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Which hyperopic patients are destined for trouble?

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Numerous studies of animal models have clearly demonstrated that abnormal visual experience can lead to abnormal visual development.[1–5] Although there are a number of logical parallels in clinical patients, for example, infants with congenital cataracts or ptosis, patients with bilateral hyperopia present a more subtle challenge.[6] Individuals with the same amount of hyperopia, siblings even, develop along different paths, exhibiting no noticeable abnormality, refractive esotropia and amblyopia, or bilateral amblyopia with no strabismus.

If a child with hyperopia develops refractive strabismus, the onset is typically months or years after birth,[7] and it is assumed that cases of bilateral amblyopia also develop experience-dependent vision loss postnatally—the fact that amblyopia can be treated with manipulations of visual experience supports the idea that the amblyopia's existence was also related to visual experience.[8–10] If these conditions arise postnatally, was the child who accommodated to overcome their hyperopia the child who drove their accommodative convergence into a strabismus? Was the child who did not accommodate the child who experienced poor retinal image quality in both eyes leading to bilateral amblyopia?

These are both logical behaviors that might explain the different clinical outcomes. If so, one might predict that those who accommodate consistently would be the ones at risk for strabismus and those who do not would be at risk for bilateral amblyopia. Is there evidence to support this? In the only prospective longitudinal study to observe accommodation in hyperopia in the context of clinical outcome, the authors determined that infants who went on to develop strabismus tended to have larger accommodative errors before the onset of the deviation.[11] Thus, it appears that the most common behavior might actually be to avoid accommodating in all cases in which the accommodation and vergence systems are under stress. For some reason, months or years after birth, some patients appear to exert enough accommodation to develop esotropia whereas others, with a preference for single vision perhaps, maintain poor accommodation and develop bilateral amblyopia.

Logic suggests that preventative optical correction of hyperopia should relieve stress on the relationship between accommodation and vergence to prevent the strabismus and amblyopia. Two groups have attempted these trials, with mixed results.[12–16] Prescribing glasses for higher hyperopes during the first year after birth did not lead to a dramatic or systematic reduction in the incidence of strabismus, although it did consistently result in reduced prevalence of significant amblyopia at the outcome visit.

Where are we now? We know that visual experience can affect development[17]; we know that higher hyperopic children who do not emmetropize during infancy are at risk for strabismus and amblyopia; we know that simple optical correction starting during the first year does not routinely eliminate strabismus and amblyopia; and we know that patients who

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do not accommodate well may be at risk for poor emmetropization,[18] strabismus, and amblyopia.[11]

In parallel, there is increasing interest in conducting vision screening at earlier ages.[19] These programs are identifying young children with apparently asymptomatic moderate and high hyperopia who are still at risk for developing strabismus or amblyopia. Which children might need to be monitored? How should these children be managed? We also now know that the most dramatic period of emmetropization occurs during the first year of life in typically developing children and therefore that older children with hyperopia are likely to remain at significant risk even if they undergo some later emmetropization.[18,20]

On the basis of the literature described, one evidence-based logical screening approach is to target the children with poor accommodation. If they are the least likely to emmetropize and the most likely to develop strabismus and amblyopia, these would be the individuals on whom to concentrate limited resources. On the basis of the treatment trials, it is not clear that we can prevent strabismus with optical correction, but it is likely that the prevalence of significant amblyopia can be reduced and any strabismus can be detected rapidly with recognition of the individual's risk. A model also incorporating family history is likely to have even greater sensitivity and specificity.[21]

The study by Dr. Tarczy-Hornoch[22] in this issue of the *Journal of AAPOS* provides insight into the patients that might fail such a test or screening. She examined accommodative accuracy as a function of refractive error in 5- to 24-month-old patients. Her work suggests that a criterion of greater than 1.25 D of accommodative lag measured with modified Bell retinoscopy would identify the outer 5% of the distribution of performance and that individuals with lags greater than this value frequently have hyperopia greater than 4 D. These individuals with large lags have visual experience that is abnormal relative to their peers and appear to be at the most risk for strabismus and amblyopia,[11] Now that we have consensus-based clinical guidelines for prescribing for hyperopia,[23] studying these children with higher hyperopia in a prospective longitudinal design is complex and this study is important in identifying a lower refractive error bound for those at the greatest risk based on retinal image quality.

Our work supports Dr. Tarczy-Hornoch's findings. We have recently published a related project[24] in which we examined subjects 4 to 90 months of age who had never had any form of clinical intervention or treatment in their eye care. When we considered the group as a whole, those with less than approximately 4 D of hyperopia on cycloplegic refraction demonstrated small and similar lags of accommodation, whereas those with higher hyperopia, amblyopia, or strabismus had more variable lags. A receiver operating characteristic analysis designed to detect hyperopia greater than 5 D in any meridian, plus amblyopia and/ or strabismus, had an area under the curve of 0.90 (95% confidence interval 0.82–0.95), and for a lag criterion of 1.3 D had a sensitivity of 83.3% and a specificity of 96.5%. In agreement with Dr. Tarczy-Hornoch, this study also suggested that hyperopic subjects of more than approximately 4 D were at the greatest risk for increased accommodative lag, which, using Nott retinoscopy as opposed to modified Bell retinoscopy, was also shown to start at a little over a diopter of lag.

These data provided by Dr. Tarczy-Hornoch[22] (and our work in agreement) provide clinicians with a clearer quantitative picture of the patients at risk for abnormal visual experience and abnormal visual development. The data do not address prediction of strabismus and amblyopia, but they do identify those patients apparently at greater risk. In moving forward, there are a number of important questions that need to be targeted. For example, we need to know how stable an individual's accommodative performance is and to

determine whether a hyperopic child might exhibit a large lag at one visit with a lag within the normal range at another visit. The variability in performance of higher hyperopes noted in both cross-sectional studies might reflect the range that any single individual would exhibit over time. Also, the bigger questions of when to identify these patients and the optimal management strategy remain. Data collected early in the first year might predict which infants will undergo typical emmetropization,[18,20,25] whereas data collected later might help identify the hyperopic children at most risk and who might benefit from an intervention.[11] Managing this risk and any remaining potential for some emmetropization in a preventative approach will be another challenge, which we will need to compare with the effort required and success achieved in a treatment approach once strabismus and amblyopia have developed. In addition this, of course, does not address the impact of accommodative performance on function during sustained near activity as is required in school.

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