Reduction of Anisometropia & Amblyopia in a Non-fixating Eye

Following Esotropia Surgery & Vision Therapy

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Abstract

This is the case of a 28-month-old child who presented to us with anisometropia, amblyopia and a partially accommodative esotropia. The latter condition was subsequently surgically altered, resulting in a consecutive exotropia. The patient's anisometropia decreased following a regimen of full spectacle correction, occlusion (direct patching) and vision therapy. The reduction of anisometropia coincided with the improvement of binocularity and visual acuity. A discussion of the relationship among the development of anisometropia, amblyopia, esotropia and consecutive exotropia is presented.

Key Words

amblyopia, anisometropia, binocularity, consecutive exotropia, emmetropization, esotropia, partially accommodative esotropia, occlusion, strabismus, strabismus surgery, vision therapy

Introduction

Esotropia is the most common cause of strabismic amblyopia in children.[1] It can either present as congenital esotropia, which occurs within the first 6 months of life, or accommodative esotropia, which generally occurs between 6 months to seven years of age.[2] However, not all esotropias present in one of these two pure states. Accommodative esotropia can present solely as a consequence of hyperopia or in association with a high accommodative convergence ratio (AC/A). This presentation is correctable with a hyperopic spectacle prescription. A third type, termed partially accommodative esotropia, has a residual component even with a full hyperopic refractive correction, and often requires surgery. Non-accommodative esotropia, as is implied, has no accommodative component.[3]

In order to obtain the best functional results, esotropia should be treated as quickly as possible following its manifestation. Goals of treatment include: achieving or maintaining normal visual acuity in each eye, restoring ocular alignment, and achieving or maintaining binocularity. Treatment can include spectacles, occlusion therapy, vision therapy (VT), surgery, or a combination of the above. There is a poorer prognosis with an increased frequency of turn, increased constancy of turn and increased duration from onset. Thus, a long-standing constant esotropia has a poorer prognosis than a recent onset intermittent squint. [3,4]

When the deviation is eliminated with a spectacle prescription, it is termed *fully accommodative*. A *partially accommodative* esotropia has a residual deviation with the full spectacle correction. Most strabismus surgeons agree with Costenbeder,[5,6] who proposes that only the latter type requires surgery to achieve alignment. The surgery should correct for the manifest esotropia with full spectacle correction. Other eye care practitioners prefer spectacles in conjunction with vision therapy (VT) as the first mode of treatment.[7]

Surgery for esotropia often requires multiple procedures. Approximately 38-69% of patients require a second surgery, due to an under- or over-correction of the deviation.[8,9] This can be a result of poor surgical judgment, inaccurate or incomplete diagnosis, undiscovered anatomical abnormalities, lack of binocularity prior to surgery, or amblyopia.

The following is the case of a child who showed a reduction of amblyopia, partially accommodative esotropia and anisometropia with treatments that included spectacles, patching, surgery and VT. The reduction of anisometropia will be considered as it relates to the emmetropization process.

Case Report

Patient VZ, a 28 month-old female of Greek / Asian parents, presented to the Infant Vision Clinic of the University Optometric Center (UOC) of the State University of New York, State College of Optometry on 5/26/2004. The parents sought a second opinion regarding treatment options for her constant left esotropia. The onset of the child's devia-

tion was at 18 months of age. The mother reported a normal full-term pregnancy, which culminated in a Caesarian section delivery, secondary to prolonged labor. The healthy neonate weighed 7 lbs. 12 oz. Developmental milestones such as sitting at 6 months, crawling at 7-10 months, walking at 10 months, and talking at 12 months were within normal limits. VZ's personal, including review of systems, and family medical histories were unremarkable. She was not taking medications and had no known allergies. The family history did not reveal a predisposition to strabismus.

For the previous five months, VZ was managed by a pediatric ophthalmologist. See Table 1 for his findings on three office visits during this time. His initial diagnoses (9/30/03) were esotropia and amblyopia. Precise visual acuities and measurement of the esotropia were not possible at this visit because of poor fixation. A cycloplegic refraction indicated:

OD: +1.75-0.75x165,
OS: +5.75-1.25x170.

These lenses were prescribed for full time wear.

The child's fixation apparently improved so that on 12/10/03, visual acuities (VA) with the spectacles were OD: 20/30- and OS: 20/100 with picture chart testing. After two and one half months of spectacle wear, VZ still manifested a residual esotropia of 18^{Δ} at distance and 20^{Δ} at near. Though not precisely measured, her unaided esotropia was of a greater angle; thus, the diagnoses of a partially accommodative esotropia and OS amblyopia. As in the previous visit, an over-action of the left inferior oblique was noted. The treatment was to continue wearing the glasses full time with constant direct (OD) occlusion.

Six weeks later (1/27/04) testing revealed a stable OD VA and an improvement of the OS VA to 20/30-. The esotropia had increased slightly at distance and substantially at near. Treatment was to continue full time wear of the glasses, but patching was reduced to an unspecified "part time."

Initial Examination at UOC (2/23/04)

VZ's corrected VAs were 20/25 OD and 20/50 OS, taken with a picture chart. With the spectacles in place, the distance cover test revealed a 20^{Δ} constant left esotropia, and a 25^{Δ} constant left esotropia with an intermittent 4^{Δ} left hypertropia at near. A probe +3.00D, OU add did not alter the magnitude of the near deviation. Extraocular motilities revealed an inferior oblique over-action (IOOA) in the left eye. The cycloplegic refraction was essentially the same as her current spectacles. The ocular health examination, including a dilated fundus evaluation, was negative. VZ was referred for surgery, which was performed one month later (3/18/04).

Examination at UOC 5/26/04

On this visit , two months after the surgery, there was evidence of a surgical over-correction; 10^{Δ}-15^{Δ} of consecutive left exotropia and some reduced VA in the OS. (Table 1) Direct patching using visual motor tasks was initiated for one hour daily for the next month, and she was enrolled in our pre-school VT program commencing on 6/23/04. See Table 1.

Treatment

Our overall strategy was first to treat the amblyopia, and then the exotropia, as proposed by Caloroso and Rouse.[10] In this regard, we reinstituted direct patching for one hour per day. However, because of VZ's age, techniques to treat the amblyopia were somewhat limited. Thus, we found it beneficial to incorporate techniques to simultaneously treat the exotropia early in the program. We also used the hierarchical sequential approach espoused by Soden. In this manner we first sought to maximize monocular oculomotor and accommodative skills, then proceeded to techniques to enhance biocular, and finally binocular functioning.[11]

Techniques to improve the amblyopia included basic monocular fixation tasks, such as attaching beads or cheerios on a string, rolling a ball to a person or target along the Z axis. These proceeded to diplopia awareness caused by vertical prism. The biocular phase of treatment included vectogram and anaglyph techniques incorporating monocular fixation in a binocular field (MFBF). Finally, treatment of the exotropia included basic convergence techniques such as placing a pointer in a straw at various distances and proceeded to more demanding convergence techniques such as Fusion Games[a] and the Clown Vectogram.[b]

Examinations and Treatments 9/1/04, 12/15/04 at UOC (Table 1.)

Four months post-surgery and two plus months into therapy (9/1/04), VZ's visual acuities did not improve beyond 20/25 OD and 20/40 OS. Because of this, we decided to perform a cycloplegic examination considering a possible change in refractive state as a contributing factor to the lack of substantial VA improvement in the OS. Retinoscopy revealed a decrease in hyperopia in the strabismic eye and a stable refraction in the non-strabismic eye. The following cycloplegic refraction was prescribed:

OD: +1.50-0.75x165;
OS: +3.50-1.25x170.

VT was continued with an increased emphasis on the development of binocular qualities. There was a gradual steady progression in the patient's ability to appreciate and respond to increasing levels of fusion, from first to third degree. Three months later (12/15/04), VA was 20/25 in each eye, and VZ was orthophoric at all distances of gaze. We recommended that she continue with VT; however, due to childcare issues further office-based therapy was declined. See Table 1.

Discussion

In this discussion, we relate the treatments VZ received for her conditions to a review of the literature for each of these diagnostic entities. These comprise: amblyopia, partially accommodative esotropia, consecutive exotropia resulting from a surgical over correction, and strabismic anisometropia.

Amblyopia

The Amblyopia Treatment Study (ATS) concluded that moderate amblyopia could be treated with patching or atropine with similar results.[12] Full-time patching was the treatment of choice for the pediatric ophthalmologist, who initially treated our patient's moderate amblyopia. Subsequent ATS studies have revealed that part-time patching would have been just as efficient for the treatment of moderate amblyopia.[13] However, at the initial treatment time, this information was relatively new. The ATS protocols did provide for some doctor discretion, so that full time occlusion could be used in some instances. Regardless, VZ was initially provided with appropriate standard of care; i.e., full anisometropic cycloplegic refractive cor-

Table 1. VZ's Findings								
		9/30/03*	12/10/03*	1/27/04*	2/23/04**	5/26/04**	9/01/04**	12/15/04**
Visual Acuity (cc)	OD OS	unavailable	20/30 20/100	20/30- 20/30-	20/25 20/50	20/25 20/70	20/25 20/40	20/25 20/25
Distance CT (cc)		ET poor fixation	18$^{\Delta}$ ET	20$^{\Delta}$ ET	20$^{\Delta}$ constant LET	10-15$^{\Delta}$ consecutive LXT	10$^{\Delta}$ intermittent LXT	Orthophoria
Near CT (cc)		~25$^{\Delta}$ ET	20$^{\Delta}$ ET	35$^{\Delta}$ ET	25 constant LET with 4$^{\Delta}$ LHyper; IOOA	10-15$^{\Delta}$ consecutive LXT	4-5$^{\Delta}$ intermittent LXT	Orthophoria
Cycloplegic Refraction	OD OS	+1.50-0.75x165 +5.50-1.25x170	As 9/30/03	As 9/30/03	+2.00-0.75x165 +5.50-1.25x170	As 2/23/04	+1.50-0.75x165 +3.50-1.25x170	As 9/01/04
Treatment		Full-time spectacles	Start full-time patch OD	Reduce to part-time patching	Surgery scheduled for 3/18/04	Start VT, continue patching 1 hr/day for 1 month	New spectacle prescription. Continue VT	Continue with spectacles. Further VT declined.

*at the office of the pediatric ophthalmologist
**at the University Optometric Center
CT= Cover Test
ET= Esotropia
Hyper=Hypertropia
IOOA=Inferior Oblique overaction
VT= Vision Therapy
XT=Exotropia
The findings on 9/20/03 are without indicated lenses; all subsequent findings are with indicated lenses

rection and direct occlusion with the treatment goal of reduction of the amblyopia. With the improvement of VA to 20/30- in the OS at the 1/27/04 visit, the occlusion therapy was reduced to part time. At this point, not surprisingly, the anisometropia and the strabismus were unchanged. Following the discontinuance of full time occlusion, there was a slight regression of the OS VA to 20/50 vision on 2/23/04. (See Table 1.)

Weakley and Holland found strabismic surgical success outcomes were related to the depth of amblyopia. Non-amblyopic (84.3%) and mildly amblyopic (81.6%) patients had similar post-surgical success rates. Moderate amblyopic patients' success rate fell to 61.5%.[14] Following direct occlusion therapy, our patient conformed to their mild category, thus the consideration of surgery was entertained and will be discussed in the next section.

Partially Accommodative Esotropia

At 18 months of age**,** the patient had an accommodative component to her esotropia. Full refractive correction did not completely resolve the strabismus; thus the pediatric ophthalmologist made a diagnosis of a partially accommodative esotropia**.**

Baker and Parks noted a progressive nature to what they termed an early onset accommodative esotropia.[15] If there is inaccurate parental observation, the stated onset of the strabismus can be misleading. Thus, some cases considered to be accommodative in nature may also have a congenital aspect, which is not noticed until the accommodative component becomes more involved. Authors tend to agree that early onset accommodative esotropia can deteriorate or progress. Various decompensating patterns have been proposed:

1. An esophoria decompensating to an esotropia and the development of a nonaccommodative component,[15]
2. A masked pre-existing microtropia precedes the decompensating accommodative component,[16]
3. Poor management of an accommodative esotropia,[17]
4. Reduced fusional function (especially divergence) with a normal AC/A,[18]
5. The presence of a high AC/A and its influence on alignment.[15,19]

Raab found a non-significant relationship between strabismic deterioration and normal or high AC/A ratios. He did note the increased frequency of an IOOA as companion to deterioration.[17] During our examination on 2/23/05, an IOOA and a hyper component to the patient's esotropia were noted.

VZ's fixing eye's spherical equivalent refraction was essentially +1.50D; this is +0.75D less than the low end of Baker and Park's study.[15] However, her esotropia did increase, similar to Nakagawa's finding.[16] It is possible that**,** prior to her initial evaluation at 24 months of age**,** she had more hyperopia, which decreased. Her AC/A ratio, as derived from distance-near alignment, was normal, not high. This tends to match Raab's study, [17] while the existence of amblyopia matched that of Baker and Parks,[15] who reported an amblyopic incidence of 50%.

At our initial examination, the alteration of our patient's prescription had no significant effect on establishing better binocular alignment, and a probe add did not alter her deviation at near. A residual turn conformed to the diagnosis of a partially accommodative esotropia. Treatment options at this point were surgery or VT. Long standing esotropias, which are constant and do not respond to additional plus, tend to have a guarded VT prognosis.[3] Additionally, the window of opportunity for what is described as successful functional strabismic surgery was at a threshold for positive results.[20,21] Consequently, although the amblyopia was still

mild, we chose to refer the patient for a surgical evaluation and procedure. It was our intention to continue post surgical amblyopia therapy, as well as binocular enhancement.

Consecutive Exotropia

The esotropic surgical outcome was a consecutive exotropia. Consecutive exotropia is considered an overcorrection of greater than, or equal to, either 5[22] or 10[23-25] prism diopters of exotropia at distance or near following esotropia surgery. This was originally thought to range from 4% to 20% of cases.[8,9] Arnoldi used a mean follow-up of 1.3 years and found the incidence of consecutive exotropia to be 44%.[23] Others have reported that the incidence of consecutive exotropia increases with a longer follow-up time.[24-26] In fact, Page noted it might present up to 25 years after surgery.[22]

Potential etiologies for the development of consecutive exotropia are: a surgical over-correction, a primary vertical deviation, anisometropia of more than 0.75D, poor binocularity, and amblyopia[22-27]. The effect of varying degrees of hyperopia is debatable. Arnoldi[23] and Folk et al[24] often found less than 4.00D and 2.50D, respectively, of hyperopia in the consecutive exotropes they studied. Arnoldi found that anisometropia was significantly greater in those subjects who developed consecutive exotropia after surgery than in those whose surgery resulted in residual esotropia.[23] Folk et al.'s, anisometropic sample was limited and not enumerated.[24] In contrast, the amount of hyperopia was not statistically significant in Page, et al.'s, study.[22]

Some believe consecutive exotropia is an undesirable outcome, because it may lead to diplopia. They recommend corrective surgery if the exotropia remains stable for six months.[28,29] However, Wright suggested that a consecutive exotropia leads to a greater likelihood of achieving fusion than does a residual esotropia.[30] If this perception is accurate, it would seem that some active treatment is needed post surgically, rather than a tincture of time. Caputo, et al., reported on 345 post surgical esotropes who developed consecutive exotropia; they were either orthophoric or exotropic within six months following surgery.[31] This indicates that satisfactory post surgical results are not a guarantee of continued success, and again, there is the implication that VT is needed to assist the development of binocularity. In keeping with this perception, our patient pursued an active VT plan, which included the enhancement of monocular, binocular, and fusional abilities.

Strabismic Anisometropia

A difference of one diopter between two hyperopic eyes, or three diopters between two myopic eyes can lead to amblyopia. Approximately one third of anisometropes also demonstrate a strabismus.[32] Flom and Neumaier reported a prevalence of amblyopia in one percent of their school aged sample of 2,762.[33] Of this one percent, 38% were pure strabismics, 34% presented with anisometropia, and 28% had a combination of both strabismus and anisometropia. Abrahamsson, et al., found a higher prevalence: 2.7% of his young subjects were strabismic, 4.2% were anisometropic, and 1.4% had combination of strabismus and anisometropia.[34]

The details of the relationship between esotropia and anisometropia are still debated. Some believe that the strabismus occurs first, followed by the failure of the deviating eye to emmetropize, resulting in anisometropia.[35-38] Others propose that the anisometropia causes a suppressed central fixation area due to blur, which results in a microtropia.[39] This may eventually decompensate into a larger angle of strabismus.[36]

Kiorpes and Wallman[40] demonstrated an association between amblyopia and hyperopic anisometropia in monkeys. Two thirds of the treated monkeys became amblyopic either from induced strabismus or unilateral defocus. In more than half of these, a hyperopic anisometropia developed, with the higher amount of hyperopia in the amblyopic eye. Kiorpes and Wallman suggested that amblyopia causes an increase in hyperopia due to alterations in eye growth. In humans, Burtolo, et al., found a similar phenomena, such that the non-fixing eyes of hyperopic anisometropic amblyopes increased in hyperopia. His myopic sample had their non-fixing eye increase in axial length.[41] These studies suggest that an early correction of the amblyopia is important in the treatment of anisometropes to prevent an increase in magnitude of anisometropia.

This raises the issue of the relationship between improved binocularity, and the reduction of anisometropia in an originally non-fixating eye. Our patient demonstrated a marked reduction in anisometropia in conjunction with improved binocular function and VA. Fitz-Gerald and Gruning[42] published a similar case of a child with accommodative esotropia in conjunction with anisometropia.

VZ initially presented to the pediatric ophthalmologist with four diopters of anisometropia. She was fit with the appropriate spectacle prescription, and a period of occlusion therapy was initiated to improve the VA in the amblyopic eye. After the surgery, we prescribed VT and patching (5/26/04). Because of vacation plans, VZ was not able to attend three VT office visits. However, after a total of 10 sessions and compliant home VT, on 12/15/04 she showed a marked improvement, and equalization of VA (20/25) and ocular alignment at distance and near. Also, both eyes' refractions remained stable for a three month period, and the anisometropia had decreased by 1.50 diopters.

Abrahamsson, et al.,[34] followed the change in refractive status in 9,715 normal and strabismic children one to four years of age. They noticed that some esotropes developed anisometropia after the onset of strabismus. In fact, the majority of esotropes demonstrated an increase of hyperopia in the deviating eye and in some cases, there was a decrease of hyperopia in the fixating eye. He proposed that the fixating eye is allowed to emmetropize while that same process is disrupted in the strabismic eye. This is supported by the findings in Aurell's study, which suggest that the development of esotropia in children with a family history of strabismus is caused by a disruption in the emmetropization process.[43]

Ohlsson et al. followed anisometropic and strabismic amblyopic patients for 10 years.[44] They found that non-strabismic anisometropic amblyopes demonstrated a decrease in anisometropia over time; however, strabismic anisometropic amblyopes showed less of a decrease.

These studies agree with the active process mechanism theory, which proposes that emmetropization is regulated by retinal blur. The eye either shortens or elongates, depending on the amount and type of retinal blur.[45,46] Additionally, in this particular case, the plasticity of the vi-

sual system seems to seek a homeostasis with an increase in binocularity resulting in a more balanced ametropia. Whether the mechanism for the strabismus was based on pure anisometropia or whether it was a strabismus, which preceded and precipitated the anisometropia cannot be factually determined. The combination of both etiologies could also be a possibility. Regardless, VZ became less anisometropic in conjunction with her improved binocular state and visual acuity.

Summary

We have reported on a 28-month-old child, who presented to us with amblyopia, partially accommodative esotropia and hyperopic anisometropia. Surgical intervention resulted in a consecutive exotropia. We applied patching and vision therapy techniques, which improved best corrected visual acuity and binocularity. As the binocularity and visual acuity improved there was a reduction in the hyperopic anisometropia, which suggests a dynamic and intimate relationship among the various components of this case. The treatment plans and care given in this case are backed by vision research and served as an example of the clinical application of the literature.

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Date accepted for publication:
August 10, 2005