All children are tested for monocular visual acuity at the age of 4 years (and also at 5.5 years in some areas), at the Child Health Care Centres, and in school at 7 years and 10 years of age. Visual acuity (VA) is tested on charts with optotypes in rows.

A more extensive study was performed in three different populations of 10-years old children (Kvarnström et al. 1998, Kvarnström et al. 2001), in order to determine the efficiency of the system of screening at the Child Health Care Centers. Some of the results of this study will be presented in the following:

The attendance rate was more than 99%. The sensitivity was 92 % and specificity was 97%, both very high. The numbers of false negative and false positive cases were small.

Figure 1 show the total number of patients who are referred to the Eye Clinic at different ages. As expected there is a predominant peak at the age of 4 and less predominant peaks in the first year of life, and at 5 and 7 years. After the age of 8, the patients are mostly referred to opticians. These children are not included in this diagram.
Figure 1. Age at referral to the eye clinic (Jakobsson et al. 1996).

Figure 2 shows a more detailed view of when refractive errors are detected. The first vision test is done at 4 years and as can be seen the main part of the ametropes are detected here. The ametropes detected earlier than this are mainly those with known hereditary factors. Quite a few of the ametropias are also diagnosed after the age of 4, which is seen in the figure. The graph does not display the children who are referred to the optician. This means, for instance, that children older than 8 years who are developing myopia do not show up in this diagram.

Figure 2. Age at detection of refractive errors (Jakobsson et al. 1996).

In the first year of life many cases of strabismus are diagnosed (Figure 3). Among these are the children with infantile esotropia and those with known heredity. Between 1 and 4 years additional cases of strabismus are discovered. Many children with strabismus are detected at 4 years of age, and one third of them have microtropia. After the age of 4, very few cases of
strabismus are detected, which is also a sign of the efficiency of the screening system at the earlier ages.

**Figure 3.** Age at detection of strabismus (Jakobsson et al. 1996).

How efficient has the screening system in combination with early treatment been at reducing the prevalence of amblyopia? This is illustrated in Table 1 where a comparison has been made between the prevalence of amblyopia prior to the screening system (Lennerstrand 2000) and after (Kvarnström et al. 1998). The table shows that the benefits of screening and amblyopia treatment are most pronounced for the lower visual acuities. The number of persons with visual acuity \( \leq 0.3 \) is reduced 10-fold while the number of persons with visual acuity \( \leq 0.1 \) is reduced almost 20-fold.

**Table 1.** The prevalence of persons with different degrees of amblyopia before (Lennerstrand et al. 2000) and after screening (Kvarnström et al. 1998).

<table>
<thead>
<tr>
<th>Visual acuity</th>
<th>( \leq 0.1 )</th>
<th>( \leq 0.3 )</th>
<th>( \leq 0.5 )</th>
<th>( \leq 0.7 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lennerstrand et al. 2000</td>
<td>1.15%</td>
<td>2.00%</td>
<td>2.84%</td>
<td>3.77%</td>
</tr>
<tr>
<td>Kvarnström et al 1998</td>
<td>0.06%</td>
<td>0.19%</td>
<td>0.90%</td>
<td>1.70%</td>
</tr>
</tbody>
</table>
At which age should the child be tested?

Since amblyopia should be detected as early as possible Kvarnström and Jakobsson (2005) tested if visual acuity could be examined at the age of 3 years instead of 4. Three-year-old children co-operate well in visual acuity testing. However, the examination time is a little longer and the testability rate is about 10% lower than at 4 years. However, the positive predictive value was 58% for the 3-year-olds as compared to 75% for the 4-year-olds. This puts an extra load on the eye clinics and it is therefore doubtful whether visual acuity testing at 3 years is worthwhile.

Conclusions

Screening for visual disorders in combination with treatment has proven to be an efficient way of reducing visual impairment and amblyopia. Visual acuity testing in 4-year-old children has a high sensitivity and specificity. The prevalence of amblyopia with visual acuity below 0.5 is very low compared to the prevalence without visual screening. Together with additional measures in Child Health Care system to detect ocular disorders, the rate of serious amblyopia has been substantially reduced.

References


