ARTICLE

A Treatise on Re-Defining Success in Optometric Vision Therapy for Strabismus Based on a Case Series of 75 Patients

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ABSTRACT

In the mid nineteenth century, the father of modern ophthalmology and founder of Archives of Ophthalmology, Albrecht von Graefe, summarized the role of orthoptic training for patients with strabismus: "People are really not worthy of all that trouble." Neither 100 testimonials of patients treated for strabismus nor a retrospective chart review of adult and school-age patients with strabismus seen in my private practice between 2015 and 2022 support von Graefe's speculations. Of 140 patients seen with strabismus, 75 both received optometric vision therapy (OVT) and met uniform criteria including age, length of therapy, and documented pre/post therapy findings. Of these 75 patients, 65 (87%) were judged successful. In this article, we address a number of questions, but principally these two: 1) What is the role of optometric vision therapy in the treatment of patients with strabismus? 2) How should we judge success in the treatment of strabismus? The two questions cannot be separated, for each defines the other. A sample of guidelines predicated on the work of such notable experts in strabismus treatment as Jampolsky, Parks, Flom, and others reveals no consensus on what constitutes success in the treatment of patients with strabismus. Rather, there are different success criteria for surgery and vision therapy, making it difficult for the lay public to compare outcomes of prior studies. In this paper, I propose a guideline for a "basic behavioral success" that will work equally well for surgery and therapy, making comparisons between the two approaches easier. Extending my previous publications, I factor in new data from testimonials of patients with strabismus as well as 75 questionnaires completed by the patients in this study. From these, I propose guidelines for Behavioral Quality of Life Questionnaires that can be useful for children as well as adults with strabismus.

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INTRODUCTION

Strabismus is a condition in which both eyes fail to align at the same place at the same time. Either constantly or intermittently, those with strabismus use one eye or the other for more careful inspection while allowing the fellow eye to point elsewhere. Doctors have been attempting to treat patients with the condition for over 4000 years.[1] Affecting somewhere between 2 and 5 percent of the population,[2] strabismus impacts both how patients look and how they see.

Emphasizing the cosmetic aspects of the condition, the American Academy of Ophthalmology writes, "Strabismus can have a negative impact on an individual's employment opportunities, school performance, self-image, and ability to find a partner because the inability of the strabismic patient to maintain normal eye contact interferes with communication and interpersonal relationships."[3]

While agreeing with these claims, optometrists inside the United States and ophthalmologists outside the United States, tend to also stress

that performance of patients with strabismus suffers from reduced stereopsis, the two-eyed awareness of spatial depth between objects typically attributed to retinal disparity created by the difference of perspective between the two eyes. Reduced stereopsis may affect balance,[4] sensorimotor development, school and sports.[5] "Among kindergarteners and first graders with average intelligence, stereoacuity is correlated with standardized reading scores and teacher's ratings of reading abilities."[6] Reduced stereopsis can similarly affect confidence when driving.[7]

In this paper, we will consider seven concerns drawn from the literature, patient testimonials, and from my experience treating 75 patients with strabismus:

1. What might be a useful criterion for judging success in the treatment of patients with strabismus?
2. Can optometric vision therapy (OVT) help adults and school-age children with cosmetically noticeable esotropias of 15 to 45 prism diopters (pd)?
3. Can OVT be beneficial to patients with cosmetically unnoticeable esotropia under 15 pd?
4. Can OVT help older patients (> 4-years-old) with esotropia to develop monofixation syndrome or better binocularity?
5. Can patients with monofixation syndrome benefit from OVT?
6. Can OVT help patients control their cosmetically noticeable intermittent exotropias between 15 pd and 50 pd?
7. Could a behavioral quality of life questionnaire provide outcome measures that would also improve our understanding of the benefits of OVT for treatment of patients with strabismus?

As our title suggests, I do not treat strabismus; I use OVT to treat patients with strabismus. In doing so, I am forced to consider both the physical and behavioral changes that enhance the quality of patients' lives. In truth, however, most patients with cosmetically misaligned eyes come to us over the embarrassment of how they look, and concerns about how others view them. The inefficiencies of how they see typically come second. Unless the onset of the strabismus is recent, patients are often no more aware of their constricted visual performance than unexamined nearsighted children are aware of unseen leaves on trees. It is often not until after therapy that patients with strabismus appreciate, or even marvel at,[8] the changes in their perception and interactions with the world. To maximize quality of life according to the wishes of patients with strabismus, not to mention the goals of doctors, neither function nor cosmesis may be ignored.

Today, glasses, occlusion, eye-muscle surgery, and OVT are all common tools for helping patients with strabismus. Experts on surgery and experts on OVT, however, disagree on the best approach for helping a given patient with strabismus. As we will examine, some of the best and most knowledgeable strabismus surgeons have argued that vision therapy is unwarranted for patients whose esotropias are under 10 or 15 pd. These opinion leaders have also argued that early surgery is necessary for achieving stable, small angle turns with peripheral stereopsis and that these stable small angle turns are not worth improving with further treatment beyond glasses or patching.

My clinical experience does not agree with these surgical opinions, but as I have written elsewhere, *in my clinical experience* is a "euphemism for a practitioner's selective recall tempered by theory, ego, and economics."[9] Thus, rather than relying on my experience I will, after first exploring some examples from the literature suggesting how surgeons vary from optometric vision therapists in defining the word "success," compare these opinions to my actual clinical results with 52 patients with esotropia. I will separately share my results in treating 23 patients with intermittent exotropia, so as not to confuse the stereopsis results by mixing the two very different forms of strabismus.

What is Success and Are Patients Really Worthy of all that Trouble?

Both surgery and vision therapy in one form or another for the treatment of patients with strabismus

have existed for a century and a half, and for at least 150 years of that time doctors have argued about the relative merits of the two approaches. During the infancy of strabismus surgery, for instance, French physician Emile Javal (1839-1907)[10,11,12] developed a nonsurgical, dichoptic (presenting each eye with its own target) instrument treatment (orthoptics) to develop binocular fusion and save his sister Sophie from what he called "the massacre of the medial rectus muscles," an approach that had disfigured his father. Albrecht von Graefe, a famous surgeon of the day who later become known as "the father of modern ophthalmology" was unimpressed, remarking, "People are really not worthy of all that trouble." Despite this clash of viewpoints, Sophie received surgery from von Graefe and pre and post orthoptics from her brother. Her eyes remained straight until her eighties. Despite his sister's success, Javal, his optimism perhaps blunted by his growing blindness from glaucoma, later admitted, "Von Graefe was right."

Without detailing the debate, I'll provide a few examples of how it continues to shape viewpoints on providing care for patients with strabismus. In 1956, for instance, during a time when ophthalmologists were more familiar with orthoptics, Arthur Jampolsky, an inquisitive and thoughtful strabismus surgeon studying the quirks of smaller angle esotropia wrote: "In general, it may be said that in visual adults with convergent deviation of less than 10 to 15 prism diopters, no harm will result in abstaining from any therapy and much feverish activity of doubtful value to the patient will be avoided."[13] Jampolsky also reasoned, "the only valid reason for undertaking therapy is for cosmetic improvement or for the elimination of symptoms."[14]

In support of his cosmetic and symptom free success criteria, Jampolsky went back twenty years to the 1936 *Squint Training*. M. A. Pugh, the author discussed alternating squints left after operation

> *… with a small deviation of perhaps 8 to 10 degrees [using a conversion factor of 1.75 prism diopters per degree, this is approximately 14 to 17 prism diopters] and these patients may develop abnormal retinal correspondence … they are little worse off than normal since their vision is full in either eye, they have some fusion although it is of a less accurate type than macular fusion, and from a cosmetic standpoint their eyes are to all appearances straight … If the squint has been present from birth it is a much more difficult proposition, but the percentage of cases that will not develop fusion is small."*[15]

Mary Agnes Pugh was a medical officer in charge of the squint (strabismus) department at Moorfields in London, England. Her book reportedly "gave a clear classification of a thousand cases and laid down the appropriate line of treatment to be followed … The book cleared the ground for a new systematic approach, laid down sound guidelines, and introduced much new material."[16] It seems ironic, that the name of a medical doctor who devoted much of a lifetime to orthoptics should be quoted out of context to dismiss her life's work. But, Jampolsky ignored Pugh's claim that most of these cases will "develop fusion." He highlighted instead the end of Pugh's paragraph: "it is doubtful whether the end result is worth the trouble, and this must be left to the patient to decide. As stated above, … he gains very little for the expenditure of a great deal of application and a considerable amount of time which may be ill spared in a busy life."[17]

Jampolsky apparently considered it the physician's, not the patient's job to decide on the merits of possibly improved binocularity. His position against treating asymptomatic patients with turns under 15 prism diopters essentially mirrors von Graefe's pronouncement that "people aren't worthy of all the trouble." An important question, however, about Jampolsky's reflections is how do we define "asymptomatic"? The term probably relates more to the listening and questioning skills of the practitioner than the performance of the patient. If by symptoms, we mean extreme discomfort or pain, then the paucity of symptoms related to smaller angle esotropia probably agrees with Jampolsky's perceptions. If we include headaches, blurred or double vision, or asthenopia (ocular discomfort) symptoms may increase; and if we

include concerns about cosmesis or unstable vision, avoiding sports, bumping into things, clumsiness while dancing, or hesitancy to drive at night, then symptoms may well be more common than doctors fixated on eye muscles generally realize. Our suspicions aside about the reality of the term "asymptomatic," Jampolsky is probably defining success as cosmetic alignment without persistent complaints loud enough to pierce the armor of the physician's busy schedule.

By the beginning of the 1960s the debate on whether patients were worth the effort, was being decided by insurance companies, not doctors. According to MotivHealth,[18] "Between 1940 and 1960, the total number of Americans enrolled in insurance plans grew from 20.5 million to 142.3 million, and by the end of the 1950s, three-quarters of Americans had some form of health coverage." Strabismus surgery had become affordable, and patient care reflected the change. In 1955 Cooper,[19] for instance, compared surgery with and without orthoptics to treat patients with esotropia. By 1968 Fisher, et al[20] were comparing surgery in the first and second years of life to treat patients with esotropia. They reported that over half of the patients required a second operation. Today, the promotional site for the American Association for Pediatric Ophthalmology and Strabismus (AAPOS)[21] does not mention orthoptics or any other form of "eye exercises" for the treatment of esotropia, just glasses, prisms, bifocals, strabismus surgery, and, perhaps, botulinum toxin.

Was the transition from orthoptics and surgery to multiple surgeries fueled by economics or reason? From the surgeons' viewpoint, the answer was reason: the studies, as designed, performed and interpreted by surgeons, favored surgery. Still, more recently, it has been noted that non-surgical intervention for intermittent exotropia remains more popular outside the United States where the economics do not so favor surgery and the economic competition between surgical and nonsurgical practitioners is not as keen.[22] Whether science drives medical economics and politics or medical economics and politics drive which studies will be pursued by science is beyond the scope of this article, but it may be useful to examine one of the 1960s era's more scientific papers used to support von Graefe's surgical rather than Javal's therapy perspective.

In 1969, Fletcher, et al. turned to science to settle the Javal-von Graefe argument. They performed a 3-year randomized study of constant esotropia, which included an orthoptic-training-and-surgery experimental group and a surgery-only control group. Confident of their methodology, the authors asserted "that the only reliable method of assessing results of orthoptic treatment was by a controlled random study..."[23] Their conclusion: "In a random study of the treatment of alternating esotropia, age 5 to 17 years, orthoptic treatment administered intensively preoperatively and postoperatively was found to be of no added benefit over conventional glasses, miotics, and surgery."[24]

In retrospect, the study reminds one of a quote by Scottish author Andrew Lang (1844-1912), a contemporary of von Graefe and Javal: "[They use] statistics as a drunken man uses a lamppost—for support rather than illumination."[25] Omitted from the conclusion, was essential information about the non-orthoptics control group: "Binocular vision was encouraged in those found with casual fusion postoperatively. This was done with the use of home exercises (TV screen, prism bars, etc) but no formal orthoptic treatment was used."[26] Thus, if there was any sign of fusion after a surgery, home-based anti-suppression training was initiated. Seven patients in the experimental group received "home orthoptics" in the first year and 2 received home orthoptics in the second year, while 7 of the controls received home orthoptics in the first year and 4 received home orthoptics in the second year. Thus, rather than compare surgery with and without orthoptics, the study compared surgery with in-instrument orthoptic training and out-of-instrument anti-suppression training to surgery with out-of-instrument anti-suppression training.

Despite its misleading conclusion, that the Fletcher study, nevertheless, had its effect on—or at least reinforced—ophthalmological opinion is suggested by the introduction to a John Flynn paper in which the study is cited two years later:

"Recent opinions, though not unanimous, have cast doubt on the efficacy of orthoptic therapy in the treatment of sensori aspects of certain motility disturbances."[27] That the opinions persisted and multiplied is suggested by today's approximately 1.2 million strabismus surgeries per year.[28] In constrast, orthoptics and its cousin optometric vision therapy are seldom covered by insurance.[29]

Probably far more influential than Fletcher, et al. in changing attitudes on success in treating patients with strabismus was the work of Marshall Parks. If there ever was an opinion leader in pediatric ophthalmology, it was Parks. He was trained by and became the Washington D.C. partner of Frank Costenbader, renowned for being the first ophthalmologist limiting his practice to pediatrics. Before his death in 1985, Parks had trained over 150 fellows, and his speaking had undoubtedly influenced countless others. In 1961, "Monofixational Phoria" appeared in which Parks defined a new level of sensorimotor success that was in reach of the strabismus surgeon: "Monofixational phoria is that particular type of extraocular muscle imbalance in which the deviation is made partially latent by peripheral fusion but in which a small residual deviation of one fovea remains manifest—the image projected on the deviating macular area being suppressed."[30]

Other surgeons were soon following Parks' lead. In 1967, for instance, Taylor, an advocate of strabismus surgery on children before the second year of life, defined his own perspective on success:

> *To avoid confusion it is necessary to define our objectives. Our major goal is to convert a tropia to a phoria. ... The degree of binocular single vision present in a phoria can vary considerably. This may range from gross peripheral fusion with foveal suppression as seen in monofixational phoria to perfect stereoscopic vision in all directions of gaze.*[31]

In 1969, Parks furthered his recognition in the field of strabismus surgery with his paper "Monofixation Syndrome."[32] Based on Parks' thorough review of the literature on small-angle esotropia and his personal study of 100 meticulously-evaluated patients, Parks defined monofixation syndrome: "Essentially the patients with this syndrome have a form of binocular single vision in which their inability to bifixate is proved by a demonstrable scotoma in the visual field of the non-fixating eye during binocular vision."[33] Thus, for Parks, the term *bifixation* implied not only to the two eyes' visual axes intersecting at the object of regard, but both eyes being used and neither suppressed.

Parks demonstrated that patients with monofixation syndrome had vergence amplitudes and 3000 (stereo fly) to 67 seconds of arc stereo acuity. Park's included refractive amblyopia in his syndrome not to mention monofixational phoria with its angle of deviation measuring 8 prism diopters or less on a simultaneous prism and unilateral cover test.[34] It was permissible for an angle of deviation to build to two or three times as much on an alternate cover test. Parks evidently intuited that it was the unilateral, not the alternate cover test finding that signaled a successful cosmetic alignment.

Parks argued that monofixation syndrome was both a form of binocular vision (with normal retinal correspondence in the periphery and a suppression scotoma precluding correspondence centrally) and a logical stopping place in the treatment of patients with strabismus: "The most impressive prognostic feature of patients with the monofixation syndrome is their static alignment state. Over the years their eyes continue to remain aligned as well as if they were bifixating..."[35] Reviewing the status of 74 patients he aligned within 8 prism diopters by surgery, Parks found that they were still straight upon follow up an average of nine years later. From these results and other references from the literature, Parks made this conclusion: "These data reveal the tendency for the alignment of the monofixator to persist unchanged over the years... Peripheral fusion alone seems to be just as effective as the combination of peripheral and central fusion in maintaining straight eyes."[36] Unfortunately, Parks also argued, "Apparently the monofixator has such a poor prognosis to ever become a bifixator that no therapy of the disorder appears justified other

than providing the ideal optical correction and occlusion for amblyopia."[37]

Parks' recognition and insistence that monofixation syndrome could be a cosmetically and functionally stable form of binocularlity was a milestone in the treatment of patients with strabismus. His stringent definition for a "bifixation cure," however, were less helpful. His arguments acknowledged no difference between 67 and 3000 seconds of arc because both met his criteria for monofixation syndrome and neither met his criteria for bifixation. And for Parks, converting 67 seconds of stereo acuity to 40 seconds was not enough to qualify for bifixation either; he demanded no suppression on an A-O Vectographic Project-O-Chart slide, on a Worth-4-dot test across the room, or on binocular field plotting. I can't imagine how many pilots who have passed their flight physicals with 40 seconds of stereo acuity might fail Parks' other demands. His stringent requirements for an all-or-nothing "bifixation cure" provided another excuse to justify von Graefe's conclusion that "people are really not worthy of all that trouble."

Whatever portion of the full truth Parks had discovered, his thinking continues to permeate surgical thinking. In 1994, one of Parks' fellows, Kenneth Wright, performed strabismus surgery on seven infants between the ages of 13 and 19 weeks.[38] After 5 years of follow-up, the published results claimed random dot stereopsis in 60%. Most also exhibited no shift to cover testing or 4 diopter base-out prism testing. In Parks' terminology, they displayed most of the features of "bifixators." Whatever the results of 7 infants in an age range where esotropia is known to spontaneously disappear and preoperative assessment is more difficult if not inconclusive, the case histories do tell us that some surgeons are so interested in stereopsis that they are willing to operate on 4-month-old infants.

More recently, in 2005,[39] Lawrence Tychsen reviewed early surgery for esotropia and again defined success:

> *...[T]he job of the ophthalmic surgeon is to realign the eyes to within an envelope of 2.5 to 5.0 deg. That allows ODCs [ocular dominance columns] mediating fusion in the cortex to be separated by no more than 1 to 2 horizontal neuron lengths. If the surgeon accomplishes that job within ~60 days after onset of strabismus, a substantial number of infants can regain high-grade fusion and stereopsis—in Parks' nomenclature, nearly normal bifixation. If the surgeon accomplishes that job beyond ~60 days of deprivation, the majority of infants will miss out on bifixation but will still benefit from Parks' monofixation.*

Here, the criteria for success seems to break down into either bifixation or monofixation syndrome, precise alignment and stereopsis of eight prism diopters or less of deviation with peripheral stereopsis and a good prognosis for long time alignment. Moreover, the author suggested that in the surgical treatment of infantile esotropia greater than 18 months after onset, stereopsis is rare.[40] In actuality, stereopsis in infantile esotropia is indeed rare. Birch's review of the topic concluded that the treatment of infantile esotropia "for binocular sensory dysfunction is rarely successful. Even with optical correction and early surgery, <0.5% of this prospective cohort developed normal stereoacuity by 5 years of age and over 60% had nil stereoacuity.[34]

So, what is the consensus of surgeons on the success in the treatment of patients with strabismus? Of twenty-eight strabismus experts from around the world surveyed,[41] all with peer-reviewed papers in their curriculum vitaes, 96 percent agreed on assessing stereopsis during evaluation of sensory status. To the question, "What do you consider as a motor success after surgery?" there was no consensus. Of those surveyed, 15 percent agreed with 10 diopters or less of phoria, 22 percent agreed with +/- 10 diopters "from straight," and 40 percent agreed with 10 diopters of under correction but disagreed on allowable size and control of overcorrections.

In the second half of the 1950's, ophthalmologists were not, however, the only doctors to note the disparity between unilateral and alternate cover tests in some patients with esotropia. Nor was

Parks the only opinion leader of the period whose efforts have arguably affected the quality of life of patients with strabismus. In Optometry, Merton Flom was a beloved UC-Berkeley professor who set up the Berkeley binocular vision clinic and would later become an associate dean at the University of Houston as well as president of the American Academy of Optometry and editor of its journal. In 1958, Flom published a paper[42] describing a video he has presented two years earlier at the Academy meeting. The video captured an esotrope with a larger movement on an alternate cover test and just "a flick" on a unilateral cover test. Flom was uncertain if the flick represented "An unusually large fixation disparity associated with a large heterophoria and otherwise normal binocular vision"[43] or a constant strabismus with "unharmonious anomalous correspondence with a small angle of anomaly." In optometry at least, the second interpretation seems to have won recent votes of consensus, questioning the flick's status as an example of functional binocularity.

Both Parks in the 1960s and Jampolsky predating Flom's video by a few months in 1956,[44] interpreted the flick as a fixation disparity allowed by a suppression-enlarged Panum's area. While the two influential surgeons favored a definition of the flick that granted "phoria," "fusion," and "normal retinal correspondence" status to post-surgical infantile esotropes, Flom withheld any definitive judgement on the flick and instead defined success in the treatment of patients with strabismus as a "functional" cure:

> *Clear, comfortable single binocular vision must be present at all distances up to the near point of convergence, which is normal itself; there must be stereopsis and normal ranges of motor fusion; an occasional turning of the eyes may occur (up to about 1 % of the time) providing diplopia is experienced whenever this happens; correction lenses and small amounts of prism (up to 5 prism diopter) may be worn if necessary.*[45]

Flom was a staunch defender of what we might call "the better binocular illusions," those instances when our eyes do not agree with our senses of smell, touch, hearing, or taste. When those of us who have earned the right to think of ourselves as "normal" look into a pair of binoculars, or a stereoscope, or a major amblyoscope our hands tell us there are two tubes, but we still perceive the binocular illusion of two images in two different locations blending together into one. Many patients with strabismus, however, see two tubes, their images not really having anything to do with each other unless we encourage the patient to alternate, think, and remember until they believe the images are one. Similarly, if a patient who is privy to the better binocular illusions is eating a peppermint ice-cream cone held a third of a meter in front of her nose and suddenly develops a 30 diopter esotropia, she should see the illusion of two ice cream cones, 10 centimeters apart and be unable to tell, which is real and which unreal, which cone will smell and taste of peppermint, which will not, which cone can be reached for and which can not, which cone will produce slurping or crunching sounds and which will not, which cone will be cold and which will not. If, however, the patient lacks the better binocular-illusions, that patient will see only one cone that feels, sounds, smells, and tastes like a single peppermint ice-cream cone.

Instead of basing a cure on performance in the real world, Flom demanded that to be cured, the patients beheld the better binocular illusions whenever the eyes were misaligned. And Flom would doubtlessly have declared a patient to be anomalous if that patient saw major amblyoscope images in their true directions aligned with the eyes rather than sharing an ocular illusion of being in the same direction. Surgeons, it seemed had better things to occupy their time than to worry about the proper illusions, with one exception: dichoptic stereopsis, the illusion of combining two flat, disparate targets into one three-dimensional target. This illusion was sought after in both optometric and ophthalmological care.

Despite his insistence that patients share the better binocular illusions, the "Flom cure" was a major step forward in the optometric care of patients with strabismus. A stream of optometric studies utilizing the cure[46-52] followed. Flom

had initiated a veritable optometric golden age in strabismus exploration. He quickly realized, however, the shortcomings of his own criteria. As he would subsequently acknowledge, patients without strabismus can have subnormal ranges, asthenopia, suppression, reduced stereopsis, and amblyopia.[53,54] To require more of patients with strabismus than without strabismus might be taking things too far, Flom reasoned. Thus, despite the role his "cure" with its insistence on the "right" binocular and dichoptic images would play in optometry for decades, Flom himself had abandoned his original criteria within 5 years. In 1963, he rewrote his description of success for the treatment of patients with strabismus:

> *It must be remembered that strabismus is* ***an oculomotor anomaly characterized by lack of bifoveal fixation.*** *Therefore, the prime requirement for its correction should be maintenance of bifoveal fixation in the ordinary situations of life. Loss of bifixation should not occur more often than 1 percent of the time, i.e., at most, about 5 to 10 minutes a day. Vision should be clear and generally comfortable. The range of bifixation should include all fields of gaze and extend from very great viewing distances to only a few centimeters. Corrective lenses and reasonable amounts of prism may be worn [Emphasis added].*[55]

Most helpfully, Flom had eliminated his earlier requirement for diplopia when the eyes turned. Thus, a truck driver with a sought-after 1-percent-of-the-time deviation would no longer have to experience five or ten minutes of intermittent and unpredictable double vision a day while driving just so his doctor could claim to have achieved a "Flom cure." Still, other than eliminating the diplopia requirement, Flom's revised criteria may not have been an improvement. While Flom correctly cautioned that to "view strabismus only as a cosmetic problem is to deny some children the opportunity of obtaining normal binocular vision,"[56] his new criteria required bifixation only (both visual axes intersecting at the object of regard), not normal binocular vision. One wonders, just how valuable is physical bifixation without the stereopsis, vergence control, or simultaneous foveal perception we normally expect to accompany "normal binocular vision"?

Flom fostered another belief potentially limiting the reach of optometrists treating patients with strabismus. He failed to create a continuum of success moving from 1) cosmetic alignment without stereopsis through 2) cosmetic alignment with improved local stereopsis and stereo awareness in the world to 3) bifixation accompanied by increasingly excellent local or even global stereopsis. Instead, Flom, as Parks would later do for "bifixation," set rigid, frequently unobtainable criteria for a "functional cure." Flom's criteria have constricted classical-optometric thought on binocularity ever since. Failing to recognize the value and stability of the "flick" he himself had previously documented on video and in print, Flom created a false dichotomy between a functional and cosmetic cure: "If the prognosis for … [normal binocular vision] is extremely poor" Flom wrote, "then the prognosis for improved cosmesis without normal binocular vision should be considered…."[57]

The problem with this statement is that some optometrists may continue to equate mere cosmetic care with surgical care and overlook optometric vision therapy (OVT) as a viable option for possibly obtaining cosmesis while at the same time increasing stability of seeing, stereopsis on testing, and spatial awareness in the world outside the therapy room. Such optometrists fail to note that Flom was dealing with targets that were 2 to 6 degrees[58] and isolated from the actions of the hands and body by the narrow arms of an instrument that later failed Fletcher's random, controlled, and statistical study and today is more a museum piece than a readily available instrument. Today's projected polaroid, anaglyphic, liquid crystal, virtual reality, and augmented reality targets often fill much of the approximate 120 degrees of the binocular field overlap and bypass anomalous central binocular illusions. Thus, when we speak of the dictates of Flom we are at best comparing the apples of a bygone age with the oranges supplied by modern science and engineering that have revolutionized the potential for non-surgical care of patients with strabismus.

Similarly, Flom states, "Knowing the factors that influence functional correction and being able to estimate the probability of obtaining it are vital in achieving a sense of balance [between functional and cosmetic cures.]"[59] Flom was referring to his careful analysis of prognosis based on sensory and motor diagnosis.[60] Again, his statement may apply to the patient with constant esotropia and anomalous correspondence who needs to perceive the dichoptic illusion of 40 seconds of stereo to become a pilot. If, however, this same patient is merely interested in cosmetic alignment, surer coordination, and more confidence with night driving, Flom's viewpoint on diagnosis and prognosis for functional cure may actually distract the clinician from helping the patient because of hesitations of disturbing central sensorimotor adaptations with the minute, inescapable, anti-suppression targets of a major amblyoscope. In clinic, we daily see patients with little chance for a Flom cure and yet every chance for the successful cosmesis and awareness of egocentric depth available to those with monofixation syndrome.

Reconsidering Outcomes for Basic Behavioral Success

In 1977, hoping to expand upon the idea of the Flom cure, Wick and Cook proposed a "'functionally adequate cosmetic cure' … in which binocular function is much improved from the deep amblyopia and large-angle esotropia that is often present before therapy." They went on to suggest criteria for their "cure":

1. Cosmetic alignment with peripheral fusion, reduced stereopsis (possibly as good as 100 sec arc), and central suppression.
2. There could be no blurring, diplopia, or visual discomfort.
3. A small strabismic angle of 5 prism diopters or less could be present.
4. Corrective lenses and reasonable amounts of prism (up to 5′′′′) could be worn.
5. There could be a slight amblyopia; acuity no worse than 6/12 (20/40).[61]

While a step in the right direction, I imagine that such abrupt boundaries are more useful for improving the quality of scientific studies than improving the patient's quality of life. Today I would find another name for the cumbersome and somewhat disparaging "functionally adequate cosmetic cure." First, the term cure suggests an unearned finality. Like an extinct volcano about to go dormant, a patient's "cured" strabismus may re-erupt at any time. *Cure* also suggests "normality." *Success* is a term that more accurately reflects the treatment of patients with strabismus. An operation for an inflamed appendix is a "success" not a "cure." The patient will never again have "normal" anatomy. Providing the operation was not a success while the patient died, a success suggests that the patient can again successfully interact with the environment. When it comes to appendicitis and strabismus, that is enough to hope for or expect.

Similarly, when discussing the treatment of patients with strabismus, I favor the term *behavioral*, not *functional*. Systems function; people behave. The accommodative and vergence systems function. For people, vision is something they do, not something that happens to them. We use *behaviorial* to remind us we are working with people, not stimulus-response oculo-motor systems, not disease. The term *behavioral* calls to mind the patient's volition, body, language, reasoning, emotions, and environment in our treatments.

Rather than a "functionally adequate cosmetic cure," I'll, therefore, use "basic behavioral success." The "behavioral" reminds us that there is more to patient care than findings. The "success" reminds us that whatever qualifies for success in strabismus surgery should qualify for success in vision therapy for patients with strabismus. To allow comparison of surgical and vision therapy treatments, I have, therefore, retained only two criteria to define a basic behavioral success for studies treating patients with esotropia:

1. Stereo fly or better stereo with 8 prism diopters or less of deviation on a simultaneous prism unilateral cover test. As suggested by Marshall Parks, a monofixational phoria is attained with perception of the stereo fly,

8 prism diopters or less of movement on a simultaneous prism cover test, and a central suppression scotoma precluding diplopia. If a monofixational phoria is considered a successful, stable surgical outcome then it can reasonably be considered a successful OVT outcome.

2. For patients who began therapy meeting Park's monofixation criteria, then improved stereopsis may be added as a second criteria for a basic behavioral success. Since these patients were already cosmetically aligned, an improvement in stereopsis seems warranted to justify a positive change.

In truth, even these two simple criteria continue to share their pluses and minuses. On the plus side, the smaller angle required generally ensures cosmesis, and the improvement in stereo suggests improved performance. Even so, the two criteria combined are often too stringent for surgical care in which 10 pd of remaining deviation may be accepted as success, and stereopsis may either remain undocumented or be confused by mixing patients with both esotropia and exotropia, the latter typically having better and more easily improved stereopsis and masking the lack of stereo improvement in patients with esotropia.

While useful for a study that does not require more of vision therapy than of surgery, this basic behavioral success certainly falls below my personal expectations for patients. We will explore an "expanded behavioral success" for treatment goals after we have evaluated our study's patients from the viewpoint of a basic behavioral success.

In summary, while there is no firm consensus on what doctors consider to be "success" in the treatment of patients with strabismus, a patient freed from concerns about cosmetic alignment seems to be a common goal for most vision therapy optometrists and strabismus surgeons. Among surgeons with an academic interest in the subject of strabismus, stereopsis also persists as a consideration, as may monofixation syndrome and bifixation. Optometrists, in their studies at least, seem to fixate on bifixation, ignore monofixation, and deprecate mere cosmesis. This deprecation is not entirely unjustified, for cosmetic-only treatments can provide patients with the false security that "I look okay" means "I see okay." Of equal concern, however, is the optometrist's tendency to apply a different criterion of success for vision therapy than for surgery, demanding precise alignment and stereopsis for vision therapy and only cosmetic alignment on a cover test for surgery. This tendency leaves patients, referring doctors, and insurance companies to compare apples with oranges when reading the abstracts of studies.

To avoid this confusion, I have limited our basic behavioral cure to comparing angle of deviation and seconds of stereopsis before and after optometric vision therapy (OVT). As we have seen, these two measurements are frequently common to studies of both surgery and vision therapy as interventions for patients with strabismus. Angle of deviation provides some insight into cosmesis, and stereopsis provides some insight into binocular performance. Even though it would require an expanded behavioral success to capture the possible performance changes afforded by treatment of patients with strabismus (a subject we will return to later), a literature in which surgical intervention is evaluated differently than non-surgical intervention confounds decisions about patient care.

Having briefly considered the concept of success in the treatment of patients with strabismus, we turn now to their treatment using optometric vision therapy.

Optometric Vision Therapy (OVT)

The term optometric vision therapy (OVT) is useful in that it separates what we do from vision enhancing procedures offered by occupational therapists, orthoptists, physical therapists, chiropractors, educators, and psychologists. Optometrists may use instruments such as chiroscopes, stereoscopes correct-eye scopes, and/or major amblyoscopes to concentrate on central fusion. More importantly, optometrists typically work in free space, incorporating most of the 120-or-so

degrees of overlap of the binocular visual field. In their vision therapies, optometrists use lenses, prisms, optical instruments, sector occlusion, mirrors, polarization, colored filters, liquid crystal technology, virtual reality, and augmented reality, often combined with full-body movement and balance to integrate, eyes, brain, mind, body movement and vestibular input with the world.

OVT, like surgery, is an art which borrows from science. While most surgeons share much the same basic scientific background, it is the variations in their practiced surgical art that distinguishes them from each other. This reliance on experience is every bit as true in optometric vision therapy in which the visual process can scarcely be separated from the human being. For those skilled in OVT, convergence, for instance, has as much to do with emotion, caring, motivation, and volition as it has to do physiological eye movements. Just as no two surgeons perform their procedures exactly alike, no two optometrists perform their vision therapy exactly alike. In optometric vision therapy we have dozens of philosophies and hundreds of procedures to choose from. How we combine them to fit the patient in front of us is the art.

At its most basic level, OVT enhances the visual process allowing the viewer to convert light information into action. We reduce this process to individual skills at our own risk, for the visual process emerges to be greater than the sum of its parts. Nevertheless, therapists enhance visualization, allowing patients better to imagine targets further away and enhance divergence. Therapists enhance eye movements (fixations, saccades, pursuits, vergences and/or vestibular) to improve identification and localization. Therapists employ vigorous ocular calisthenics to reduce muscle contractions or post-surgical adhesions. Therapists guide control of the accommodative system to allow alignment without blurred vision. Therapists frequently aid patients to select an expanded volume of simultaneous three-dimensional spatial awareness, encouraging visual attention to expand on all three axes: x, y, and z.

Elsewhere I have described the size of this expanded spatial awareness as the "Circle of Attention"[62] or the "Zone of Simultaneous Awareness (ZOSA)"[63,64] and outlined its use in the treatment of strabismus (see also Appendix A). The importance of attention to the periphery cannot be overestimated when treating those with strabismus. Burian[65] has shown that peripheral fusion is stronger than foveal fusion. Parks[66] has stated, "Peripheral fusion alone seems to be just as effective as the combination of peripheral and central fusion in maintaining aligned eyes." Ludlam[67] has reported that sensory adaptations such as ARC may be confined to central vision, and Griffin and Borsting, interpreting observations and speculations by Flom,[68] have surmised, "The peripheral horopter in ARC cases was similar … [to normals] and, in that sense, these patients can said to have normal peripheral fusion… [and] the patient may be said to have no central fusion, and the visual information within the axes is processed monocularly."[69] Perhaps most applicable to clinical practice, Brock[70] has written, "aversion to fusion seems to be limited mainly to the macular and paramacular region. For this reason, fusion training should begin with the periphery and only gradually include the center."

Essentially, OVT is performed on a continuum between habitual, automatic, unconscious seeing and novel, volitional, conscious seeing. Using base-in, base-out, monocular, or yoked prisms, a lens or instrument, or novel instructions ("Hold your eyes on the bead!" or "Be aware of the distance between you and the target!"), a patient learns to adapt to a novel action. What makes the action visual is that it depends on past or present light information. In the case of patients with strabismus, the novelty of the action could be produced by combining movement, balance, or cognitive activities with volitionally aligned eyes until the alignment passes into habit and automaticity. We might also use peripheral stereo or peripheral awareness and luster to shift the patient into a peripheral mode of seeing to appreciate fusional targets that are normally ignored because of central adaptations such as suppression or anomalous binocular correspondence (ABC). The patient comes to recognize what gross ocular alignment

feels like and how to incorporate that feeling during interaction with the physical or social world.

In the case of OVT directed at aligning eyes there are two main approaches. One we could characterize as "the stick"; the other, "the carrot." The stick approach eliminates sensory adaptations such as suppression and/or anomalous binocular correspondence (ABC) leaving the patient with confusion and diplopia when the eyes are not aligned. The patient then endeavors to put the diplopic images together despite the need for convergence or divergence. This method has it merits for patients capable of true bifixation, randot stereopsis, and the ability to align their eyes intermittently at all distances and in all directions. If such a person's angle of deviation is small enough, the diplopia is hard to ignore and may even initiate fusion. But if the angle is larger, the pathological diplopia may be no more noticeable for the patient with strabismus than physiological diplopia is noticeable to the rest of us in our daily lives. We see what we value, of course, and if we teach patients to value diplopia, they may indeed see it. But driving a car or reading without symptoms is probably a better goal than being aware of diplopia.

There is a second concern with this diplopia to fusion approach. About his working with constant strabismics in the 1940s, Brock later noted:

> *We found that some individuals for whom we held high hopes, could be brought to the appreciation of diplopia and could be subjected to Risley prisms for the purpose of bringing the diplopic images to fusion. However, we discovered with quite a few that fusion was reported while the eyes, on cover test, still were several degrees out of exact alignment. These individuals were then put through the paces by straightjacketing their visual perceptions.*[71]

Thus, about 15 years before Flom and Jampolsky and 20 years before Parks, Brock had essentially described the "interesting movements on the cover test" that eventually fell under Parks' "monofixational phoria" or "monofixation syndrome." Being a clever clinician, Brock combined central targets with reference markers in the vertical NRC periphery to eliminate the central suppression and create the diplopia needed to allow range extension with Risley prisms:

> *To our great dismay these images then failed to exhibit any degree of fusion-attraction; they would not be drawn together by reflex action. To compound matters, some individuals reported seeing twin objects sliding through each other or climbing around each other as the prism power was increased.... This type of behavior had been reported by other observers and had been given the name of "Horror Fusionalis" which we accepted as evidence supporting Worth's assumptions regarding the need for early fusion. Whatever the cause, this served as an indication that the diplopia-to-fusion approach has its serious limitations.*[72]

At this point, Brock retraced his steps and found that many of these patients had peripheral stereopsis or the perception of "SILO" (the targets appearing to get smaller and move in closer or grow larger and move outward.) He found that the key to SILO was "binocular posture" (which apparently could include a flick on a cover test). Since central diplopia distracts from rather than enhancing the perception of SILO, Brock began working in the periphery encouraging binocular posture and SILO in the patient with constant esotropia rather than diplopia and ranges to measure his success. He wrote that the SILO effect "is quite as definite and valid an indication of binocular integration as are break and recovery findings. *This, therefore provides a way to induce binocular fixation without prior awareness of diplopia.*"[73] Brock further reasoned that "excessive phorias and "inadequate" ductions are not nearly as destructive to visual comfort and visual achievement as when they are associated with postural deficiencies."[74] In other words, train the patient (especially with constant esotropia) to effortlessly regain and maintain posture (including a monofixational phoria), and the ranges need not come. This approach of rewarding alignment with stereopsis could be called "the carrot" approach. Attention to alignment rather than dissociated

measurements is not inconsistent with Parks' attention to the unilateral rather than alternate cover test.

With this introduction to OVT, we turn to our 75 patients. We will begin with the 52 with esotropia and then turn to the 23 with intermittent exotropia. We will view these outcomes both together and separately so as not to obscure the stereo changes we found in esotropia, otherwise the excellent stereo often enjoyed by patients with intermittent exotropia might skew our results.

Esotropia Selection

Reviewing seven years of patient files from between 2015 and 2022, we found 72 patients with esotropia. Of these, 52 patients met the following criteria: age 5 or above; received 10 or more hours of in-office OVT; not an accommodative esotrope (although could have an accommodative component), measurements in my records were available for stereoacuity and unilateral distant cover testing before and after therapy. We divided these patients into two groups. Thirty-seven of these patients had under 15 pd of esotropia at distance and, already cosmetically aligned, would be less likely to be considered as candidates for surgery. Fifteen patients had 15 pd or greater of esotropia and would be more likely to be considered as surgical candidates. The larger angles give us more insight into the non-surgical cosmetic alignment of adults and school-age children with esotropia using vision therapy. The range of ages was from 5 to 55 years of age with a mean age of 11 years old and median age of 9 years old. The duration of therapy varied between 11 and 130.5 hours, the mean hours being 34 and the median hours being 27.

Esotropia Protocol

The following protocol[75] for patients with esotropia was typically used.

1. Use monocular ocular calisthenics to eliminate any muscle contractions or post-surgical adhesions. Stretch especially in the direction provoking nystagmus or discomfort until full and effortless ranges or motion have been achieved. The procedure is used daily throughout (and after) a therapy program to maintain a full range of motion in each eye.
2. Maximize the vergence range by stressing near-far jump vergences until both eyes converge and diverge at the same rate as fully as possible throughout the entire available range, which even at the conclusion of therapy may fall short of full alignment.
3. Use physiological diplopia inside the centration point to provide biofeedback for further vergence control.
4. Coach the patient to contract and expand the zone of simultaneous awareness (ZOSA) … until the patient can feel the difference between ambiocular and monofixation responses.
5. Increase the centration range and reduce the angle of deviation by expanding the ZOSA, improving the accuracy of egocentric stereopsis at increasing distances from the nose. Combine egocentric stereopsis with near-far jumps and cover/uncover/recover vergence eye movements. Increase stereoacuity through control of the ZOSA. The angle is reduced using motor awareness and peripheral stereo. In the case of monfixation syndrome, no effort is used to create diplopia at the angle of the flick.
6. Expand the ZOSA in free space to transfer therapy out of the therapy room.
7. Use awareness of increase in the size of the ZOSA to integrate … [the vestibular system, posture, and movement] with improved binocular function [SILO with dichoptic targets or egocentric, three-dimensional awareness of free space].

The above procedures are detailed in Applied Concepts in Vision Therapy 2.0.[76] If the patient had randot ranges on the VTS4 or if during therapy the patient's esotropia became intermittent and randot stereopsis was perceived, then, added to the above, vergence ranges, especially base-in, were expanded using computer-generated randot stereograms and vectogram ranges monitored by

Table 1: 37 Patients with Esotropia < 15 Prism Diopters

No.	Age	Hours of Therapy	Cover Test Before DV	Cover Test Before NV	Cover Test After DV	Cover Test After NV	Seconds Stereo Before	Percent Stereo Before	Seconds Stereo After	Percent Stereo After	Post Surg
1	15	12.5	3	6	2	6	Fly 3600	<1%	40	79.1%	Yes
2	7	54	7	3	0	0	160	37.1%	63	64%	No
3	10	59.5	10 IET	10 IET	0	0	50	72.5%	40	79.1%	No
4	10	24	6	20	2	0	Fly 3600	<1%	400A	17.5%	No
5	9	15	1	2	0	0	400 A 5 BI RD	17.5%	32 N 28 D	85%	No
6	9	36	2	3	0	3	100 A 400RD	47.5%	40	79.1%	No
7	6	16	1	2	1	2	Quoit	Nil	400A	17.5%	No
8	9	31	3	2	2	2	100A	47.5%	100A	47.5%	No
9	6	58.5	6	3	3	3	Fly 3600	<1%	60	67.5%	No
10	9	21	2	2	2	1	Fly 3600	<1%	100A	47.5%	No
11	7	43	8	25 (T)	0	0	40	79.1%	20	97.5%	No
12	14	15.5	5	5	5	5	100A	47.5%	100A	47.5%	No
13	7	32.5	2	12	0	0	400A	17.5%	100A	47.5%	No
14	5	130.5	10	1	0	0	100A	47.5%	40	79.1%	No
15	12	24	5	2	0	0	100A 11BI RD	47.5%	40RD	79.1%	No
16	6	49	4	0	0	-	Fly 3600	<1%	100A	47.5%	No
17	12	30.5	2	5	1	-	100A	47.5%	100A	47.5%	-
18	8	83	3	3	0	0	100A 6BI-BO	47.5%	20	97.5%	No
19	9	42	4	3	0	0	Fly 3600	<1%	400A	17.5%	Yes
20	38	26	0(7)	3	0	1	60N/293D	67%	20N/28D	97.5%	Yes
21	8	13.5	3	3	3	2	Fly 3600	<1%	100A	47.5%	No
22	6	26.5	8	4	12	3	Quoit	Nil	Fly	<1%	No
23	7	48	10	8	2	2	Quoit	Nil	400A	17.5%	No
24	8	10.5	5	3	0	-	Fly 3600	<1%	50	72.5%	No
25	9	43.5	2	16	1	2	Quoit	Nil	Fly/640 400@10"	9.3%	No
26	11	15.5	2	1	2	2	400A	17.5%	100A	47.5%	No
27	8	43	12	15	5	5	Fly 3600	<1%	400A	17.5%	No
28	6	13	3	2	3	-	Quoit	Nil	Fly	<1%	No
29	9	41	3	2	2	3	Fly 3600	<1%	200A	31.4%	Yes
30	17	34	1	2	1	3	100A	47.5%	100A	47.5%	No
31	12	33	5	12	5	5	Quoit	Nil	Fly/800 400A@ 8"	6.3%	No
32	7	67.5	1	0	0	2	Quoit	Nil	200A	31.4%	No
33	36	34	14	11	0	0	Fly 3600	<1%	200A	31.4%	No
34	17	23.5	12	13	9	7	Fly 3600	<1%	Fly	<1%	No
35	10	43	11	5	1	2	Fly 3600	<1%	50	72.5%	No
36	7	79.5	11	5	10	3	Quoit	Nil	400A	17.5%	No
37	29	21.5	14	28	0	0	200A 7BO-3BI RD	31.4%	50	72.5%	No

correct SILO rather than diplopia awareness. If the angle was larger and randot stereo was present, then base-out prism neutralization was sometimes added and the prism reduced as vergence ranges and peripheral stereo improved. In the case of an accommodative component to the esotropia, the ability to use peripheral awareness to align the eyes with and without glasses was developed until patients preferred fusion to clarity when without their glasses. This typically allowed cosmetic alignment when looking over the bifocal during social interaction, but the use of necessary plus was likely to remain for careful seeing such as reading.

Esotropia Results

Tables 1 and 3 display the data for treatment of the 52 patients with esotropia. Since the cover test was unilateral, it is clear which patients were phoric before compared to after therapy. Since stereo information is provided, it is also clear which patients had monfixational phorias before compared to after therapy. Since surgical studies frequently ignore the phoria/tropia distinction so have we, centering instead on stereoacuity and magnitude of deviation.

Table 1 includes the 37 patients who before therapy had under 15 prism diopters (pd) of distance deviation; Table 3 includes 15 patients who before therapy had 15 or more pd of esotropic deviation. Deviations were measured at distance using a simultaneous prism and unilateral cover test.

The changes between pre and post therapy are presented in

Table 2: Results Esotropia <15 pd

Results of 37 Patients with < 15 pd Esotropia	Before Therapy	After Therapy
Mean Deviation	5 pd	2 pd
Median Deviation	4 pd	1 pd
Mean Percent Stereo	19.8%	47.3%
Improved Stereopsis	31/37 (84%)	
Behavioral Success (Improved Stereo)	32/37 (86%)	

Table 3: Patients with Esotropia ≥15 Prism Diopters

No.	Age	Hours of Therapy	Cover Test Before DV	Cover Test Before NV	Cover Test After DV	Cover Test After NV	Seconds Stereo Before	Percent Stereo Before	Seconds Stereo After	Percent Stereo After	Post Surg
38	30	16.5	30	30	2	2	None	nil	400A	17.5%	Yes
39	7	15	30	30	2	2	100A 10 BI RD	47.5%	125DV	43%	No
40	12	34.5	25	10	0	3	400A	17.5%	200A	31.4%	Yes
41	19	11	15	15	5	5	Fly 3600	<1%	Fly	<1%	No
42	9	23.5	18	30	5	-	None	nil	Quoit	nil	Yes
43	9	21	24	3	5	5	Quoit	nil	100A	47.5%	No
44	10	27	25	30	0	0	Fly 3600	<1%	Fly	<1%	No
45	15	15.5	30	30	25	15	None	nil	Fly	<1%	No
46	37	24	22	33	0	0	Fly 3600	<1%	100A	47.5%	Yes
47	12	18	25	30	0	0	200A	31.4%	40RD	79.1%	Yes
48	6	15	16	22	0	2	100A	47.5%	25	91.5%	No
49	7	53	15	12	0	0	Quoit	nil	33 (25@12")	84.3%	No
50	55	17.5	35	40	3	3	Fly 3600	<1%	Fly/640 (400A@10")	9.3%	Yes
51	8	72.5	40	35	0 12BO	0 12BO	Quoit	nil	20N 28D	97.5%	No
52	13	18.5	45	30	0 5BO	0 5BO	Fly 3600	<1%	50N 28D	88.3%	No

Table 4: Results Esotropia ≥15 pd

Results of 15 Patients with 15-45 pd Esotropia	Before Therapy	After Therapy
Mean Deviation	26 pd	4 pd
Median Deviation	25 pd	1 pd
Mean Percent Stereo	9.9%	42.7%
Behavioral Success (≤ 8pd + ≤ Stereo Fly)	12/15 (80%)	

Table 5: Results Esotropia

Results of All 52 Patients with Esotropia 1pd to 45 pd	Before Therapy	After Therapy
Mean Deviation All 52 Patients	11 pd	3 pd
Median Deviation All 52 Patients	8 pd	1 pd
Mean Percent Stereo All 52 Patients	17.0%	46.0%
Reduced Angles of Deviation	45/52 (86%)	
Improved Stereopsis	44/52 (85%)	
Behavioral Success (≤ 8 pd or Stereo+)	44/52 (85%) + Stereo	
Less than 67 arc seconds of stereo	18/52 (35%)	
Barely perceptible movement (≤2pd) + Stereo	31/52 (60%)	

Table 5. The initial size of the deviations varied between 1 PD and 45 PD with a mean of 11 PD and a median of 8 PD. After therapy, the mean angle was 3 PD. The medium was 1 PD. The mean percent stereo[77] before treatment was 17.0 percent. The mean percent stereo after treatment was 46.0%. Of the 37 patients with deviations under 15 PD (Table 2), the median deviation before therapy was 4 prism diopters and 1 prism diopter after therapy. Of the patients with deviations of 15 pd to 45pd (Table 4) the median deviation was 25 PD before therapy and 1 PD after therapy. Of the 52 patients, 45 (86%) had reduced angles and 44 (85%) had improved stereopsis. Forty-four (85%) were behavioral successes achieving both improved stereopsis and angles ≤ 8 pd.

Another way of presenting the data is considering the 33 patients who had not achieved monofixation syndrome before therapy and the 19 patients who began therapy having already achieved monofixation syndrome. Table 4 shares the data of the 33 patient who before therapy either had greater than 8 prism diopters of deviation of did not perceive the stereo fly.

Table 6 includes the findings of these 33 patients who initially could not be diagnosed as having monofixation syndrome. Table 7 evaluates their results. Their angles of deviation varied between 1 pd and 45 pd with a mean of 18 pd and a median or 16 pd. After therapy the mean angle of deviation had improved to 4 pd and the median to 2 pd. Before therapy 8 patients (24%) had angles ≤ to 8 pd. After therapy the number rose to 29 patients (88%). Before therapy 15 patients failed the monofixation criteria because they lacked the peripheral stereo to perceive the Titmus Stereo Fly. After therapy, only 1 patient could still not perceive the fly. Twenty-seven or 82% of the 33 patients ended up with monofixation syndrome or better. In the group the average percent stereopsis rose from 11% to 54 %. Nine of the 33 patients (27 %) ended up with better than 67 seconds of stereo. Six of the 33 patients

Table 6: 33 Patients Beginning Without Monofixation Syndrome (>8 PD Esotropia or No Fly)

No.	Cover Test Before	Cover Test After	Stereo Before	Stereo After	No.	Cover Test Before	Cover Test After	Stereo Before	Stereo After	No.	Cover Test Before	Cover Test After	Stereo Before	Stereo After
3	10	0	160	63	33	14	0	Fly	200	46	22	0	F	100
4	20	2	Fly	400	34	12	9	Fly	Fly	47	25	0	200	40
7	1	1	Quoit	400A	35	11	1	Fly	200	48	16	2	100	25
11	25	0	40	20	36	11	10	Quoit	400	49	15	0	Quoit	33
13	12	0	400	100	37	14	0	200	50	50	35	3	Quoit	640
14	10	0	100	40	38	30	2	None	400	51	40	12	Quoit	20
22	8	12	Quoit	Fly	39	30	2	100	125	52	45	5	Fly	50
23	19	2	Quoit	400	40	25	3	400	200					
25	16	2	Quoit	640	41	15	5	F	F					
27	12	5	Fly	400	42	18	5	None	Quoit					
28	2	3	Quoit	Fly	43	24	5	Quoit	100					
31	12	5	Quoit	800	44	25	0	Fly	Fly					
32	1	0	Quoit	200	45	30	25	None	Fly					

Table 7: Results of 33 Patients Beginning Without Monofixation Syndrome: No fly or Angle > 8pd.

Patients Beginning Therapy Without Monofixation	Before Therapy	After Therapy
Mean angle	18	4
Median angle	16	2
Angle ≤ 8 pd	8 (24%)	29(88%)
Stereo fly	18 (55%)	32 (97%)
Nil stereopsis (no stereo fly)	15	1
Monofixation syndrome or possibly better	0	27 (82%)
Group's average percent stereo	11%	54%
Better than 67 seconds of arc	0 (0%)	9 (27%)
Normal stereopsis (40 seconds of arc)	0 (0 %)	6 (18%)
Behavioral success: ≤ 8 pd + increased stereo	—	28 (85%)

Table 8: Findings of 19 Patients Beginning with Monofixation Syndrome (≤ 8 PD ET and Peripheral Stereo—Fly or Better

No	Cover Test Before	Cover Test After	Stereo Before	% Stereo Before	Stereo After	% Stereo After	No	Cover Test Before	Cover Test After	Stereo Before	% Stereo Before	Stereo After	% Stereo After
1	3	2	Fly	<1%	40	79.1%	17	2	1	100	47.5%	100	47.5%
2	7	0	160	37.1%	63	64%	18	3	0	100	47.5%	20	97.5%
5	1	0	400	17.5%	32	85%	19	4	0	Fly	<1%	400	17.5%
6	2	0	100	47.5%	40	79.1%	20	7	0	60	67%	20	97.5%
8	3	2	100	47.5%	100	47.5%	21	3	3	Fly	<1%	100	47.5%
9	6	3	Fly	<1%	60	67.5%	24	5	0	Fly	<1%	50	72.5%
10	2	2	Fly	<1%	100	47.5%	26	2	2	400	17.5%	100	47.5%
12	5	5	100	47.5%	100	47.5%	29	3	3	Fly	<1%	200	31.4%
15	5	0	100	47.5%	40	79.1%	30	1	1	100	47.5%	100	47.5%
16	4	0	Fly	<1%	100	47.5%							

Table 9: Results of 19 Patients Beginning with Monofixation Syndrome (Deviation ≤ 8 pd with PerpheralStereo—Fly or Better

Patients Beginning Therapy With Monofixation Syndrome	Before Therapy	After Therapy
Median angle	3	1
Mean angle	4	1
Mean percent stereo	25%	60%
Stereo ≤ 100 Sec of Arc		
Stereo ≤ 67 Sec of Arc	1/19 (5%)	9/19 (47%)
Stereo ≤ 40 Sec of Arc	(0%)	6 (32%
Wick and Cook Cure	7/19 (37 %)	17/19 (89%)
Behavioral Success (Stereo +)	15/19 (79%)	

(18%) achieved 40 seconds of stereo to fall in the normal range. Of the 33 patients, 28 (85%) obtained angles under 8 pd (actually ≤ 5 pd) and also demonstrated improved stereopsis, qualifying as "behavioral successes." Six failed because of angle, one of these having 20 seconds of stereo when supported by 12 diopters of base-out prism, which the family deemed cosmetically acceptable.

Table 8 presents the findings belonging to 19 patients who could be classified with monofixation syndrome before therapy due to having peripheral stereopsis (fly) and deviations ≤ 8pd. An evaluation of these findings is provided in Table 9. Before therapy, the mean angle was 4 pd, the median angle, 3 pd. After therapy both the mean and median angles were 1 pd. Before therapy the average percent stereo was 25%. After therapy the average percent stereo was 60%. Six of the 19 patients (32%) ended with normal stereopsis (40 seconds or better). Fifteen of the 19 patients (79%) demonstrated behavioral cures having both ≤ 8 pd of deviation and improved stereopsis. Four patients had 100 seconds of arc stereo both before and after VT. Thus, if we were to adopt the 1987 Wick/Cook "functionally adequate cosmetic success," criteria, the success rate rose from 7/19 (37%) to 17/19 (89%).

Does OVT Have a Place in the Treatment of Patients with Esotropia?

Our results suggest that in light of the major changes in moving from the field-constricted instruments of orthoptic training to an out-of-instrument approach including most of the overlap of the visual fields—not to mention integration of aligned eyes with movement and cognitive loading—OVT should be considered in the treatment of adult and school-age esotropia.

Is there a window of age for developing a monofixational phoria as defined by peripheral stereo and an angle under 9 prism diopters on the unilateral cover test? The work of Taylor, tabulated by Fisher, et

al,[78] certainly supported the conclusion that "when surgery is performed after 24 or after 36 months of age, conversion of a tropia to a phoria [including monofixational phoria] is less likely to occur than when surgery is performed before these ages."[79] In our sample of 33 patients, ages 5 to 55, with esotropia and without monofixation syndrome or better before OVT, 27 (82%) demonstrated monofixation or better after OVT. For our sample, the age of 2 or 3 was not a cut off for developing a monofixational phoria.[80]

As seen above, Parks—beyond glasses and patching—did not advocate working with patients with monofixation syndrome. In our sample of 19 patients who demonstrated 8 pd or less of deviation combined with peripheral fusion, both the mean and median angles of deviation reduced by 2 pd. Fifteen patients (79 %) demonstrated improved stereopsis, the group's mean percent stereopsis improving form 25 to 60 percent. Nine patients (almost half) got better than 67 seconds of arc. Six patients (about a third) achieved at least 40 seconds of stereo. Although these patients were not necessarily the infantile esotropes that Parks dedicated much of his life to studying and teaching about, our findings caution us against generalizing Parks' suggestions beyond the surgical treatment of patients with strabismus.

As we discussed, Jampolsky similarly maintained that it was generally not useful to work with patients left with under 15 prism diopters of turn. In our sample of 37 patients with esotropic turns under 15 prism diopters (Table 2), 31 (84%) showed improvement in stereopsis, the mean percentage of stereo rising from 19.8 % to 47.3 % after OVT. If improved stereopsis is a worthwhile goal, then our results do not support Jampolsky's contentions. Ultimately, patients should be educated as to their options and then left to make their decisions weighing time commitment and cost against possible benefits such as those explored in our quality-of-life section below.

Exotropia Selection

We selected patients with exotropia based on the following criteria:

- Age 5 or above
- Received at least 16 hours of in-office OVT
- Pre and post stereo testing available
- Intermittent, at least enough to perceive the stereo fly.
- Not post-surgical, ruling out consecutive exotropia.

In our records from 2015 through 2022, we found 24 of 68 patients with exotropia who met these criteria. Their median age was 9 years old. They were seen between 16.5 and 59.5 weekly hours of in-office vision therapy with a median of 32 hours accompanied by about an hour of weekly home therapy. Their angles of deviation on a distance, alternate cover test varied from 15 to 50 pd with a median deviation of 25 pd.

Exotropia Protocol

While it is easier to improve stereopsis in patients with exotopia compared to patient with esotropia, achieving cosmetic alignment in patients with exotropia is, in my opinion, much harder. Sure, it is easier to change their exam findings, but transferring those findings to the out-of-office environment can be challenging. When patients with esotropia relax, their eyes relax outward. When patients with exotropia relax, their eyes also relax outward. Once peripheral fusion is maintained during thought and action, those with esotropia require little effort to maintain alignment. In exotropia, however, there typically comes a time after the development of both vergence control and peripheral fusion during action are mastered, when the person with exotropia needs to make a decision to maintain aligned eye or continue being coached by their optometrist for the rest of their lives. Otherwise, no matter how wonderful their visual skills in the exam room, they may misalign as soon as they leave the room.

Aligning the eyes is like learning to speak a foreign language. No matter how good the language skills, the mother tongue is still enjoyed—even if it means gradually reversing the alignment of a strabismus surgery. For this reason, while I may work with younger patients to improve their

visual processing, I do not ordinarily accept children with exotropia for the goal of alignment until they demonstrate during testing the necessary development and cooperation. Frequently, this development and cooperation does not arrive until a child is 8 or 9 years old. Depending on the precocity of the child, however, there are exceptions. Indeed, in our sample 7 of 23 patients were under eight when they began therapy.

Because of the difficulty of alignment, our protocol for patients with intermittent exotropia is more rigorous. In addition to requiring 1) central-peripheral integration (an expanded ZOSA integrated with central acuity) I also require 2) complete voluntary control of the vergence system without using accommodation.

By voluntary control of the vergence system, I'm referring to the ability to control convergence and divergence without the need to use accommodation or a fixation target, even while thinking and moving. Imagine, if you will, being able to effortlessly control the Brock string, but with no need for the string. Voluntary control of vergence can be demonstrated in many ways: 1) great BI and BO ranges using simultaneous perception targets rather than relying on flat fusion or stereoscopic fusion targets to align the eyes. 2) effortless chiastopic fusion at distance and near without blurred vision or the need for a fixation target to aid convergence. 3) aligned eyes when dissociated, meaning orthophoria on an alternate cover test at distance and near. 4) aligned eyes when under heavy cognitive and movement demands.

Our second goal is central/peripheral integration. For this we want an expanded ZOSA so the patient can see what and where at the same time. It is easier to point your eyes at something when you know where that something and the rest of the room is compared to yourself (egocentric localization). For instance, if you have a tender NPC and you look at your thumb five inches in front of your nose, you will experience discomfort. If, instead, you are successful at concentrating on simultaneously perceiving the distance between your nose and thumb you are likely to be more comfortable. You can align your eyes using voluntary vergences, or you can align your eyes by expanding your ZOSA and simultaneously seeing where something is compared to yourself and the rest of the room. The latter approach, being more comfortable, is more likely to be successful.

Therapy is continued until the patient would rather maintain aligned eyes than continue therapy.

We don't conclude therapy until the eyes are aligned. The way out is the way through.

Procedures used to expand both voluntary convergence and the ZOSA are found in Appendix A.

Exotropia Results

The results from the work with the 23 patients with exotropia are recorded in Table 10. My interpretation of the results appears in Table 11. The mean and median distant deviation measured with the alternate cover test were both 25 prism diopters before therapy. After therapy the deviations reduced

Table 10: Patients with Intermittent Exotropia ≥ 15 Prism Diopters

No.	Age	Hours of Therapy	Cover Test Before DV	Cover Test Before NV	Cover Test After DV	Cover Test After NV	Seconds Stereo Before	% Stereo Before	Seconds Stereo After	% Stereo After	DV Jumps	Chiastopic Fusion
1	5	54.5	20	15	0	0	125D	43%	28D	88.3%	4/30	Yes
2	6	59.5	25	9	0	0	100N	47.5%	20N/28D	97.5%	4/24	Yes
3	6	16.5	16	14	0	0	200N	31.4%	25	91.5%	4/14	Yes
4	30	47.5	25	8	6	0	40N	79.1%	50	72.5	6/30	Yes
5	14	30.5	25	30	0	0	20N	97.5%	28D	88.3%	4/30	Yes
6	32	48	50	30	31	18	400N	17.5%	32N/42D	85%	No	No
7	8	30.5	20	10	0	0	100N	47.5%	63N	64%	4/30	Yes
8	9	34.5	15	9	6	2e	40N	79.1%	40N	79.1%	4/30	Yes
9	9	29.5	16	2	20X	30X	100	47.5	25N/28D	91.5	4/30	Yes
10	26	17	35	30	0	0	40	79.1	25N/14D	103.3%	4/30	Yes
11	14	40	30	35	0	0	63N	64%	25N	91.5	4/24	Yes
12	15	29.5	16	25	0	0	25N	91.5%	10N	110%	4/30	Yes
13	5	19	22 6RH	16 6RH	2	8	100N	47.5%	32N	85%	4/15	No
14	9	32	20	30	0	0	100N	47.5%	20N/97D	97.5%	4/30	?
15	7	33.5	16	12	6	0	20N	97.5%	42D	77.5%	4/30	Yes
16	9	44.5	35	2	0	2ESO	40N	79.1%	20N/42D	97.5%	4/30	Yes
17	12	32	30	8	0	0	125N	43%	28D	88.3%	4/24	Yes
18	6	39	25	15	0	0	20N	97.5%	20N	97.5%	4/24	Yes
19	10	59.5	25	4	15	2ESO	40N	79.1%	25N/42D	91.5%	4/30	Yes
20	11	20	20	25	0	0	100N	47.5%	40N	79.1%	8/16	Yes
21	8	40.5	20 10RH	15	0	0	40N	79.1%	14D	103.3%	4/30	Yes
22	7	28	30 5RH	10	0	0	100N	47.5%	20N/56D	97.5%	4/18	No
23	26	42	25	15	0	0	Fly	1%	200A	31.5%	4/30	Yes N & D

Table 11: Results Exotropia

23 Patients with Intermittent Exotropia		
Mean deviation alternate cover test	25 pd	4pd
Median deviation alternate cover test	25 pd	0pd
Percent Stereopsis	60.5%	83.4%
Better than 67 seconds of stereo		22/23 (96%)
Behavioral Success < 6 pd exophoria on DV cover		22/23 (96%)
≥ Sheard's criterion on distance jump ductions		22/23 (96%)
≤ 6 pd exophoria + better than 67 seconds of stereo		20/23 (87%)
Stereo 40 seconds or better		19/23 (83%)
Voluntary convergence—chiastopic fusion		19/23 (83%)
Jump ductions: 4BI/24BO		18/23 (78%)
Orthophoric after OVT		16/23 (70%)
Exophoria ≤2 pd + stereo 40 seconds or better		15/23 (65%)

to a mean of 4 pd of exophoria and median of 0 pd. Of the 23 patients, 16 (70%) were orthophoric on distance cover testing. Of the 23, (96%) had 6 pd or less of distance exophoria and thus certainly met surgical standards for success. Although having 15 and 20 pd of exophoria and, therefore, not qualifying for success by surgical standards—2 had 25 seconds of stereopsis, could perform 4BI/30BO pd jump ductions in the distance, could perform chiastopic fusion, and had aligned eyes when not tired, upset, or sick. Of the 23 patients with exotropia, 19 (83%) had chiastopic fusion, 18 (78%) could at distance perform 4BI/24 or greater BO random-dot jump ductions on the VTS4, and 17 (71%) could perform both the jump ductions and chiastopic fusion. One patient could perform chiastopic fusion at twenty feet while moving, balancing, and maintaining both stereo and SILO awareness—a goal I have since incorporated into the treatment of all such patients.

In addition to the high percentage of patients with cosmetically aligned eyes, these patients with intermittent exotropia also showed great gains in stereopsis. Before treatment, the average percentage of stereo was 60.5 percent. After therapy the average percentage of stereo rose to 83.4 percent. Of the 23 patients, 19 (83%) demonstrated 40 seconds of stereopsis or better; 22 (96%) ended with better than 67 seconds of stereopsis; 20 (87%) had both less than 8 pd of exophoria and better than 67 arc seconds of stereopsis.

Finally, 15/23 (65%) of these hopeful patients had 40 arc seconds or better of stereopsis and 2 or less pd of exophoria. They were binocularly successful enough to fly a jet for the military or even become strabismus surgeons. I'll leave it up to the reader to ponder the merits of this type of success.

Is OVT a suitable option for treating patients with intermittent exotropia?

Just as patients without strabismus can be helped to improve their visual performance, so, it appears, can patients with intermittent exotropia. In our sample, for example, the mean percent stereopsis rose by over 25%. The reason for working with those with intermittent exotropia, however, is most often cosmesis. Indeed, 10/23 (43%) of our sample began with a normal 40 seconds of stereopsis. In truth, many patients with intermittent exotropia align their eyes for stereo tasks and deviate their eyes when panoramic viewing is desired.[81] Thus, they can misbehave and keep an eye on mom all at the same time. Like the chameleon with stereo vision for fly catching and panoramic vison for spotting predators, their visual systems could even be considered to be superior for certain tasks. The famous actress, dancer, and WWII GI love goddess Rita Hayward had exotropia, as did the athletes Wilt Chamberland, Jackie Robinson, and, more recently, Tom Brady. Often, to accommodate parents' concerns about cosmesis, children, temporarily at least sacrifice function. At the same time, eleven of our exotropic sample began with 100 seconds of less of stereo. Four had higher deviations at near than at far and some, as I recall, had accommodative, vergence, and oculomotor problems superimposed on their strabismus. Nevertheless, the success of therapy will most probably be judged by the presence or absence of a deviating eye. Thus, our real question becomes, "Can OVT be used to align the eyes of patients with exotropia, and the answer, according to our sample, is a resounding yes, but a great deal of dedication may be necessary. One of the

reasons for our success, is that most of our patients with intermittent exotropia see us to avoid surgery. Thus, as a group they are different to begin with than those who would prefer the reported ease, cost, and convenience of a surgery or surgeries to solve a cosmetic concern.

Patients with intermittent exotropia typically present with a favorable sensory status for treatment. In the current study, 88 percent of the patients surpassed typical surgical requirement ≤ 10 pd. Not only were the angles of deviation within range, they were all phoric and there were no overcorrections. Most would have met Flom's original criteria except for the up to 10 minutes a day of double vision. Even those 3 patients with exophorias over 8 diopters were generally phoric, having the skills to maintain aligned eyes. The exception was the patient who began with the 50-diopter eye turn, did not complete therapy, was lost to follow up for a year, and was already regressing upon returning for a progress exam. In most cases once voluntary convergence is obtained, it takes about a minute a day of maintenance therapy to maintain gains. Occasionally, a 12 hour touch up may be necessary, especially if the maintenance therapy is neglected. Occasionally, surgery may be a part of the treatment to help ensure than when a patient takes a break from alignment an eye no longer drifts far enough outward to be seen.

The major problem with treatment revolves around development, motivation and attention. If the deviation is the parent's problem and not the child's, and the child is not particularly interested in pleasing adults, alignment may be difficult. Younger children with developmental delays or poor attention may be worked with to improve visual skills for performance in school, play, or sports, but they will often not be good candidates for aligned eyes until they are old enough to actively participate. If the parents' immediate concern is the 3-year-old child's cosmesis for dating, the parents may prefer a surgical option for their child. Precocious 4-and-5-year-olds may have the cooperation necessary for improved alignment, with the caution that we may have to return later to complete their therapy. By age 9 most patients have the development and attention to be worked with successfully. When in their teens, even more children have the motivation.

DISCUSSION

First, this is not a multi-center study. We paid our rent and, therefore, did not have to move before we finished. The question remains, however, would this study have been better if we had not paid our rent? The following discussion considers some of the limitations as well as strengths of our retrospective approach.

Using the grading system of the Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence,[82] systematic reviews or randomized clinical trials provide "Level 1" evidence for deciding treatment options. The current study's value as evidence for deciding treatment options rests on the low end of Level 4. This places the study's evidence value just above your neighbor's expert, observation-formed opinion on the most recent presidential election.

While prospective studies do their best to adapt treatment to science, retrospective studies do their best to adapt science to treatment. Neither approach is perfect. One strength of the present study is that it was based on what I actually do in private practice rather than what researchers imagine I do. Another strength of this study is while the goal of dividing evidence into distinct levels is to eliminate bias, the cost of gold-standard studies nevertheless bias acceptable evidence toward the viewpoint of groups with the resources to fund such model research. The primary cost of this study was the hundreds of hours of my time taken from self-improvement—such as watching reality TV.

On the downside, while the goal of a prospective study would have been to test a stated protocol by treating all subjects the same. I tailored every therapy program to the individual patient, treating every participant a bit differently based on the bias of my training, study, and experience rather than any strict protocol. Nor were the therapists treating the patients merely trained in a protocol. They averaged 16 years of vision therapy experience. Similarly, a prospective study would have prescribed the same length of therapy for each patient. I set no arbitrary

length of therapy but charged a global fee and continued until all were satisfied. Furthermore, the home therapy selected for families with a high level of organization and responsibility, and the fees—not being covered by insurance—discouraged participation from families who were not committed or confident about the treatment. Doctor and patients alike believed we were part of an effort to share the best possible treatment available, not to discover if the provided care was of worth. Our mindsets were entirely different than those of participants in properly designed prospective study. Thus, while our results may well have been a better indicator of what goes on in successful vision therapy private practice, the study would not be expected to predict what kind of results less experienced practitioners would obtain.

Controls

Sadly, our study was not controlled—meaning we know that patients got better, but we can't say with certainty why. What role did time and nature play? The same is true about our lack of placebo control. In truth, when patients are upset, their angles of deviation tend to increase. Indeed, back when doctors were treating patients rather than just eye muscles, Pugh[83] classified 20 percent of strabismus as having a "psychological etiology." In our study, the over 80 percent of patients who succeeded may have succeeded for the wrong reason—not that it mattered to the patients. Again, we knew what happened, but not why.

Unfortunately, as I have argued elsewhere,[84] creating a visually inert but convincing placebo vision therapy that is less expensive and time consuming than real vision therapy may not be feasible, just as doing placebo surgeries for the study of strabismus may not be ethical. Still, surgeries with their attendant near-death and born-again experiences can be emotionally-charged events. Moerman,[85] for instance, has studied how surgery can provide a powerful placebo effect (68%) in heart surgery (Remember, run-of-the-mill placebos run about 35 percent). Because strabismus surgery can have serious, even sight-threatening complications,[86] however, placebo-controlled studies for such surgeries are even more essential than for vision therapy. Lacking placebo-controlled studies of either therapy or surgical treatment for patients with strabismus, we can only speculate on how much of each treatment is mental and how much is physical (again, not that it matters to the patients themselves). In other words, when it comes to separating the physical from emotional aspects of treatment[87] doctors treating strabismus all live in glass houses and should be careful about throwing stones.

Cover Test

Experts[88] tend to agree that 2 pd is the smallest movement that can be detected with a cover test. Perhaps perceptions vary. Perhaps not. To see for yourself observe while a subject at one meter fixates between two targets first one and then two centimeters apart. Can you see the one-centimeter movement? In taking my measurements (usually on patients with mild strabismic amblyopia) I assumed that the smallest movement that I could ever-so-faintly detect on a unilateral cover test was 1 pd. My records are based on this assumption. Whether or not I was correct is a difference that may or may not make a difference. Even if observations of cover-test eye movements are accurate only to +/- 2 pd, little changes. Those reaching our basic behavioral criteria for success remain much the same. Most patients classified as behavioral successes had 5 or less prism diopters of movement on a cover test, which was definitely lower than our 8 pd success criteria for monofixation syndrome. If my cover test, in the heat of battle with recalcitrant children, was accurate, 24 of 52 (46%), 2 with the help of prism, showed no movement on a unilateral cover test, 23 of which had 100 or better seconds of arc stereopsis. If I was hallucinating on the 1 pd turns, then 29 of the 52 (56%) were aligned on a unilateral cover test (phoric), with 26 having 100 or better seconds of arc. Either way, about half of the 52 were aligned and had decent stereopsis after OVT. Because, however, the faint cover-test movements were hard to see, I may have missed them sometimes, making it hard to differentiate between constant and intermittent turns. When I

repeated a cover test several times, I frequently could not consistently see the movement.

One might also reasonably ask why I concentrated on the unilateral cover test with the patients with esotropia and the alternate cover test on patients with exotropia. Quite simply, in the case of esotropia, the unilateral test relates best to cosmesis and is useful for diagnosing monofixational phorias. After therapy, almost all of those with intermittent exotropia fuse well enough to align their eyes for a unilateral cover, but their ability to maintain aligned eyes without fusion is a better measure of a patient's vergence control needed to navigate the real world. Movement on the alternate cover tests suggests that such control is still capable of improvement.

Stereopsis

While studying patients with esotropia, I used local stereopsis, such as the Titmus fly, animals and Wirt circles. These measures could be criticized because of their monocular cues. According to Leske and Holmes,[89] "False-positive results occurred with Titmus Fly (6%), Titmus Animals (10%), Titmus Circles (35%)." and many could do the first 4 circles of the Wirt test monocularly. For this reason, unless a patient could see all three animals (100 sec) I did not use the Wirt test. In my experience, truly constant esotropes typically do not perceive the shapes in the random dot test.[90] Those with a very small angle on a unilateral cover test may occasionally see a bulge where the shapes may be. They are initially more likely to perceive the random dot bulges on the VTS4 with the targets at maximum size if they perceive any random dot stereo at all. For this reason, the Titmus fly, animals, Wirt and other Wirt-circles-like local stereo tests (for esotropia at least) are more likely to reflect the progress being made as patients learn to deal with ever-more central stereo targets in the therapy room. Although randot tests are relatively free of monocular clues, these tests may miss ongoing improvements in stereopsis in monofixators. Indeed, Park's monofixation syndrome was defined by local, not global stereopsis. Had Parks had only global stereo testing at his disposal, it's possible he would not have found the common peripheral stereo component of his constant esotropic monofixation-syndrome patients.

The real question should be, can dichoptic illusions offer us the final word on judging depth in the real world? Leske and Holmes[91] found no false-positive results with the Frisby test, suggesting that real stereopsis rather than dichoptic illusions may be a better way to go on stereo testing. Although the Frisby has been criticized because movement provides the monocular cue of motion parallax,[92] the Frisby and Howard Dolman tests may still be preferrable because it's the patient's depth perception, not just stereopsis, that is more likely to be most related to quality of life. Arguments that real life depth perception is not as dependable as dichoptic illusions place the cart before the horse. Illusions are at best correlated with real depth perception. Real depth perception is real depth perception and should be the gold standard, not dichoptic illusions. Thus, our findings could be criticized because we did not use the Frisby and Howard Doman real stereo tests.

In studying exotropia, I initially didn't test distance stereopsis on exotropic patients whose eyes were stubbornly misaligned in the distance. For that matter, I didn't have the instrumentation for distance stereopsis testing in the earlier periods from which we collected the data from the patients. Since I found the distance testing more demanding on patients, almost always demonstrating a higher number of seconds of arc, I later preferred distance testing over near testing when possible. Thus, in comparing before and after stereopsis testing, we are often comparing the less-difficult initial near testing to the more difficult final distance testing. For this reason, a number of stereo findings that would probably have improved did not.

Amblyopia

Although many of these patients had mild amblyopia, I limited the study to strabismus. My interest was in exploring the possible role of OVT as an alternative or adjunct to surgery in the treatment of patients with strabismus. Just as in most surgical

studies, our primary outcome was alignment and stereoscopic performance, not comparing acuity gains between OVT and patching, not exploring performance reduced as an artifact when an eye is occluded. It could well be argued that seeing the relationship between mild amblyopia and our binocular outcomes would be interesting. I agree, but considering that we obtained an 80 percent basic behavioral success rate, the mild amblyopia was apparently not a game changer.

Why no Flom Cures?

As mentioned earlier, I believe that Flom's Cure can be a distraction from helping patients, especially those with constant esotropia. Rather than concentrate on cosmetic alignment, best possible stereopsis, the increased spatial awareness of an expanded ZOSA in and out of the office, and obtaining patients goals by working whatever other areas that are necessary (tachistoscope/speed of perception, visualization, eye-hand coordination, eye-body coordination, eye movements, tracking, etc.) to help achieve goals in reading, writing, sports, and driving or hobbies, the clinician expends valuable time worrying about things that will generally work themselves out before the conclusion of therapy.

Other than those rare instances, when 40 seconds of stereo is needed for a career, it is not necessary (or even possible) to predict the exact level of stereopsis that will be obtained. Flom concerned himself with ARC. Those indoctrinated in Flom's approach to prognosis are probably more likely not to share the benefits of OVT with patients with esotropia accompanied by ARC. The reduced prognosis for achieving exact bifixation combined with a fear of persistent diplopia too often precludes treatment.

In working with patients with intermittent exotropia, Flom's cure is adequate, because motor skills are easy enough to train, stereopsis is generally obtainable, and ARC, even according to Flom,[93] does not affect prognosis. Success, as defined by Flom pretty much boils down to aligned eyes at all distances and in all directions pretty much all the time. In the case of helping patients with exotropia, at least, our goals for voluntary vergence, central-peripheral integration, and alignment with movement and thinking are actually a step ahead of Flom's goals for success.

Anomalous Binocular Correspondence (ABC)

ARC, now preferably called ABC (probably because it's easier to spell) exists when the two foveal images are not seen in the same direction.[94] There are two main theories to explain the phenomenon.[95] West Coast optometrists, following the teaching of Bielschowki,[96] Burian,[97] and Flom tend to imagine a rewiring of the visual cortex in which the fovea of one eye is now cortically united with a non-foveal point in the other eye. East Coast optometrists, tend to follow the double-monocular model of Verhoef,[98] Duane,[99] and Brock[100] in which cortical correspondence is suspended and perception is built on language, logic, and registration of eye movements compared to the head, body, action, and environment.

Back when therapy was commonly performed in instrument, ABC was more of a problem because patients were treated while their eyes were misaligned and frequently ignored dichoptic illusions. They could easily see that one tube of the major amblyoscope was in a different direction than the other tube. They could easily see when the tubes were aligned. Thus, logic could be used to combine images sequentially rather than simultaneously. Today's larger targets, added to blurring and shaking of the images, tends to work around ABC, simultaneously reducing the angle of deviation and the angle of anomaly while at the same time allowing more and more central stereopsis. Considering the time involved, perception of the random dot E or the fully magnified random dot targets of the Vision Therapy Systems IV (VTS4), I would imagine, are far better predictors of the path of therapy than are tests of retinal correspondence.

Diplopia

Other than surgeons trying to scare patients from receiving vision therapy, the most common reason for not using OVT to help patients with ABC is the naïve clinician's fear of creating

persistent diplopia, a fear that could be real if the therapist trained patients to value diplopia, used central targets (including the Brock String to create diplopia behind the fixated bead) to break down central suppression, worked when the eyes were misaligned, and then hoped—as Brock once did—that the images would somehow miraculously find their way together.

Crone[101] studied 60 cases of persistent diplopia. Forty-one of the cases involved ARC. Forty-two involved strabismus surgery. Of this iatrogenic diplopia associated with surgery, 28 cases were caused by over-correction. Amblyopia training accounted for 8 diplopia cases. Incomitance was involved in 7 cases. Instrument orthoptic training was involved in 6 cases. These numbers suggest that patients with strabismus are seven times more likely to experience diplopia from surgery than from even central, instrument orthoptics.

Of the 52 patients with esotropia that we treated with OVT, none complained of double vision. Nor would we expect them too. Patients see what they value. We didn't teach patients to value diplopia. Also, when working with adults, we frequently all but ignored amblyopia and concentrated instead on alignment. While using central targets (such as employed in a major amblyoscope training) may require a certain level of acuity, the peripheral, one-hundred-or-more degree targets used in our OVT do not. Peripheral stereopsis can be worked from the first day. We eschew central diplopia training. Rather than use diplopia to punish misalignment we use peripheral stereopsis and verbal feedback to reward alignment. We concentrate on expanding the ZOSA until peripheral fusion can align the eyes sufficiently for more central detail to be tolerated and perceived without avoidance of bifixation.

Alignment Outside the Therapy Room

In the case of patients with exotropia, without using sensors to monitor eye movements outside the therapy room, it is difficult to say what percentage of the time a patient's eyes are actually aligned. This would apply equally to patients who had received surgery or vision therapy. If careful monitoring revealed that an exotrope allowed otherwise non-detectable deviations when not actively using their eyes, this might help to predict the need for repeated surgeries or repeated vision therapy touch ups. Without such objective monitoring, a scored case history form might be useful for home observation: 1) Never deviated, 2) Rarely deviated, 3) Occasionally deviated, 4) Often deviated, and 5) Always deviated.

Long Term Alignment

The current cases provide us with no information about long term success. Just as surgical cases who were cosmetically aligned after surgery may fail and require additional operations, so may patients who used vision therapy to learn how to control and use their eyes may need a touch up from time, to time—especially if not spending as much time on their post-therapy maintenance routines as they do on brushing their teeth. Parks has noted that monofixation syndrome seems to be stable over time, so there is no reason to suppose that those with esotropia who achieve a general behavioral success will not maintain their cosmetic grains and peripheral fusion. Similarly, Ludlam,[102] in his long-term follow up demonstrated that patients with good sensory outcomes tended to improve when examined 3 years later. Poor sensory outcomes tended to deteriorate.

In actually fact, I counsel patients with esotropia to continue with a half a minute a day of near/far jumps to maintain vergence flexibility and to be consciously aware of space when walking or driving. I counsel patients with exotropia to, in addition to being aware of space when walking and driving, continue with chiastopic fusion for a minute a day to maintain voluntary convergence. When the patient is compliant, a dozen touch-up sessions from time to time are less likely to be needed.

Comparison with other Studies

Comparing studies about OVT for patients with strabismus is often like comparing apples and oranges. Constant? Is the patient really constant or do the eyes occasionally align at 3 to 6 inches?

Are eyes that are fully aligned on a cover test really fully aligned if stereopsis is 67 seconds of arc or greater? Is there really bifixation? Is there eccentric fixation? Is information from only one fovea being used? Would some of this study's 14 patients with barely perceptible turns (1-2 pd) on a unilateral cover test, whose eyes were more turned on an alternate cover test and snapped ostensibly straight when the paddle was removed, been counted as functional cures? How many doctors trained before the early 1960s carefully looked for Flom's, Jampolsky's and Parks' interesting movements on a cover test.

In truth, however, no one but an optometrist or a pedant would ask such questions. Certainly, no surgeon would waste time on such foolishness. Our general behavioral success, similarly avoids wasting our clinical time and effort on things that matter to the very smallest percentage of patients—those seeking jobs that require 40 seconds of arc stereo.

That said, of Flom's 91 patients with esotropia, 24 (26%) were reported as functional cures (without the degree of stereopsis being reported). In our sample, 18 of 52 patients with esotropia (35%) had better than 67 seconds of stereo. Thus, our approach of ignoring and working around ARC does not seem to harm functional cure rates and may well have overall led to straighter eyes and improved stereopsis in a greater percent of patients. Of Flom's intermittent exotropes, 29/49 (59%) were reported as functionally cured. If 6 exophoria or less at all distances and better than 67 seconds of stereo (added to patients rarely seeing the eye out) can be considered a functional cure, then our approach (21/23—96%) appears to have done better than Flom's theories and students. Similarly, of Ludlam's[103] 71 esotropes—treated by seasoned professionals at the Optometric Center of New York—43 (61%) were reported as functionally cured. For constant esotropia, Flom reported 11% cured; Ludlam, 55%. Again, whether the two clinicians paid the same attention to the almost imperceptible flicks on the unilateral cover test cannot be determined. If I ignore flicks of ≤ 2 pd, our functional cures rise to 60 percent, not statistically much different than Ludlam's findings.

In a retrospective private practice study, perhaps the most similar to our own, Etting[104] reported 30/43 patients with esotropia (70%) as functional cures and 93% of his esotropic sample to have deviations ≤ 15pd. He reported 83% of his 30 patients with exotropia as functional cures and 87 percent to be ≤ 15pd. Of his 17 patients with constant esotropia, 10 (59%) had functional cures and 14 (82%) were cosmetically aligned, as opposed to our 80% general behavioral success on 15 patients with moderate angle esotropia. More importantly, Etting wrote:

> *"Most importantly of all is that these patients demonstrate great improvement in everyday life from sports performance to school achievement. This raises a question as to the validity of a criterion for success which classifies those patients as failures.*[105]

Thus, Etting was saying in 1978 what we're saying in 2025—probably because I stole the idea from him and his partner, Don Getz. When graduating from optometry school in 1978, I visited their practice and later modelled my own practice after their own. Most optometrists succeeding in vision therapy private practice would probably agree with Etting. Which is why we have to consider one more area before completing our comments on behavioral success: quality of life.

Considering an Expanded Behavioral Success Including Quality of life

If we are looking for quantifiable criteria for a basic behavioral success for patients with esotropia that are only slightly above those most frequently used to evaluate studies of strabismus surgery, then 8 or less pd of turn with improved stereopsis is a good place to begin. Personally, however, my goals are for what we could call an expanded behavioral success:

1. The angle of deviation should be the small enough to cause the patient no cosmetic concerns, exact angle or cutoffs are less useful.

Table 12: Changes Noted after OVT By 828 Patients With and Without Strabismus

Changes Reported	#	%
Eyes straighter, less crossed, turning less, more easily controlled, focusing together	105	13%
Improved Reading	684	78%
Headaches/eyestrain/double vision relieved	260	31%
Better vision, clear, not blurry, sees smaller letters, sees further away.	142	17%
Better schoolwork, handwriting, attention	484	58%
More confidence, improved behavior or attitude, less embarrassment, easier social interaction	476	57%
Improved coordination/sports/depth perception	152	18%

2. Stereopsis should be the best we can obtain before plateauing. Why stop at some arbitrary number if we are still improving?
3. The patient should have no concerns about blurring, diplopia, or visual discomfort.
4. The patient should be satisfied with any previously discussed goals for cosmesis, sports, driving, general coordination, efficiency at work, and/or academic performance.
5. Lenses and prisms that are cosmetically acceptable to the patient may be worn to improve performance.
6. Whenever possible, SILO should be present. The relative stereoacuity allowing perception of the relative position of an approaching car's review mirror and side mirror may be less useful than the egocentric depth perception revealing simultaneously the space between the viewer and an approaching car. Our how-little-depth-can-you-see stereoacuity tests ignore egocentric depth perception. As described elsewhere,[106] a patient with reduced stereopsis, may be capable of better egocentric depth perception/SILO than a patient with 40 seconds of stereo. With such egocentric depth perception in mind, our behavioral goals should include accurate localization on peripheral vectographic targets in the therapy room and egocentric depth awareness in free space. This expansion of the "sphere of attention" or "zone of simultaneous awareness" (ZOSA) is described in other publications and, in that faulty perception known as "my clinical experience" is useful for stabilizing results over time. Indeed, adult patients with esotropia have reported that continued awareness of space was enough to maintain there therapy gains.

These goals, while possibly more useful in inspiring a lasting success, nevertheless fail to capture what the word *behavioral* suggests, a success that is based on behavior rather than optometric findings. Looking back, I wish I had had patients fill out a quality-of-life forms before and after therapy. Indeed, many of the cosmetically aligned patients I saw, came to me for difficulty with performance in school, sports, or driving.

What would such a form include?

In 1995,[107] I published "Vision Therapy and Quality of Life" in which 828 vision therapy recipients—both strabismic and non-strabismic—were asked the fairly-open question, "What changes have you seen since beginning vision therapy?" A summary of results appears in . The 828 patients were being seen for any number of reasons such as strabismus, amblyopia, non-strabismic binocular dysfunctions, acuity-enhancement, sports. The most common reasons for presenting to the center were difficulty with reading and schoolwork. All of the patients received oculomotor, accommodative, and vergence training. Some received training in tracking, visual-motor integration and visualization as well. Of the 2303 changes noted by patients, 25 changes were noted 30 or more times each. They appear in Table 13.

Wondering if patients with strabismus and amblyopia would note different changes, I recently reread all our success stories saved from the past. I located 100 that were completed between 1988 and 2015 by patients who apparently had strabismus and/or amblyopia (see Table 14). Table 15 compares the two groups (all patients compared to strabismus and amblyopia patients) showed similarities in ocular symptoms such as headaches,

Table 13: Changes Seen Since Beginning Vision Therapy

Changes Reported	Times Reported
1. Improved reading (unspecified)	254
2. Reduced frequency of headaches	162
3. Better grades in school	137
4. Improved confidence or self-confidence	132
5. Enjoys reading	110
6. Better schoolwork	101
7. Improvement in Sports	81
8. Improved reading comprehension	72
9. Improved handwriting	70
10. Less difficulty with homework	65
11. Reading for longer periods	61
12. Eyes aligned, straighter, drift less	60
13. Improved or more positive attitude	59
14. Sees better, better vision (unspecified)	51
15. Improved distance vision	47
16. Better control of eyes	45
17. Reads on his/her own	43
18. Reduced or no double vision	42
19. Completes school work	42
20. Improved self esteem	40
21. Reduced eye strain/ eyes no longer hurt	40
22. Improved concentration	36
23. Improved attention span	34
24. Faster reading	30
25. Happier	30

Table 14: Changes Noted after OVT By 100 Patients with Strabismus and/or Amblyopia

Changes Reported	#	%
Eyes straighter, less crossed, turning less, more easily controlled, focusing together	75	75%
Improved Reading	39	39%
Headaches/eyestrain/double vision relieved	34	34%
Better vision, clear, not blurry, sees smaller letters, sees further away.	33	33%
Better schoolwork, handwriting, attention	28	28%
More confidence, improved behavior or attitude, less embarrassment, easier social interaction	32	32%
Improved coordination/sports/depth perception	20	20%

eyestrain, and double vision (31% versus 34 %). They showed similar improvements in moving their bodies; that is, in "coordination, sports, depth perception. Although "improved reading" was the most common change noted (78%) in our primarily learning-related general group, improved reading (39%) was our second most common change noted in our strabismus and/or amblyopia group. "Better schoolwork" was similarly noted more often in the patients being seen for learning-related problems (55% versus 28%). Conversely "straight eyes" (75% versus 13%) and improved acuity (33% versus 17 percent) were, not surprisingly, changes more often noted by the patients being seen for turned and lazy eyes than reading problems. Interestingly, the learning group's confidence, behavior, and social interactions rose more (57% versus 28%) than did those of the strabismus group. Thus, it is quite possible that, contrary to surgical thinking, improved performance drives confidence as much or more than just cosmesis.

Trying to quantify the types of changes noted, however, gives us less of a feeling for the emotional impact of vision therapy than do some of the comments excerpted from 19 of the 100 testimonials (see Appendix B).

So, if we were to develop a pre-treatment and post-treatment never-rarely-sometimes-often-always type of questionnaire for use with patients who have strabismus, what questions would we ask?

The Adult Strabismus Quality of Life Questionnaire began when a group from the Mayo Clinic Department of Ophthalmology and the John Hopkins Department of Epidemiology developed a health-related quality of life (HRQOL) questionnaire for adults with strabismus.[108] Interviewing patients, they generated a 181-item questionnaire which they presented to 29 adults with strabismus. Using factor analysis, they arrived at the 20 questions. Items 1-10 provide a "psychosocial sub-scale" (How You Look). Items 11-20 provide a "function sub-scale" (How You See). The patients are instructed to consider the last month and score each item "Never, Rarely, Sometimes, Often, Always."

Items 1-10 elicit the patients' feelings about the negative effects of the appearance of their

Table 15: Changes Noted after OVT Comparing all Patients to those with Strabismus and/or Amblyopia

Changes Reported	All Patients	Strabismus & Amblyopia
Eyes straighter, less crossed, turning less, more easily controlled, focusing together	13%	75%
Improved Reading	78%	39%
Headaches/eyestrain/double vision relieved	31%	34%
Better vision, clear, not blurry, sees smaller letters, sees further away.	17%	33%
Better schoolwork, handwriting, attention	58%	28%
More confidence, improved behavior or attitude, less embarrassment, easier social interaction	57%	32%
Improved coordination/sports/depth perception	18%	20%

Table 16: Adult Strabismus Quality of Life Questionnaire (AS-20)

Never	Rarely	Sometimes	Often	Always
1. I worry about what people will think about my eyes.				
2. I feel that people are thinking about my eyes even when they don't say anything.				
3. I feel uncomfortable when people are looking at me because of my eyes.				
4. I wonder what people are thinking when they are looking at my eyes.				
5. People don't give me opportunities because of my eyes.				
6. I am self conscious about my eyes.				
7. People avoid looking at me because of my eyes.				
8. I feel inferior to others because of my eyes.				
9. People react differently to me because of my eyes.				
10. I find it hard to initiate contact with people I don't know because of my eyes.				
11. I cover or close one eye to see things better.				
12. I avoid reading because of my eyes.				
13. I stop doing things because of my eyes.				
14. I have problems with depth perception.				
15. My eyes feel strained.				
16. I have problems reading because of my eye condition.				
17. I feel stressed because of my eyes.				
18. I worry about my eyes.				
19. I can't enjoy my hobbies because of my eyes.				
20. I need to take frequent breaks when reading because of my eyes.				

eyes on self and others. The AS-20 emphasizes the cosmetic concerns, which mirrors our own Table 14. Indeed, 75 percent of our patients with strabismus and amblyopia thought of and took time to note the changed appearance of the eyes. In our 100 success stories, the words *straight* or *straighten* appeared 33 times. The words *cross* or *crossed* appeared 16 times. The words *drift* and *turn* (in, out, etc.) each appeared 11 times. The word *wanders* appeared 4 times. Words such as "stray," "going out," "floating off," "pull inward," "focus together" also were used. Cosmetic concerns were paramount. Also, such success story comments as "I am no longer embarrassed and am happy to interact with other people" and "He didn't want to go to school because other kids made fun of his eye turning" support the AS-20's "I find it hard to initiate contact with people I don't know because of my eyes."

The AS-20's questions 11-20, the "how-you-see" or "function" subscale also aligned well with the Table 10's "What changes have you seen since beginning vision therapy (CSSBVT), revealing, without leading them, what respondents found important enough to report.

Just as "reading" scores high on the CSSBVT, three of the ten function questions on the AS-20 involved reading. While the AS-20 mentions "covering an eye," the CSSBVT mentions "reduced or no double vision." The AS-20 mentions difficulty with concentration; the CSBVT, improved concentration. The AS-20 mentions "frequent breaks while reading"; the CSSBVT mentions "reading for longer periods." The AS-20 mentions "worry about my eyes"; the CSSBVT mentions confidence, self-confidence, and self-esteem. The AS-20 mentions "depth perception" and "hobbies"; the CSSBVT, "improvement in sports."

So, the question arises, would the AS-20 be a good outcome measure for clinical trials on the non-surgical treatment of strabismus. Without a doubt, the AS-20 would be better than no-before-and-after-quality-of-life assessment as in the current study. But clinicians tend to define success around the limits of their treatments. We see what we value and surgeons primarily value cosmesis,

not performance. All the questions revolve around "eyes" not "vision" (how we use our eyes). Questions 1-10 are largely about the effect of poor cosmesis on perception (the patient's and those around the patient). The "because of my eyes" questions 12, 13, 16, 17,18, and 19 could all be interpreted, not as performance questions but as emotional issues and benefits created by cosmesis. "I worry about my eyes," again, is about emotion, not performance.

Not that emotion isn't intimately linked to the visual process. Accommodation itself is run by the sympathetic-parasympathetic, fight-or-flight system. In my experience, when stressed, patients often constrict their spatial awareness; when relaxed they expand spatial awareness. As mentioned, when we considered placebo for strabismus surgery, the eyes of patients with intermittent strabismus are, according to their parents, likely to deviate when the patients are upset and straighten when they are relaxed. Tubular fields and acuity loss are similarly tied to patients' emotion. As suggested by our excerpts from the success stories, therapy creates positive emotional responses. Emotion affects vision and vision affects emotion. As adults feel their eyes not working, they often believe that their eyes are cosmetically deviated (whether or not this is the case). Thus, again stabilizing function can lead to patients having improved self-images.

That said, by asking the same cosmesis-based question ten different ways, the AS-20 is constructed to favor cosmetic alignment. If a surgery creates alignment, it can dramatically effect pre and post treatment scores. As can the questions asked. As mentioned, the AS-20 began with the interviewing of patients to generate 181 questions. The nature of the interviews (which was not reported) essentially shaped the test. The interviewer's tone of voice could have affected the patient's mood, and thus the patients answers being more positive or negative. If the interviewer asked a non-leading question, such as "How do your eyes affect your life?", repeating the question until the patient ran out of answers, we might end up with a less biased representation of the way strabismus affects quality of life. But if the interviewer asked specific questions such as, "How do you feel when you think about your eyes?" or "How do your eyes affect your relationships with others?" or "How have your eyes affected your reading and studying?" the questions generated for the study would already be biased.

And so we must ask, were the interviews biased in the direction of surgical rather than vision therapy perspectives?

Similarly, the AS-20 creators decided to exclude questions that used the words *diplopia* or *double vision*, rationalizing their choice with the argument that double vision was a symptom, not a quality-of-life measure. Considering, however, that, as mentioned above, Crone found strabismus surgery to be one of the leading causes of persistent diplopia, excluding double vision's mention may not have been about quality of life, but about quality of outcome measures. Quality of life survey questions could have included: "I am bothered by double vision." "I am made dizzy by double vision." "I am confused by double vision. I am afraid to drive because of double vision." "I am less confident because of double vision." All such questions speak directly, not to the symptom but to the way the patient's quality of life is affected by the symptom. Why is "I have to cover or close an eye to avoid seeing double" less of a quality-of-life question than "I cover or close one eye to see things better?" Would an outcome measure that did not exclude a common iatrogenic consequence of adult strabismus surgery be more truthful? Shouldn't we know how diplopia affected quality of life before and after treatment?

I, therefore find the authors' exclusion of symptoms, "My eyes feel strained" not "Eyestrain exhausts me" to be reasonable but unconvincing. While it is probably true that more patients with strabismus are embarrassed by their appearances than bothered by double vison, if the double vision questions instead of the appearance/embarrassment questions were asked 10 different ways, the outcomes measured might be quite different. Again, we see what we value and the questions we ask not only transfer our values to patients but affect what they see.

Table 17: Behavioral Quality of Life Questionnaire Completed by 15 Adults with Strabismus

1. Things are blurry for a moment when I look up from reading or computer work. (8)	14. I have difficulty judging how far away other cars are. (11)
2. I get headaches or eye strain when using my eyes for careful seeing. (13)	15. It makes me nervous to drive when traffic is heavy. (7)
3. Things blur in and out of focus. (12)	16. My productivity goes down as the day progresses. (9)
4. My eye drifts in toward my nose or out toward my ear. (14)	17. I have more trouble seeing the computer screen as the day goes on. (9)
5. When I read, the print blurs. (9)	18. I get eyestrain or headaches during computer work. (11)
6. When I read, the print looks unsteady or dances .(8)	19. When it comes to ball sports, I'm a klutz. 9()
7. Reading gives me eye strain or headaches. (10)	20. It's hard to catch or hit a ball. (11)
8. Reading puts me to sleep. (9)	21. I bump into things. (9)
9. I lose my place and skip and reread lines. (10)	22. When dancing I have two left feet. (7)
10. I have to reread sentences to understand them. ((9)	23. I'm clumsy. (10)
11. I get eyestrain or headaches when I drive. (8)	24. I trip and stumble if I'm not careful. (7)
12. I have to look twice because I can't trust my eyes to see things correctly the first time. (11)	25. I have trouble maintaining eye contact when speaking to someone. (8)
13. I dislike driving at night. (8)	26. I'm embarrassed by the appearance of my eye turning. (10)

In summary, in developing a behaviorally influenced outcome measure for patients with strabismus, it would be good to borrow from the AS-20 and include questions that suggest how our eyes' appearance affect both self and others. For instance, "I am self-conscious about the appearance of my eyes" and "People react differently to me because of my eyes." Our quality-of-life questionnaires, however, need not differentiate people with strabismus from people without strabismus. The questionnaire is not being used as a screening device. We are working with people, not a disease, so we should see many of the same gains whether or not a patient has strabismus. We are helping people to control their attention in direction, distance, and extent. We are helping people to use light to direct action in familiar and especially novel environments. All of this may be accomplished even as we guide patients to align their eyes. Any questionnaire we create to round out behavioral treatment should help capture how we guide patients to use light to interact with their physical and social worlds. I imagine.

Based on the results of the CSSBVT, I constructed a 100-item survey for children and a 90-item survey for adults, both of which I have used in the office since the 1990s. Looking at the pre-therapy surveys of 60 children with strabismus from our study and 15 adults (we unfortunately did not have post-therapy surveys), I pruned away all items that were selected less than 40 percent of the time, the majority of the items being selected over 50 percent of the time. The result?

Table 17, "Behavioral Quality of Life Questionnaire completed by from 15 Adults with strabismus," lists 26 behaviors selected positively by at least 45 percent of the 15 responding adults with strabismus. Each item is followed, in parentheses, by the total number of participants selecting it. Table 18, "Behavioral Quality of Life Questionnaire completed by the parents of 60 Children with Strabismus," similarly lists 26 behaviors selected positively by at least 45 percent of the participants. Each item is followed, in parentheses, by the total number of participants selecting it. The behaviors listed include several each from the areas of seeing, reading, coordination, sports, attention, relationships and, for the adults, driving.

As I have repeatedly mentioned, we do not treat strabismus; we treat patients with strabismus. Other than the items about cosmetically apparent eye turns or the embarrassment associated with

Table 18: Behavioral Quality of Life Questionnaire Completed by the Parents of 60 Children with Strabismus

1. Headaches when reading or doing desk work. (27)	14. Struggles to get thoughts down on paper. (37)
2.Exhausted after a day a school. (43)	15. Your child runs into things. (30)
3. Complains of blur despite normal screenings and routine eye exams. (28)	16. Your child stumbles, trips, or falls. (38)
4. Eyestrain during reading and desk work. (32)	17. Your child is clumsy or has poor balance. (29)
5. Tilts and turns head to side. (29)	18. Your child knocks things over. ((29)
6. Squints when looking from near to far or far to near. (32)	19. Attention better using ears to listen than eyes to read. (35)
7.One eye turns in or out. (51)	20. Attention better using ears to listen than eyes to read. (35)
8. Reads well for a short time then begins to make careless errors. (31)	21. During reading or homework, there comes a time when pushing doesn't help. Your child shuts down (35)
9. Rapidly tires out and loses comprehension when reading. (30).	22. The longer your child reads or writes, the greater the frustration and fidgeting. (40).
10. Reading not as good as intelligence predicts. (36)	23. Homework is a battle. (32)
11. Makes errors in copying from desk to paper. (34)	24. Your child cannot stay on task when reading or writing. (29)
12. Handwriting is off lines, going "up" and "down." (38)	25. Your child's self-confidence is low, attitude is poor. (30)
13. When writing, words are poorly spaced. (40)	26. Your child comes home from school either worn out or angry. (28)

them, the questionnaire stresses behaviors already reported to improve after OVT.[109] Why? Reducing the answer to eye movements and stereopsis is a bit like reducing Niagara Falls to hydrogen and oxygen. The question is not if misaligned visual axes contribute to symptoms. The question is if using OVT to help patients with misaligned visual axes improves visual performance. In a behavioral success, we cannot say whether this performance change is due to a change in the deviation, stereopsis, or merely learning to use the visual process to transform light information into action. And what mix of eyes, brains, minds, bodies, emotions, and unknowns affected the transformation? I would suggest that humility rather than assertion is in order until we know the basics about how both life and consciousness appeared, for the visual process, in all probability, is intimately related to both.

Our ignorance aside, so far as patients were concerned, the cosmetic alignment of the eyes was paramount—much as surgeons maintain. Of the children's questionnaire respondents 51/60 (85%) marked positively the "Eye turns in or out" survey question. Of these, 32 (53%) selected "often" or "always." On the adult survey, 14/15 (93%) marked the eye-turning item. Of these, 10/15 (67%) selected "often" or "always." On the children's survey, the next most marked items were "Exhausted after a day at school" (43/60—72%), and 40/60 (67%) for both "When writing, words are poorly spaced" and "The longer your child reads or writes, the greater the frustration and fidgeting." For adults, the second and third most selected items were "I get headaches or eyestrain when using my eyes for careful seeing" (13/15—87%) and "Things blur in and out of focus" (12/15—80%).

To get a better impression of the behavioral success of OVT for helping patients with strabismus, I would recommend a questionnaire containing these questions as well as cosmetic questions based on the AS-20—items which tell us how the patient or parents feel about the appearance of the eyes and about how the patient or parent feels that others feel about and treat them based on the appearance of the eyes. I would also include the item, especially for adults: "I am bothered by seeing double: never, rarely, sometimes, often, always." The question did not make the short form because only 19 out of 60 parents of children responded positively to the question, "See's

two of things when only one is there." And, I neglected to include a diplopia question on the adult questionnaire, asking the question instead directly during the examination.

Finally, in developing a medical-viewpoint questionnaire for children, here is another source to consult.[110]

CONCLUSIONS

1. What might be a useful criterion for judging success in the treatment of patients with strabismus?

There is no universal agreement on what constitutes success in the treatment of patients with strabismus. Ideally, OVT should improve the entire visual process to optimize light-guided interaction with both habitual and novel words and both the physical and social worlds. This should be true whether or not the patient has strabismus. Creating one set of standards for surgical treatment and a different set of standards for OVT may teach us more about professional chauvinism and rivalry than patient care.

Most clinicians of both professions would agree that cosmetically aligned eyes may allow patients to interact better in the social environment. Most clinicians would agree that stereopsis may be useful in using light to guide interaction with the physical environment. As a compromise in judging success when helping patients with their esotropia, I propose a "general behavioral success":

1. The angle of esotropia should be ≤ 8 pd on a simultaneous prism and unilateral cover test.
2. If the initial esotropia is < 15 pd, then stereopsis should improve.
3. If the initial angle is ≥ 15 pd then appreciation of the stereo fly will suffice.
4. In the case of intermittent exotropia ≥ 15 pd, a "general behavioral success" requires exophoria with appreciation of the stereo fly.
5. For the benefit of patients, not studies, the basic behavioral success may be expanded to include the following goals:
   a. With esotropia, while not required, the lowest possible angle and best possible relative and egocentric depth perception and awareness of space are desired including SILO in the therapy room and expanded spatial awareness outside the therapy room.
   b. With exotropia, awareness of space and effortless voluntary convergence at distance and near are also desired.
   c. With all patients, as time permits, enhancement of the visual process to maximize interaction with habitual and novel worlds is desirable.

2. Can optometric vision therapy (OVT) contribute to helping patients control esotropia in the range of 15 to 45 pd?

In our sample of 15 patients in this group, the median deviation reduced from 25 pd to 1 pd; the mean percent stereo improved from 10.3 % to 42.7 %; and, 80% of the sample achieved a basic behavioral success. This outcome suggests that OVT may contribute to patients' ability to control their cosmetic esotropias.

3. Can OVT be beneficial to patients with esotropia under 15 pd?

In our sample of 37 patients in this group, the median deviation went from 4 pd to 1 pd; the mean percent stereo improved from 19% to 47%; and, 84% or the sample achieved a behavioral success. This outcome suggests, that patients with smaller angle esotropia's may benefit from OVT.

4. Can OVT help older patients (> age 4) with esotropia to develop monofixation syndrome or better?

Of 33 patients ≥ age 4 who began OVT either lacking peripheral stereo or with an angle > 8 pd, 27 (82%) reached an angle ≤ 8 pd and perceived the stereo fly or better. Before OVT, 5/33 patients (15%) had deviations ≤ 8 pd. After OVT 29/33 patients (88%) had deviations ≤ 8 prism diopters. Before OVT 15 patients had no perception of the stereo fly. After OVT 14/15 patients (93%) perceived the stereo fly for the first time. This last outcome is especially important because it

suggests that at least some patients who continued to have larger angles of esotropia after age two may yet develop peripheral fusion at a later age.

5. Can patients who already have monofixation syndrome benefit from OVT?

In our sample, 19 patients with esotropia began with peripheral stereo (stereo fly or better) and an angle ≤ 8 pd. Of these, the median angle of deviation reduced from 4 pd to 1 pd. Stereopsis improved in 15/19 patients (79%). The mean percent stereopsis rose from 25% to 60%. Before OVT, 1/19 patients (5%) had 67 seconds or better stereo. After OVT this rose to 9/19 patients (47%). Based on these improvements, it appears that, despite Marshal Parks' speculations, patients with monofixation syndrome may benefit from OVT even if they, and hardly anyone else, is completely free from foveal suppression—at least when faced with the artifacts of testing.

6. Can OVT provide successful treatment for patients with intermittent exotropia between 15 pd and 50 pd?

In our sample of 23 patients with intermittent exotropia, the median angle of deviation reduced from 25 pd of intermittent exotropia to orthophoria. For comparison with surgery (or Flom's criteria for cure), our behavioral successes—8 or less diopters of exophoria and peripheral stereo—after OVT were 21/24 (88%). Patients with both 6 pd or less of exophoria and 67 seconds of arc or better after OVT numbered 19/24 (79%). If the visual capabilities to pass a flight physical were our criterion, then 15/24 patients (62%) ended OVT with 2 pd or less of exophoria and 40 seconds or better of stereo. The data suggest that OVT may help patients with cosmetically-apparent, intermittent exotropia to interact with both their physical and social environments.

7. Could a behavioral quality of life questionnaire provide outcome measures that would improve our understanding of the benefits of OVT for the treatment of patients with strabismus?

Table 19: Results of all 75 Patients with Strabismus Both Esotropia and Exotropia

75 Patients with Strabismus Esotropia + Exotropia	Before Therapy	After Therapy
Mean Deviation DV	15pd	3 pd
Median Deviation DV	15pd	0 pd
Percent Stereopsis	30.3%	57.4%
Reduced Angle of Deviation		66/75 (88%)
Improved Stereopsis		63/75 (84%)
Behavioral Success		65/75 (87%)
≤ 6 pd phoria + better than 67 seconds of stereo		36/75 (48%)

Reviewing the Adult Strabismus Quality of Life Questionnaire (AS-20) created from the viewpoint of strabismus surgeons to Behavioral Questionnaires based on my own previously published "Vision Therapy and Quality of Life" as well as 100 success stories completed by my patients with strabismus and 75 questionnaires completed by the patients in the current study, I conclude that the development of behavioral quality of life questionnaires for both adults and children would be useful both in understanding the benefits OVT for the treatment of patients with strabismus and providing outcome measures in future clinical trials, both retrospective and prospective. With luck, the numbers in life will help us see past the numbers in clinic.

SUMMARY

There remains no agreement of what constitutes success in the treatment of patients with strabismus. Of 75 adult and school-age patients with strabismus who received optometric vision therapy (OVT), 87 percent obtained a behavioral success: eight or less prism diopters of turn with peripheral or better stereopsis (see Table 19). This outcome suggests that OVT in a private practice setting can be useful in obtaining both cosmetic alignment and improved stereopsis for patients with small or moderate angles of strabismus. To understand the impact of OVT on the lives of people with strabismus, quality of life questionnaires will be necessary. These questionnaires, filled out both before and

after therapy, would have been useful in assessing the true behavioral changes experienced by those of our 75 patients who received OVT. Quotes from the testimonials of patients with strabismus having benefited from OVT is included in Appendix B to characterize the narrative of success. A theory of success that places findings ahead of changes in life, remains suspect. We are, after all, working with patients, not disease. And those patients, we must believe, are worthy of all the trouble.

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APPENDIX A

Some Procedures Useful for Developing Voluntary Convergence and Expanding The ZOSA

A. Voluntary control of vergence

1. Base in and base out training beginning with stereo targets, moving to flat fusion targets, and ending up with simultaneous perception targets.
2. Freeing Accommodation from vergence
   a. Monocular, biocular, and binocular accommodative rock, near and distance.
   b. Base out and plus, base in and minus (BOP & BIM) to free vergence from accommodation.
3. Cover one eye/uncover the eye/recover fusion until no movement is seen when an eye is covered.
   a. Stereo targets at several feet
   b. Stereo targets in the distance.
   c. Second degree targets (such as the Hart Chart), cover/uncover/recover at several feet, gradually combined with cognitive tasks (such as searching for letter sequences).
   d. Hart Chart cover/uncover/recover at 26 feet.
   e. Hart Chart with vertical dissociation, maintaining two charts aligned at near, then at increasing distances.
4. String
   a. With beads
   b. Without beads
   c. With vertical prism dissociation.
5. Chiastopic Fusion
   a. Using a pointer to control convergence
   b. Maintaining convergence when pointer is removed
   c. Obtained without pointer
   d. With SILO
   e. Split targets with SILO
   f. Using thumbs as the chiastopic fusion target.
   g. Separating the thumbs as far apart as they are separated from the nose.
   h. Chiastopic fusion with distance targets with SILO.
   i. Distance Chaistopic fusion with balance, movement, and SILO.

B. Expanding the ZOSA and integrating center and periphery

1. Silo during Base in and Base out ranges.
2. Silo of projected dichoptic targets while balancing and moving.
3. Silo with first and second degree targets (the terms first, second, and third degree targets actually apply to major amblyoscopes. In free space, providing the ZOSA is expanded and you know where your eyes are pointing, all targets are three dimensional, having a position in the room.)
4. Silo with chiastopic and orthoptic fusion. No SILO, patient too central.
5. Walking with 20 prism diopter yoked prisms while paying attention to the big picture and movement of the room.
6. Cover/uncover/recover with an expanded ZOSA and egocentric stereopsis as discussed under esotropia protocol.

APPENDIX B

Quotes From the Testimonials of Patients with Strabismus

"Before therapy my left eye was stuck over in the right corner of that eye and because of that I was very embarrassed and had low self-esteem. My right eye was very tired and both eyes were red all the time. Since therapy both eyes are straight and clear. I am no longer embarrassed and am happy to interact with other people because I don't have to worry about what my left eye is doing or what they are thinking about my eye."

"Before therapy … [J.] had a lot of headaches. She no longer complains of headaches … [J's] friends said she did not look at them when they spoke to her. This problem has stopped with therapy because her eyes now move together."

"Not only do her eyes cross rarely but her lazy eye has become much stronger and her vision is much better."

"I can hold my eyes straight and see clearly at the same time—for the first time in my life"

"She reads letters 10 times smaller than when she started."

Child with three previous eye-muscle surgeries: "[H.] … has more confidence in sports activities. She can spend greater lengths of time with continuous reading. Therefore, her comprehension is improved and her attitude toward study has also improved."

"[S…] can now read without losing his place on the page. When his glasses are off his eye will remain straight. I am especially happy about that! He seems to be less frustrated with his school work as reading is much easier. Prior to therapy … [he] could not stand to have his glasses off. Since therapy we were able to enroll him in swim lessons! He was able to control his eye comfortably during the lessons."

"I can now ask her to take her glasses off to take a picture and her eyes stay straight."

"Her eye problem was a disfigurement and this made me very sad. I had to worry on school picture days because I was afraid she wouldn't focus her eyes right and her pictures would be ruined."

"The double vision I was experiencing has gone and I am able to focus at most every direction more easily. Reading and using the computer terminal is much easier. Driving is not scary anymore and is not the challenge to stay steady as previously experienced. I have learned to compensate for focusing problems to the point it is a natural reflex in using my eyes and I do not have eye strain as in the past."

"Her teachers, friends etc. can even tell the difference. Comments now are "[J.] … you are looking at me with both eyes." [J.] … now is more confident, moves more gracefully, has fewer falls and stumbles less."

"[P.] … has really progressed in her large motor skills. She no longer bumps into objects. Before therapy she could not go through a door, pass furniture, or move around LARGE things without bumping into them. Her left eye not longer drifts out, and she can maintain eye contact well."

"[J.] … has stopped having headaches since vision therapy. He has gotten better at baseball and at school. His eyes are not turned in anymore. They are beautiful. He don't see two of everything anymore! Only one. It is so good looking into that face and knowing he can see clearly and see only one of everything. … He as improved so much it is hard to put into words."

"She also now loves to read. She has gained so much confidence both in school and with physical activities. In the last month of her therapy, she learned how to ride her two-wheeler, jump rope, and is a very confident, happy young lady. Thank you … for helping our family!"

"When … [L.] began her therapy there was a definite turning outward of her eyes. … It has been 7 years and her eyes are still straight."

"[B.] … can hold his eye therapy and he can now ride his bike. He spaces his letters better when he writes. He has more confidence in himself. He didn't want to go to school because other kids made fun of his eye turning in."

"[M's] eyes are definitely straighter since beginning therapy. We have seen improvement in actual visual performance. Behaviorally … [M.] has come a long way! We believe she was acting out from the frustration, but, as her vision improved so has her behavior. Her self-confidence has sky-rocketed and she is friendlier and more out-going."

"I really didn't understand her vision until she started her therapy, one night riding down the road, she ask why she no longer seen two of things. I replied to her and said there never was two baby. She is a better child behavior wise also. I am very grateful to … [the] therapy team for all their work with her."

"When I was little I used to read anything I could get my hands on, but when I had reading and studying to do for school I quickly quit my reading for fun. Now I am able to do both because my eyes don't quit on me. My hand-eye coordination, and my sports have also improved. More than anything I've noticed that my right eye no longer turns in. People used to be able to tell when I was tired because my eye would always become lazy and turn in, but not anymore."