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Treatment Options in Intermittent Exotropia: A Critical Appraisal

BRADLEY COFFEY*
College of Optometry, Pacific University, Portland and Forest Grove, Oregon

BRUCE WICK†
College of Optometry, University of Houston, Houston, Texas

SUSAN COTTER‡
JANICE SCHARRE‡
Illinois College of Optometry, Chicago, Illinois

DOUG HORNER§
School of Optometry, Indiana University, Bloomington, Indiana

ABSTRACT

Clinical opinions regarding treatment of intermittent exotropia (IXT) vary widely and there is controversy as to which treatment modality is most successful. This paper reviews the clinical literature related to five different treatment modalities used for IXT: overminus lens therapy, prism therapy, occlusion therapy, extraocular muscle surgery, and orthoptic vision therapy. Based upon review of 59 studies of treatment of IXT, and using each author's stated criteria for success, the following pooled success rates were revealed: overminus lens therapy (N=215), 28%; prism therapy (N=201), 28%; occlusion therapy (N=170), 37%; extraocular muscle surgery (N=2530), 46%; and orthoptic vision therapy (N=740), 59%. Success rates for IXT surgery differed depending upon whether a functional (43%) or cosmetic (61%) criterion was used to evaluate treatment success. These pooled success rates must be viewed carefully because nearly all the studies suffer from serious scientific flaws such as small sample sizes, selection bias, inadequately defined treatments and success criteria, absence of statistical analysis, and results reported in a manner that makes interpretation difficult. These problems indicate the need for a careful, circumscribed, and well controlled clinical trial to study the efficacy of different treatment modalities in remediating IXT.

Key Words: intermittent exotropia, overminus lens therapy, prism therapy, occlusion, extraocular muscle surgery, orthoptics, vision therapy.

Intermittent exotropia (IXT) is a common form of binocular vision dysfunction that is characterized by an abnormal outward deviation of the visual axis of one eye. The typical patient with IXT shows normal binocular alignment and sensory fusion part of the time with intervals of disrupted fusion when one eye turns outward resulting in diplopia, suppression, or anomalous correspondence. Patients report diplopia, headaches, photophobia, and reading problems, and often express displeasure with their cosmetic appearance when an eye turns.

Treatment of IXT has included various procedures intended to facilitate binocular sensory fusion. The ultimate goal when treating IXT is to reduce the frequency of eye turn by enhancing the fusional processes. A complete functional cure achieves continuous binocular alignment and binocular sensory fusion.

To attain normal binocular sensory fusion, each eye must have a clear retinal image that falls upon corresponding foveal points. To establish a clear retinal image, lenses that neutralize the refractive condition and balance accommodative effort should be prescribed when indicated. This important management step is taken initially by most, but not all, clinicians. When IXT continues to occur even with refractive correction, further treatments may include: (1) stimulating convergence with lenses (overminus lens therapy), (2) partial (or sometimes complete) compensation of the exodeviation with prism (prism therapy), (3) temporary interruption of input to one eye to reduce suppression (occlusion), (4) reduction of the exodeviation by surgical relocation of the extraocular muscles (extraocular muscle surgery), and (5) training with feedback to increase fusional vergence ranges and normalize sensory fusion [orthoptic vision therapy (VT)].

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*Optometrist, Member of Faculty.
†Optometrist, Ph.D., Member of Faculty, F.A.A.O.
‡Optometrist, Member of Faculty, F.A.A.O.
§Optometrist, Ph.D., Member of Faculty.

In this paper we review almost all studies related to efficacy of treatment of IXT that were published in English during the past 25 years. Case studies and reports involving very small samples (10 subjects or less) were not included unless important information regarding treatment efficacy was discussed. A few studies older than 25 years were included to provide a comprehensive perspective and to convey information which is not available in the more current literature. Studies are presented in the text and tables in order of increasing reported rate of success without regard to date of publication.

This review of the five IXT treatment modalities, with emphasis on studies evaluating conservative (nonsurgical) treatments, was undertaken to determine the efficacy of each in the management of IXT. In evaluating the entire literature relating to treatment of IXT it becomes apparent that: (1) many papers lack information on the sensory status of patients before and after therapy, (2) almost all studies are retrospective, (3) most lack the controls necessary to draw accurate conclusions from the results, (4) sample sizes are usually small, and (5) results are often reported in a manner that makes interpretation difficult.

Throughout the literature, criteria for success are seldom rigidly defined and there is no general agreement on the definition of "cure" or "success." The definition of successful outcome has, in the last decade, become more standardized using criteria similar to those of Flom,[1] which include: clear, comfortable binocular vision at all distances up to the nearpoint of convergence (NPC), normal NPC, stereopsis and normal motor fusion ranges, a 1% frequency of tropia is allowed provided that diplopia is noticed at these times, and up to 5^{Δ} prism may be worn in spectacles.

Notwithstanding the existence of Flom's criteria, "successful outcomes" in the various studies run the gamut from reduction of suppression to establishment of heterophoria, precise stereopsis, and fusional ranges in all positions of gaze. Authors frequently reported only on changes in cosmetic alignment without apparent consideration of sensory fusion status. The lack of a uniform definition of success, along with inconsistent definitions of diagnostic conditions and treatments, prevents the application of consistent outcome criteria in reviewing the IXT literature. In the review that follows, each paper is evaluated in terms of each author's stated success criteria, and these criteria are presented relative to emphasis on visual function or on cosmetic alignment.

It is important to recall that among patients with IXT, sensory fusion capability is present before treatment and often exists much of the time. The argument for cosmetic alignment as being a successful outcome may be valid in forms of strabismus where sensory adaptations make it difficult to restore normal sensory function (e.g., congenital esotropia). However, given that some degree of sensory fusion exists before treatment in IXT, any intervention which yields no improvement in frequency or duration of normal sensory fusion, despite a modification in cosmetic alignment, cannot be considered a functional success.

A further challenge in ascertaining the efficacy of individual treatments for IXT arises because it is frequently treated by combinations of treatment modalities. The relevant literature is representative of clinical practice in this regard. As such, published reports cannot always be categorized exclusively in terms of a specific treatment modality. For example, overminus lens therapy or prism therapy may be used at some stages of reported VT studies. Patients in surgical studies may also have been treated with various combinations of prisms, overminus lenses, occlusion, or VT to eliminate pre- or postoperative diplopia, abnormal correspondence, or suppression. This circumstance results in confounding conclusions about the individual efficacy of each treatment modality.

OPTICAL CORRECTION OF REFRACTIVE CONDITION

In clinical management of IXT, the routine initial step is evaluation of the refractive condition and ensuring that the appropriate optical correction is in place. Spectacles or contact lenses may therefore be considered the primary step in treatment. Indeed, it may be the critical step for IXT patients with otherwise normal sensory and motor function who have untreated myopia, anisometropia, or astigmatism. For these patients, clear retinal images provided by optical aids may improve fusion and lead to a reduction in frequency or even elimination of the IXT. The proportion of IXT patients who may be treated successfully solely by correction of refractive condition is unknown, and very few reports address this question (Table 1).

A widely cited study by Hiles et al.[2] reports results of 48 IXT patients who, despite being considered candidates for surgery, remained unoperated and were followed for 6 to 22 years. The only treatment provided was optical correction of their refractive condition. The average exodeviation at the start of the study was 23^{Δ} at far and 11^{Δ} at near; at the end of the study these values were 18^{Δ} and 8^{Δ}. At the start of the study, all 48 patients had IXT at far; at the end, 15 had IXT, 2 were constantly exotropic, and 31 were exophoric. At near, 41 patients were phoric and 7 had IXT at the start of the study; at the end 45 were phoric and 3 had IXT. Average NPC did not change. Prevalence of suppression at far changed from 58 to 40% over the duration of the study. During the study period, the average refractive error shifted from +0.05 to −1.59 D. Based upon cover-uncover testing, 65% of the patients who originally had IXT at far became exophoric at far after 6 to 22 years of treatment limited to refractive correction. Two (4%) patients in the sample progressed to a constant exotropia at far during the study. Hiles et al. concluded that ". . .by and large, although there is a general trend

TABLE 1. Best optical correction.

Authors, Year, Sample Size, Type of Study	Treatment; Duration	Success Criteria, Success Rate, Failure Rate	Critique
Hiles et al., 1968[2] N = 48 Retrospective	Best optical correction; 6 to 22 years	Phoric @ 20 ft. and reduced size of deviation. 65%, became phoric; 73%, reduced size of exo. Not specified	Poorly defined success criteria Small sample (<50) No control group No statistical analysis

toward the reduction of the strabismic angle, most patients stayed within approximately the same angular measurement throughout the follow-up period."

Hiles et al. acknowledged that their results contradicted the popular impression that childhood exophorias tend to progress to a constant exotropia.[3–5] von Noorden[6] documented such progression when he found an increased magnitude of deviation and/or progressive loss of binocular function in 75% of 51 young unoperated IXT's who were followed for an average of 3.5 years. Weinstein et al.[7] reported that 76% of 37 surgically undercorrected IXT patients showed a gradual increase in the exodeviation over time. Progression of IXT in terms of increased angle of deviation has also been noted during a 10-year follow-up period after surgery.[8] Hiles et al. did not attempt to justify their somewhat controversial findings, but did note that their subjects may have had "milder" forms of IXT because each had not complied with the original recommendation for surgical treatment. Epidemiological studies by Weve[9] and Frandsen[10] indicate decreased prevalence of all types of strabismus in the population after 6 years of age, suggesting that spontaneous improvement may occur in at least some cases.

OVERMINUS LENS THERAPY

Overminus lens therapy—spectacle or contact lenses with more minus (or less plus) power than necessary for best refractive neutralization—is a treatment for IXT which may have its effect through one or more of three ways: (1) The angle of deviation can be reduced by stimulation of accommodative vergence, thus allowing the residual angle to fall within the range of motor fusion. (2) Small accommodative vergence movements may be stimulated via increased accommodation as the eyes focus to clear the retinal images which were blurred by the added minus power. When the disjunctive motion begins, reflex fusional vergence may then be more readily used, analogous to the manner that blink vergence enhances fusional vergence responses.[11] (3) Overminus lenses may allow clear distance vision and, thus, facilitate fusion. Many IXT patients remark that when they maintain single vision their distance vision becomes blurred. This might occur because of a stimulation of accommodation by the excessive amount of convergence required for fusion (convergence accommodation), or because of reliance upon excessive accommodative vergence to overcome the exodeviation. For these IXT patients, added minus lenses would allow clear and single vision.

The amount of overminus lens power that is prescribed in the treatment of IXT varies among patients and practitioners. Generally, the minimum overminus power that enables constant fusion is given. Ideally, after constant fusion has been attained for a period of time, the overminus lens power is gradually reduced to zero.

Regardless of the mechanism of action or the technique of application, recent surveys of members of the American Association for Pediatric Ophthalmology and Strabismus[12] and the International Strabismus Association[13] show that overminus lens therapy is a popular treatment modality among medical practitioners who use conservative treatments for IXT before recommending strabismus surgery. The surveys of both groups of practitioners showed that overminus lens therapy was second only to occlusion therapy as the preferred conservative treatment modality.

Kennedy[14] reported on a sample of 153 patients with exodeviations (undifferentiated between constant and intermittent) who did not respond to VT and for whom strabismus surgery was not indicated or was refused. Patients' age range was unspecified but was at least 2 to 14 years based upon cases discussed. Up to 6.50 D of overminus lens power was used. Of the 153 patients, 12% became phoric with overminus lens treatment, and 37% demonstrated at least occasional fusion. Patients who were treated successfully were pleased with the cosmetic improvements and did not experience asthenopic symptoms (e.g., no blur, eye strain, or headaches). Kennedy's reported success rate is far less than that attained in the other two published studies of overminus lens therapy, possibly due to the presence of constant XT's in his undifferentiatied sample of patients with exodeviations (see Table 2).

Goodacre[15] found that 63% of 27 IXT children became exophoric within 12 months of overminus lens treatment and 33% had a decrease of at least 15^{Δ} in the magnitude of the exodeviation. The children ranged in age from 18 months to 6 years

TABLE 2. Overminus lens therapy.[a]

Authors, Year, Sample Size, Type of Study	Treatment; Duration	Success Criteria. Success Rate. Failure Rate	Critique
Kennedy, 1954[14] N = 153 (mixed IXT and XT) Retrospective	Overminus lenses and visual training; Not specified	Eyes straight and constant fusion (undefined). 12%, 33%	No control group Poorly defined success criteria Poorly defined treatment Poorly defined subjects No statistical analysis Constant XT's included Multiple Tx modalities
Goodacre, 1985[15] N = 27 (DE IXT) Retrospective	Overminus lenses with some orthoptics; 12 months with some follow-up to 67 months	Phoric at near, 6 m, and far. 63%, Not specified	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects Multiple Tx modalities
Caltrider and Jampolsky, 1983[16] N = 35 Retrospective	Overminus lenses; 2–156 months with median = 18 months Average = 35 months	Well controlled XP while wearing overminus lenses. 72%, 28%	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects

[a] Abbreviations: XP, exophoria; XT, exotropia; IXT, intermittent exotropia.

and the average prescription incorporated 2.50 D (range 1.25 to 3.75 D) of additional minus power. Overminus therapy was augmented by orthoptic procedures. Subjects were divided into two groups based upon whether a surgical procedure was eventually recommended. Those who eventually underwent surgery (35%) tended to have larger initial angles of deviation (both at far and near) and lower AC/A ratios.

Caltrider and Jampolsky[16] reported that 72% of their 35 subjects (ages 2 to 13 years) underwent a change from IXT to well controlled exophoria when wearing overminus lenses (2.00 to 4.00 D), and that 26% had a decrease of at least 15$^{\Delta}$ in the magnitude of the exodeviation. No assessment of binocular visual function beyond cover testing was reported. Duration of treatment ranged from 2 to 156 months with an average of 35 months. Ten successful subjects were followed for at least 1 year after discontinuing therapy; of these, 7 maintained their qualitative fusional improvements.

Various adverse effects have been related to use of overminus lens treatment. von Noorden[6] reported that accommodative asthenopia may occasionally occur during treatment, particularly among older children and adults. An additional hazard is the possible development of convergence excess esotropia at near as noted by Caltrider and Jampolsky.[16] This relatively rare occurrence can be avoided by appropriate diagnostic testing to determine which patients should be prescribed a bifocal lens when undergoing overminus lens treatment.

Development or increases of myopia might also be long-term risks of overminus lens correction. Such increases in myopia have been reported,[15, 16] especially among individuals who are slightly myopic at the start of therapy. To determine whether overminus lenses cause progression of myopia in IXT, Rutstein et al.[17] prescribed overminus power ranging from −0.50 to −3.75 D for 9 to 86 months. Myopia progression greater than 0.50 D per year was experienced by 25% of their pediatric exotrope sample (N=40). However, no relation was found between the rate of myopia progression and either the amount or duration of overminus therapy. The authors concluded that the rate of myopia progression was no greater than would have been expected without overminus treatment.

One obvious limitation in overminus lens therapy is that its use is limited to young patients with sufficient accommodative amplitude, and it has not been shown to be of value to the presbyopic patient. All the cited studies have involved pediatric patients. If a patient begins overminus therapy at a young age and is not able to discontinue this treatment, symptoms may eventually reappear during the early presbyopic years and some other treatment modality may have to be implemented.

Overminus Lens Success Rate

The overall rate of treatment success with overminus lens therapy, pooled across the 3 studies cited, is 28% (60 of 215). It is noteworthy that the pooled success rate increases to 68% if Kennedy's[14] historical study, which did not differentiate constant and intermittent exotropes, is eliminated. Overminus therapy for divergence excess IXT has been advocated as a desirable treatment approach when cost is considered or when travel distance for treatment is a factor.[15] It has also been suggested as a more continuous form of therapy when patient compliance in orthoptic therapy is poor,[16, 18] and as a temporizing procedure when a patient is awaiting surgical treatment.[16]

PRISM THERAPY

The use of prism in management of strabismus has a history in the vision care sciences dating from the late 1800s and continuing through current

times, especially in Europe,[6] where all forms of conservative treatment for IXT are used more frequently than in North America.[13] Prism use in modern times, as reported in the treatment of IXT, has primarily been limited to pre- or postsurgical application to facilitate binocular sensory fusion, although some IXT patients are treated solely by prism application. Use of prism in IXT has been more widely considered since the advent of Fresnel membrane prisms, which eliminate many of the problems of weight, cosmesis, and cost associated with conventional ophthalmic prisms.

There are three distinct approaches to prism therapy for management of IXT patients. The first involves prescribing prisms to compensate for a portion of the exodeviation, reducing the "demand" on fusional vergence (relieving or demand-reducing prisms). Ideally, this allows more stable fusion and reduces the frequency of the IXT. The second uses prisms that neutralize the entire exodeviation and thereby allow sensory fusion while the visual axes remain diverted (neutralizing prisms). The third involves prescribing base-in prisms beyond the value that neutralizes movement on the alternate cover test (overcompensating prisms) in an attempt to cause the IXT patient to converge to avoid the annoying diplopia that is introduced.

The three approaches to prism therapy differ in that the first two approaches are prescribed to wholly or partially compensate for an exodeviation in an effort to attain more continuous binocular sensory fusion. The third approach is prescribed to modify the exodeviation (see below) and to yield normal sensory fusion only when the overcompensating prisms are decreased in power or discontinued. Ideally all approaches involve the process of gradually reducing the prism power as fusional status improves.

Demand-Reducing (Relieving) Prism

Probably demand-reducing prism is the prism therapy modality most commonly used clinically, although studies of its efficacy have not been reported for management of IXT. Because IXT patients have normal sensory fusion a portion of the time, the clinical investigations of demand-reducing prisms in exophoric patients may be applicable. Worrel et al.[19] prescribed spectacle lenses with prism that provided fusional vergence reserves of at least 2 times the heterophoria for 43 patients, 26 of whom were exophoric. The young exophores (N = 21) did not prefer spectacles that contained prism, whereas 80% of the presbyopic subjects (N = 5) did. Payne et al.[20] prescribed prism that reduced the near fixation disparity to zero for 9 exophoric subjects. All 9 subjects had convergence insufficiency (greater exophoria at near than at distance), and preferred lenses with prism.

Neutralizing Prism

Hardesty[21] discussed the use of "fusing" (neutralizing) prism and suggested using a power midway between the values of the near and far deviation. In cases where this prism value did not elicit heterophoria at all distances, he recommended prescribing spectacles which have different prism powers in the upper and lower portions of the lenses. Such a prism prescription should be worn for a minimum of 6 months for adequate determination of the patient response, according to Hardesty. Other authors discuss the use of neutralizing prism in treating constant (rather than intermittent) exotropia,[22,23] so their reports are not included in this review. Studies of prism therapy which are included in this review are summarized in Table 3.

In a recent paper, Hardesty[24] reported on a series of 105 postsurgical patients with recurrent IXT who were treated with prism (neutralizing prism is implied, though not specified). Prisms were worn for 3 months to 15 years (average 14 months) and 34 of the patients (32%) were cured (no tropia, no ongoing treatment, stereopsis on Titmus Stereotest). He achieved best success with very young children who had a brief history of strabismus and manifested divergence excess IXT. Hardesty repeatedly emphasized the necessity of binocular fusion for achieving a long-term cure in IXT with any form of treatment.

A retrospective study of 12 young children who were prescribed neutralizing base-in Fresnel prism after surgical undercorrection of IXT has been presented by Pratt-Johnson and Tillson.[25] Subjects were prescribed prism equal to their maximum angle of deviation (near or far) which they wore more than 50% of the waking hours for 12 to 30 months. Based on measurements taken 1 month after prism therapy was discontinued, 8 (67%) subjects met the strict criteria for success: no tropia at any time, at least 40 sec arc stereopsis on the Wirt test, and presence of both positive and negative fusional vergence ranges. There was no success with patients who had a vertical component to their strabismus.

Overcompensating Prism

Prescription of overcompensating base-in prisms when a surgical procedure to correct an IXT results in an undercorrection (i.e., when an IXT remains or recurs after surgery) has been reported. The described rationale and treatment protocol involve prescription of at least 10^{Δ} of overcompensating base-in prism to move the retinal image in the deviating eye from the temporal to the nasal retina. Theoretically this produces previously unexperienced and troublesome diplopia which causes the patient to make a "convergent motor adaptation."[26] The adaptation consists of an increase in tonic convergence in order to move the image further into the periphery of the nasal retina where it causes less subjective confusion and may be more easily suppressed. When the convergent motor adaptation is complete, prism power and wearing time are gradually reduced and, ideally, the patient assumes phoric status due to the increase in tonic convergence which neutralizes the IXT.[21,26] In a later

TABLE 3. Prism therapy.[a]

Authors, Year, Sample Size, Type of Study	Treatment; Duration	Success Criteria. Success Rate. Failure Rate	Critique
Knapp, 1975[28] N = 5 IXT, N = 42 post-surgical XT Retrospective	Overcompensating prism; 6 months, some up to 3 yr	Unspecified criteria, success with IXT = 0%, success with XT = 14%. Not specified	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects No statistical analysis Postsurgical subjects included
Moore and Stockbridge, 1975[29] N = 44 Retrospective	Overcompensating or full neutralizing prism, some orthoptics; 1–24 months, average = 7 months	Constant fusion at all distances, phoria <12 XO. 11% Not specified	No control group Poorly defined subjects No statistical analysis Mostly postsurgical subjects Small sample (<50)
Hardesty, 1969[26], 1972[21] N = 7 Retrospective	Overcompensating prism, some orthoptics; 1–6 months	Constant fusion. 20–25% estimate. Not specified	No control group Small sample (<50) No statistical analysis Postsurgical subjects included Multiple Tx modalities
Veronneau-Troutman, 1971[30] N = 22 Retrospective	Overcompensating prism; less than 1 yr	Unspecified "good result." 23% Not specified	No control group Poorly defined success criteria Small sample (<50) Poorly defined treatment Poorly defined subjects No statistical analysis Postsurgical subjects included
Shippman et al., 1988[31] N = 13 Prospective	Overcompensating prism based upon PAT; 4–60 days	Improved fusion. 31% Not specified	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects No statistical analysis
Hardesty, 1990[24] N = 105 (all post-surgical) Retrospective	Neutralizing prism; 3 months to 15 yr, average = 14 months	No tropia, no ongoing therapy, stereopsis. 32% Not specified	No control group No statistical analysis Postsurgical subjects Poorly defined subjects
Pratt-Johnson and Tillson; 1979[25] N = 12 Retrospective	Neutralizing prism; 12–30 months	No tropia at any distance, 40 sec arc stereopsis. 67% Not specified	No control group Small sample (<50) No statistical analysis Postsurgical subjects included Poorly defined subjects

[a] Abbreviations: XT, exotropia; IXT, intermittent exotropia; XO, exophoria.

paper, Hardesty et al.[27] retreated from advocacy of overcompensating prism and said that, due to low rates of success, they had abandoned its use in favor of neutralizing prism.

Knapp[28] followed Hardesty's guidelines in treating 5 unoperated IXT's and 42 postsurgical undercorrected XT's. He prescribed prism that overcompensated the exodeviation by 10 to 15$^{\Delta}$ for full-time wear for a period of 6 months. None of the nonsurgical IXT's and 14% of the postsurgical XT patients converted from tropic to phoric status as a result of treatment. Little information was provided regarding patient characteristics or whether orthoptic therapy was administered during the period of prism therapy. Knapp cited the patients' refusal to wear the prism glasses as a major obstacle in treatment.

Moore and Stockbridge[29] used overcompensating prisms in treatment of 5 nonsurgical and 39 postsurgical IXT's. Orthoptic therapy was included "when appropriate." There was no success if therapy commenced more than 1 year after surgery. They attained a cure (constant fusion at all distances, phoria less than 12$^{\Delta}$ exo) rate of 11% after discontinuing prism therapy and concluded that prism therapy by itself was of no value. They suggested that it might have limited usefulness in conjunction with surgical treatment.

Hardesty, who has been a leading proponent of the use of prism therapy, estimated an overall cure (no tropia and no exophoria greater than 12$^{\Delta}$) rate of 20 to 25% among postsurgical undercorrected IXT patients he had treated using overcompensating prism.[21] His published studies[21, 26] of six successful cases showed that among those patients cured by this treatment, a convergent motor adaptation occurred (the patient's exodeviation lessened while wearing the overcompensating base-in prism) and the patient became phoric. This effect is confounded, however, by his emphasis upon the importance of orthoptic therapy being administered simultaneously with the prism therapy.

Veronneau-Troutman,[30] in a paper discussing prism therapy for all types of stabismus, reported

on 22 selected IXT's who had failed other treatment modalities or who were considered too young for other treatments. Subjects ranged in age from 8 months to 14 years and were prescribed prism that overcompensated the exodeviation by 5 to 10Δ. Approximately 23% attained an undefined "good result," and an additional 32% showed an undefined "improvement" associated with the prism treatment.

Shippman et al.[31] reported on 13 presurgical IXT's for whom overcompensating prism was prescribed as part of a preoperative diagnostic testing sequence. Prism powers that exceeded the maximum measured angle of deviation by 5Δ were worn full-time for 4 days to 2 months (average 1 to 2 weeks). The four subjects (31%) who were under 10 years of age showed improvement by demonstrating a "fusion" response on the Worth Dot test where there was initially (pretreatment) a suppression response.

Prism Success Rate

The overall rate of treatment success with prism therapy, pooled across the 8 studies specifically reporting IXT treatment, is 28% (56 of 201). The ease of treatment and generally lower cost (relative to VT or surgery) serve as the arguments in favor of prism therapy. A problem mentioned by several of the cited authors is difficulty in maintaining compliance with the prism treatment regimen, especially if the patient did not wear spectacles prior to the start of treatment. Cosmesis while wearing the prisms is a concern and cost may be a factor when frequent changes in prism power are required. Concerns about the weight of the prism spectacles have been mostly overcome with the advent of Fresnel prism, but even these thin membrane prisms are unacceptable to some patients due to poor cosmesis and/or reduced visual acuity.

Potential adverse effects associated with prolonged wear of prisms such as prism adaptation, where the angle of strabismus actually increases, remain largely unexplored in the clinical literature[32] regarding IXT. Hardesty[24] reported that this "exotropia drift" occurred only rarely among his patients who were treated with prism therapy.

The use of neutralizing vs. overcompensating prism appears to be a source of some debate. Pratt-Johnson and Tillson[25] and Hardesty[24] both used neutralizing prism, and both achieved better results than any of the investigators who used overcompensating prism. These two studies used criteria for cure that were rigorous relative to the other studies. Until further studies comparing the efficacy of neutralizing and overcompensating prism (and the usefulness of demand-reducing prism in IXT) become available, clinicians must use their own best judgment in determining appropriate strategies in applying prism therapy in treatment of IXT.

OCCLUSION THERAPY

For the individual with IXT to manifest the strabismic phase of the disorder without experiencing diplopia, either abnormal retinal correspondence (ARC) or suppression must occur. The goal of occlusion therapy (patching of one eye) is to limit binocular stimulation and thereby eliminate the need for ARC responses or suppression to avoid diplopia. Treatment regimens vary from full-time occlusion for all waking hours to part-time occlusion for 1 to several hours each day. When the suppression or ARC pattern has been changed, patching is reduced or discontinued and, in theory, fusional processes became active to restore heterophoria.

Although used routinely in the treatment of amblyopia, occlusion therapy by itself is not widely accepted as a complete treatment for IXT.[33] Because amblyopia rarely occurs in IXT, occlusion is probably used less often in IXT than for patients with esotropia. Temporary occlusion is sometimes prescribed in conjunction with surgical treatment of IXT to eliminate diplopia or treat an occasional shallow concurrent amblyopia. Patching is also used to disrupt suppression as part of an VT treatment program. Despite the accepted notion that occlusion is not a complete treatment for IXT, recent survey results by Romano revealed that it is the most commonly used conservative treatment modality among members of the American Association for Pediatric Ophthalmology and Stabismus[12] and among members of the International Stabismus Association.[13]

Reynolds and Wackerhagen[34] reported on a mix of 25 "neurologically normal and abnormal" IXT patients who were under 26 months of age when occlusion therapy commenced. Of the original subjects, 16 successfully completed at least 3 months of 4 h/day occlusion therapy. Four of the patients initially showed improvement, and one (6%) was judged to achieve "a persistent improvement in angle character" associated with the treatment (see Table 4).

Flynn et al.[33] used full-time adhesive occlusion for 6 to 12 weeks in a group of 31 IXT patients having an average age of 7.6 years. The angle of exodeviation averaged about 20Δ in the distance and 15Δ at near. Nine of the subjects had postsurgical IXT's. Results were divided into "sensory effects" (improved diplopia awareness, 50% increase in fusional vergence ranges, disappearance of suppression scotoma) and "motor effects" (improved control of exodeviation). After completing occlusion therapy, 68% of the subjects showed some positive change in response to treatment (23% showed both sensory and motor effects, 16% showed a sensory effect only, and 29% showed a motor effect only). All subjects demonstrating a sensory effect also reported greater awareness of diplopia, indicating that the occlusion therapy had an effect in reducing suppression. A conversion from IXT to exophoria occurred in 26% of the

TABLE 4. Occlusion therapy.

Authors, Year, Sample Size, Type of Study	Treatment; Duration	Success Criteria. Success Rate. Failure Rate	Critique
Reynolds and Wackerhagen, 1988[34] N = 16 Retrospective	Part-time occlusion; 3 months minimum	Improvement in fusional control. 6% Not specified	No control group Small sample (<50) Poorly defined success criteria No statistical analysis All subjects <26 months of age
Flynn et al., 1976[33] N = 31 Retrospective	Constant occlusion; 6–12 weeks	No tropia at distance or near. 26% 39%	Small sample (<50) No statistical analysis Postsurgical subjects included
Freeman and Isenberg, 1989[35] N = 11 Prospective	Part-time occlusion; 6 months with follow-up @ 3–37 months (average = 22 months)	Heterophoria. 100% success initially, 27% success long-term. Not specified	No control group Poorly defined success criteria Small sample (<50) No statistical analysis All subjects < 6 yrs of age
Cooper and Leyman, 1977[36] N = 11 Retrospective	Occlusion (unspecified); unspecified duration (estimate 12–15 weeks)	Exophoric at 60 m, 6 m, and 33 cm, and stereopsis. 36% Not specified	Small sample (<50) Poorly defined treatment No statistical analysis
Chutter, 1977[37] N = 46 Retrospective	Full-time and part-time occlusion with some orthoptics; 3–12 weeks	Became phoric at all distances. 41% 2%	Small sample (<50) No control group Poorly defined success criteria No statistical analysis Multiple Tx modalities
Iacobucci and Henderson, 1965[38] N = 17 Retrospective	Constant occlusion; 3 months	No post-tx tropia where initially present. Distance, 53%; Near, 70%. Not specified	Poorly defined success criteria Small sample (<50) Poorly defined subjects
Spoor and Hiles, 1979[39] N = 38 Prospective	Part-time occlusion; 3–42 months, 15 month average	No post-tx tropia where initially present. Distance, 54%; Near, 50%. 11%	Small sample (<50) Poorly defined subjects No control group No statistical analysis Postsurgical subjects included Nearly all subjects < 6 years of age

subjects, whereas the size and frequency of the deviation worsened in 39%.

Freeman and Isenberg[35] evaluated the efficacy of 4 to 6 h/day of occlusion therapy for 6 months in treatment of IXT among children 9 months to 5 years of age. All (100%) of their 11 subjects "converted to hetero- or orthophoria, at least temporarily." Three (27%) became and remained orthophoric. On long-term follow-up, 27% developed a constant exotropia which subsequently required surgery and surgery was "contemplated" for 5 others who remained with IXT. Little information was provided concerning sensory status.

In Cooper and Leyman's[36] study comparing different treatment modalities for IXT, 11 subjects were treated only with undefined occlusion therapy. In this group, 4 subjects (36%) became completely phoric with normal sensory function, 3 subjects (27%) showed improved binocular function as a result of treatment, and 4 subjects had a poor response. These authors recommended occlusion therapy as "useful in breaking down suppression."

Chutter[37] investigated the efficacy of occlusion therapy for the purposes of reducing suppression, improving visual acuity in the nonpreferred eye, and improving fusion ranges in a sample of 46 IXT patients, most of whom were between the ages of 4 and 10 years. Both full-time occlusion (all waking hours) and part-time occlusion (3 to 8 h/day) were used for 3 to 12 weeks. Based upon cover testing and synoptophore fusion ranges, 76% of the subjects "demonstrated stronger fusion" and 41% "became exophoric." Twelve of the subjects with convergence insufficiency IXT underwent simultaneous convergence orthoptic treatment and, among these, 100% "demonstrated stronger fusion" and 58% became exophoric. Best results were seen with smaller exodeviations (10 to 25$^{\Delta}$), and results were equivalent using full-time or part-time patching. One subject developed constant diplopia.

Iacobucci and Henderson[38] investigated the efficacy of constant occlusion for periods ranging up to 3 months. They reported only data related to motor status for their patients and, based upon their success criterion, 53% of their 17 IXT subjects "demonstrated stronger fusion" as evidenced by a conversion from IXT to exophoria on cover/uncover testing at distance. The experimental subjects

demonstrated an approximate 5Δ decrease in their average exodeviation at both distance and near, whereas the control subjects showed a 2 to 3Δ increase during the same study period.

Spoor and Hiles[39] used the same success criterion as Iacobucci and Henderson[38] in a prospective evaluation of occlusion therapy in a group of 38 infants and young children (average age, 29 months). After 3 to 42 months of part-time adhesive occlusion of the preferred eye, 54% of the patients who initially had a 6 m manifest tropia displayed a latent deviation at 6 m, and 50% of the patients who initially had a 33 cm manifest tropia displayed a latent deviation at 33 cm. Among the successful patients, there was a decrease of 9Δ in the mean exodeviation at 6 m, and a decrease of 2Δ in the mean exodeviation at 33 cm. Four patients experienced conversion of an initially latent exodeviation to a manifest exodeviation associated with the occlusion treatment. Better results were obtained with patients who had initial exodeviations less than 20Δ and who had good ability to fixate centrally.

Occlusion Success Rate

The overall rate of treatment success with occlusion therapy, pooled across the 7 studies, is 37% (63 of 170). The cited authors do not generally recommend occlusion as the sole treatment for IXT and there is some reported incidence of worsening of IXT with occlusion therapy. However, it appears that occlusion can be effective in reducing suppression for certain individuals, and it is used by some practitioners as a means of postponing surgery.[35]

EXTRAOCULAR MUSCLE SURGERY

Many clinicians who treat strabismus regard surgery as the treatment of choice for IXT.[4, 6, 40, 41] The most common procedure involves bilateral recession of the lateral rectus muscles. Other procedures include unilateral recession of the lateral rectus with resection of the medial rectus, unilateral recession of the lateral rectus, bilateral resection of the medial recti and, in some cases, simultaneous surgery on four or more of the extraocular muscles. Relocation of the insertion point(s) changes the balance of rotational forces exerted by the extraocular muscles in an attempt to achieve a more normal motor alignment of the eyes, and is intended to decrease the magnitude and frequency of the strabismus. Debate continues about the appropriateness of surgical treatment for convergence insufficiency IXT and for other types of IXT when there is less than 20Δ of distance exodeviation.[36, 41–45]

Many of the surgery studies reviewed here were designed to answer questions other than the efficacy of the treatment per se. The earliest studies were concerned with determining the best type and amount of surgery to perform and whether different diagnostic subcategories of IXT required different surgical techniques. Some studies compared success rates between intermittent and constant exotropia; others attempted to isolate additional factors which might influence surgical outcome such as refractive condition, AC/A ratio, age, size of the exodeviation, presence of amblyopia, and use of pre- or postsurgical orthoptics. Efficacy of surgery alone was difficult to ascertain in some studies as surgical management was often combined with other forms of therapy including overminus lens prescriptions, occlusion, and VT. Research to improve surgical protocol and increase success in surgical treatment of IXT is ongoing.[46, 47]

Reported success rates over the last 35 years vary from 12 to 89%, probably because of variation in treatment protocols, differences in sensory and motor characteristics of subjects, and differences in definition of what constitutes success. Some investigators define postsurgical success only in terms of motor deviation, "angle of deviation of the eyes within 10Δ of ortho" (e.g., Raab and Parks[48]); others do not consider surgery successful unless sensory fusion with stereopsis and convergence capability is present at all distances and at all times (e.g., Cooper and Leyman[36]). An inverse relation between rigor of success criteria and the percentage of success with surgical treatment is apparent in the summary of research studies in Tables 5 and 6 Although it is hazardous to compare rates of success across surgery studies due to the factors mentioned above, the information in Tables 5 and 6 organized by success rate indicates that studies from recent years tend to show higher rates of surgical success after one operation.

Surgical Studies Using Cosmetic Success Criteria

Studies which used a cosmetic appearance criterion tend to report higher success rates than those considering sensory status. In the studies reviewed, the poorest success rate using a cosmetic alignment criterion was 46% by Windsor,[49] but his criterion was somewhat more stringent in that he did not consider a case to be a surgical success if the patient showed a postsurgical tropia (cover test) under the same conditions where a presurgical tropia existed. Better success was reported by Capo et al.,[50] who compared efficacy of hang-back bilateral recession to conventional bilateral recession. They used a cosmetic alignment success criterion (postsurgical deviation within ±8Δ of ortho) and reported a success rate of 77% among 47 subjects, some of whom originally had constant XT. Schlossman et al.[45] used an "alleviation of symptoms" criterion that yielded a 93% success rate among 44 patients, but their data revealed a lower success rate (68%) based upon a criterion of "no tropia near or far." Follow-up periods for determination of success varied between studies from 6 weeks to greater than 7 years (Table 5).

TABLE 5. Surgery studies using cosmetic success criteria.[a]

Authors, Year, Sample Size, Type of Study	Treatment; Follow-Up Period	Success Criteria. Success Rate. Failure Rate	Critique
Windsor, 1971[49] N = 37 Retrospective	Surgery-mixed, most recession/resection, some orthoptics; 4 months–5 yr follow-up	No tropia on cover test where tropic before Tx. 46% Not specified	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects No statistical analysis
Rabb and Parks, 1975[48] N = 93 Retrospective	Surgery-unspecified; 5-yr average	Deviation within ±10Δ 55% Not specified	No control group Poorly defined success criteria Poorly defined subjects No statistical analysis
Richard and Parks, 1983[83] N = 111 Retrospective	Surgery-bilateral recession; 2-yr minimum, average = 4 yr	IXT ≤10Δ @ 20 ft. Success = 56% Failure = 44%	No control group Poorly defined subjects
Scott et al., 1981[84] N = 65 Retrospective	Surgery-mixed; 6 weeks, some follow-up to 2 yr	Exodeviation within ±9Δ (66% includes success with constant XT's). Not specified	No control group Poorly defined success criteria Poorly defined treatment Poorly defined subjects No statistical analysis
Capo et al., 1989[50] N = 47 (includes XT's) Prospective and Retrospective	Surgery-bilateral recession and hangback recession; success rates @ 6 weeks, 16 months average follow-up	Deviation within ±8Δ 77% Not specified	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects Constant XT's included
Schlossman et al., 1983[45] N = 44 Retrospective	Surgery, 89% recession/resection; 4–90 month follow-up	1. Alleviation of symptoms. 2. No tropia @ near or far 1. 93% 2. 68% 7%	No control group Poorly defined success criteria Small sample (<50) No statistical analysis
Hamtil and Place, 1978[85] N = 9 Retrospective	Surgery-bilateral recession; 2–12 months	Deviation within ±10Δ 100% 0%	No control group Small sample (<50) Poorly defined subjects No statistical analysis

[a] XT = exotropia; IXT = intermittent exotropia.

Surgical Studies Using Functional Success Criteria

Investigators who have used relatively rigorous functional criteria for success such as Cooper and Leyman[36] or Paakkala[42] report success rates of approximately 40% after 1 surgical procedure. The success criteria used in these studies involve demonstration of phoria at all (or several) distances and, in many studies, demonstration of stereopsis.[27, 36, 42, 51–53] Ron and Merin[46] used functional success criteria (no tropia for distance or near, and stereopsis at 40 cm) and attained a success rate of at least 75% among 24 patients with divergence excess IXT, although stereopsis was not measured at the distance where the divergence excess IXT tends to manifest. They attributed their high rate of success to use of the prism adaptation test to determine how much surgery should be done.

Strabismus surgery carries with it all the risks of any invasive procedure involving general anesthesia and is, therefore, rejected by many potential surgical patients who might otherwise benefit. IXT has long been recognized as a difficult and frustrating treatment problem because of its high recurrence rate after surgery.[54, 55] Repeated surgeries are common, with about 45 to 50% of IXT patients requiring more than 1 operation in some studies.[42, 55, 56] Over- and undercorrections frequently occur,[41, 53, 57] so these patients are often treated postsurgically with prism therapy, overminus lens therapy, or VT. Postsurgical persistent diplopia has been documented,[47] and is probably a greater risk among adults. IXT patients who are nonconcomitant or who have associated vertical deviations are a particular surgical challenge; results with these cases are so unpredictable that they are routinely excluded from published studies which report rates of treatment success. Debate continues as to the best treatment approaches when incomitance is present.[58–60]

Surgery Success Rate

Compilation, by pooling the results of the 28 surgery studies reviewed (see Tables 5 and 6), indicates that the overall success rate of surgery for treatment of IXT is 46% (1171 of 2530). The success rate in 7 studies which use a cosmetic alignment criterion is 61% (248 of 406), whereas the 20 cited studies which use some form of functional success criterion have a pooled success rate of 43% (923 of 2124). It is clear that the surgical success rate in IXT has improved over the years. If we

TABLE 6. Surgery studies using functional success criteria.[a]

Authors, Year, Sample Size, Type of Study	Treatment; Follow-Up Period	Success Criteria. Success Rate. Failure Rate	Critique
Dunlap and Gaffney, 1963[41] N = 100 Retrospective	Surgery-mixed; 12-month minimum	Phoric @ 60 m, 6 m, and 0.33 m, vergence ranges at far & near. 12% 18% multiple surgery, 43% under or overcorrected	No control group No statistical analysis
Folk, 1956[86] N = 50 Retrospective	Surgery-mixed; 2-yr average	Fusion in amblyoscope, diplopia awareness. 28% Not specified	No control group Poorly defined success criteria Poorly defined subjects No statistical analysis
Moore, 1963[82] N = 106 Retrospective	Surgery-mixed, mostly bilateral recession; antisuppression training, occlusion 10 months to 10 yr	Exophoric @ far distance, distance, and near, motor fusion ranges with no suppression. 30% 27%	Subjects not rigidly defined Limited statistical analysis Multiple Tx modalities
Mulberger and McDonald, 1954[87] N = 25 Retrospective	Surgery-bilateral recession; Not specified	"Eyes straight and fusion is present". 32% 8%	No control group Poorly defined success criteria Small sample (<50) Poorly defined subjects
Moore, 1963[82] N = 57 Retrospective	Surgery-mixed; mostly bilateral recession 10 months to 10 yr	Exophoric @ far distance, distance, and near, motor fusion ranges with no suppression. 33% 16%	Subjects not rigidly defined Limited statistical analysis
Johnson, 1958[88] N = 52 Retrospective	Surgery-mixed; Not specified	Constant fusion, no tropia on cover test. 35% 8%	No control group Poorly defined success criteria Poorly defined subjects No statistical analysis Postsurgical subjects included
Paakkala, 1982[42] N = 422 Retrospective	Surgery-mixed; 2–36 months	1. Deviation within ± 9$^{\Delta}$ 2. Improved stereopsis. 1. 55% 2. 39% 53% multiple surgeries	No control group No statistical analysis Postsurgical subjects included Multiple surgeries counted as success
Pratt-Johnson et al., 1977[52] N = 100 Prospective	Surgery-95% bilateral recession; 12-month minimum	No tropia at any distance, 40 sec arc stereopsis at near, no suppression. 41% 19% (Tr > 10$^{\Delta}$)	No control group Poorly defined treatment No statistical analysis Postsurgical subjects included
Velez, 1976[89] N = 106 Retrospective	Unspecified surgery, antisuppression treatment, orthoptics, prism, overminus; 1–6 yr	Phoria near and far (−10 to +8$^{\Delta}$) 41% 32%	No control group Poorly defined treatment No statistical analysis Poorly defined subjects Multiple Tx modalities Poorly defined success criteria
Cooper and Leyman, 1977[36] N = 264 Retrospective	Surgery-unspecified and some occlusion 12-month minimum	Phoric @ 60 m, 6 m, and 0.33 m, stereopsis, convergence ranges @ 6 m and 0.33 m. Success = 42% Failure = 17%	Poorly defined subjects No statistical analysis Multiple Tx modalities
Clarke and Noel, 1981[53] N = 78 Retrospective	Surgery-recession/resection; 21-month average	8 eso to 8 exo all distances, no tropia, stereopsis. 42% 50% undercorrected	No control group No statistical analysis Postsurgical subjects included Poorly defined subjects
Altizer, 1972[66] N = 16 Retrospective	Not specified; approximately 12 months	Phoric with fusional convergence ability. 44% Not specified	Small sample (<50) Poorly defined treatment Poorly defined subjects No statistical analysis
Newman and Mazow, 1981[44] N = 30 Retrospective	Surgery-bilateral recession, recession/resection; mean = 2 yr	Exophoric @ distance and near. 47% 33%	Poorly defined success criteria Small sample (<50) Poorly defined treatment No statistical analysis Postsurgical subjects included

TABLE 6. —Continued

Authors, Year, Sample Size, Type of Study	Treatment; Follow-Up Period	Success Criteria. Success Rate. Failure Rate	Critique
Bedrossian, 1962[56] N = 35 Retrospective	Surgery recession/resection; 1–7 yr	Normal fusion @ far and near, residual deviation ≤10Δ. 49% 51% multiple surgeries	No control group Small sample (<50) No statistical analysis
Zibrandtsen et al., 1986[8] N = 25 Retrospective	Surgery-mixed, some orthoptics; 10-yr minimum	Asymptomatic exophoric at far and near distance. Success = 52% Failure = 16%	No control group Small sample (<50) Poorly defined subjects Multiple Tx modalities Postsurgical subjects included
Cooper and Leyman, 1977[36] N = 216 Retrospective	Surgery and orthoptics; 12-month minimum	Phoric @ 60 m, 6 m, and 0.33 m, stereopsis, convergence ranges @ 6 m and 33 cm. 52% 10%	Poorly defined subjects No statistical analysis Multiple Tx modalities
Burian and Spivey, 1965[90] N = 98 Retrospective	Surgery-mixed, some orthoptics; 31-month average	Phoric at far and near. 55%. 45% continued tropia, 13% multiple surgeries.	No control group Poorly defined success criteria Limited statistical analysis Multiple Tx modalities
Hardesty et al., 1978[27] N = 100 Unspecified	Surgery-bilateral recession, prism, orthoptics; 6.1-yr average	No tropia at distance or near, stereopsis. 57% w/1 surgery 21% multiple surgeries	No control group Multiple Tx modalities
Reynolds and Wackerhagen, 1988[34] N = 19 Retrospective	Surgery-bilateral recession; Follow-up unspecified	Ortho or esophoric. 58% Not specified	No control group Small sample (<50) Poorly defined success criteria No statistical analysis
Fletcher and Silverman, 1966[51] N = 76 Retrospective	Surgery-mixed; not specified	Fusional amplitudes @ near and far, no suppression, no XT except when ill or tired. 59% Not specified	No control group Poorly defined success criteria Poorly defined subjects No statistical analysis
McNeer, 1987[57] N = 58 Prospective	Surgery-bilateral recession, postsurgical overminus, prism and orthoptics; 2-yr minimum	No tropia with cover test at distance or near. 62% 38% XT or ET	No control group Poorly defined success criteria Poorly defined subjects No statistical analysis Multiple Tx modalities
Kushner, 1988[58] N = 67 Prospective	Surgery-bilateral recession; 1 yr minimum	Phoria within +5 to −10Δ at distance and near. 64% Not specified	No control group Poorly defined subjects No statistical analysis
Ron and Merin, 1988[46] N = 24 Prospective	Surgery-bilateral recession based upon prism adaptation test. 6 months–7 yr	No tropia, no A/V pattern, stereopsis. Approximately 75% 13%	No control group Small sample (<50) No statistical analysis

[a] Abbreviations: XP = exophoria; XT = exotropia; ET = esotropia; Tr = tropia.

remove from the pooled data the 6 studies included in the review which are more than 25 years old, the resulting pooled success rate becomes 52% (1015 of 1939).

Surgical studies also report worsening in some patients. For example, progression of IXT in terms of increased angle of deviation has been reported during 5- and 10-year follow-up periods after surgery.[8, 61] McClintic and McNeer[61] reported a persistent exotropic drift rate of 0.21Δ per month when they followed a group of postsurgical exotropic patients over a 5-year period. Also, based on the reports of surgical failures in the papers reviewed, surgery does not improve (or worsen) IXT in 32% of patients (662 of 2060; data pooled across studies that reported failure rates).

ORTHOPTIC VISION THERAPY

Treatment procedures for IXT include various feedback techniques to facilitate increased vergence control and enhanced sensory fusion. Reports showing the utility of these procedures have existed for over 40 years.[62] These techniques have been called orthopics, vision therapy, or vision training by different clinicians and investigators, and here will be collectively termed orthoptic vision therapy (VT). Efficacy of VT for IXT, as reported in a review by Duckman,[63] ranges from 43 to 100%, with

TABLE 7. Orthoptic VT.

Authors, Year, Sample Size, Type of Study	Treatment; Duration	Success Criteria. Success Rate. Failure Rate	Critique
Moore, 1963[82] N = 17 Retrospective	Anti-suppression training, occlusion; 2 months	XP @ far distance, distance, and near, motor fusion ranges w/no suppression. 0% 82%	Small sample size (<50) Treatment not rigidly defined Subjects not rigidly defined Limited statistical analysis
Newman and Mazow, 1981[44] N = 30 Retrospective	Vision therapy, overminus lenses, and occlusion; approximately 12 months	XP @ distance and near. 40% 33%	Small sample size (<50) Treatment not rigidly defined Success not rigidly defined No statistical analysis Postsurgical patients included Multiple Tx modalities
Daum, 1984[72] N = 13 (DE) Retrospective	VT, some prism; 1–16 weeks, mean = 5.5	Sheard's criterion @ far and near, no symptoms, normal accommodative amplitude, no sensory adaptations. 33% 6%	No control group Small sample size (<50) Subjects not rigidly defined Mixed diagnostic conditions Success not rigidly defined Multiple Tx modalities
Daum, 1984[70] N = 22 (CI) Retrospective	VT, some prism; 1–34 weeks, mean = 4.3	Sheard's criterion @ far and near, no symptoms. 41% 3%	No control group Small sample size (<50) Subjects not rigidly defined Mixed diagnostic conditions Success not rigidly defined Multiple Tx modalities
Ludlam and Kleinman, 1965[74] N = 58 Retrospective	VT; 6–29 weeks	Phoric at all distances, stereopsis, normal fusion ranges. 52% Not specified	No control group No statistical analysis Subjects not rigidly defined
Pantano, 1982[75] N = 207 Retrospective	VT-home-based, some overminus; 1 month, followup to 2 yr	No symptoms, normal fusional ranges, NPC w/in 8 cm. 53% 5%	No control group Mixed diagnostic conditions Mixed Tx modalities No statistical analysis
Daum, 1984[71] N = 24 (BXO) Retrospective	VT, some prism; 1–56 weeks, mean = 7.6 weeks	Sheard's criterion @ far and near, no symptoms, normal accommodative amplitude, no sensory adaptations. 56% 4%	No control group Small sample size (<50) Subjects not rigidly defined Mixed diagnostic conditions Success not rigidly defined Multiple Tx modalities
Cooper and Leyman, 1977[36] N = 182 Retrospective	VI; 12–15 weeks average	Phoric @ 60 m, 6 m, and 0.33 m, stereopsis, convergence ranges @ 6 m and 33 cm. 59% 6%	No statistical analysis
Altizer, 1972[66] N = 13 Retrospective	VT, constant occlusion, and prism; approximately 12 months	Phoric with fusional convergence ability. 69% Not specified	Small sample size (<50) Subjects not rigidly defined No statistical analysis Multiple Tx modalities
Pickwell, 1979[91] N = 14 Retrospective	VT; Not specified	Phoric at distance and near, no diplopia. 71% 14% (discontinued Tx)	No control group Small sample size (<50) Subjects not rigidly defined No statistical analysis
Goldrich, 1982[76] N = 7 Retrospective	VT; 8–17 weeks	Exophoric on distance and near cover test, XT < 10% of time. 71% Not specified	No control group Small sample size (<50) No statistical analysis

TABLE 7.—Continued

Authors, Year, Sample Size, Type of Study	Treatment; Duration	Success Criteria. Success Rate. Failure Rate	Critique
Kertesz and Kertesz, 1986[77]	VT; 6–16 weeks	XP at 60 m, 6 m, and 0.33 m, stereopsis, no symptoms.	No control group Poorly defined subjects
N = 38		76%	No statistical analysis
Retrospective		24%	Small sample (<50)
Sanfilippo and Clahane, 1970[78]	VT; not specified	XP at far distance, distance, and near, fusion w/no suppression.	No control group Small sample (<50)
N = 23			Poorly defined subjects
Retrospective		78%	No statistical analysis
		0%	
Chryssanthou, 1974[79]	VT; 3–16 weeks	XP at far distance, distance, and near, fusion w/no suppression.	No control group Small sample (<50)
N = 27			Poorly defined treatment
Retrospective		78%	No statistical analysis
		11%	
Goldrich, 1980[67]	VT; 20 weeks average	XP on distance and near CT, stereopsis, no Sx;	No control group Small sample size (<50)
N = 28		82%	No statistical analysis
Retrospective		4%	
Etting, 1978[80]	VT; 20 weeks average	XP at all distances, stereopsis present.	No control group Small sample (<50)
N = 15		87%	Poorly defined treatment
Retrospective		Not specified	Poorly defined subjects No statistical analysis Postsurgical subjects included
Hoffman et al., 1970[81]	VT; not specified	Phoric at all distances, stereopsis, normal fusional ranges.	No control group Small sample (<50)
N = 22		95%	Poorly defined treatment
Retrospective		0%	Poorly defined subjects

optometric studies generally reporting higher rates of success than those reported in the medical literature. Once again, a major factor contributing to differences in efficacy between studies, as is the case in the literature related to other treatment modalities, is the definition of a successful treatment outcome. Because of the variability, the cited authors' stated outcome measures are listed when possible in the review which follows and in Table 7.

A further reason that optometric studies might have higher rates of success is a difference in the structure of the treatment programs. Flax and Duckman[64] have suggested that optometric and medical VT approaches differ in several ways, including: optometric VT frequently involves more "active" treatment (involving patient participation) vs. "passive" treatment (such as added lenses and/or occlusion), increased frequency of in-office treatment sessions, and more diverse treatment procedures. Descriptions of the actual techniques and procedures used in VT are found throughout the literature. Representative examples may be found in Ludlam,[65] Altizer,[66] Goldrich,[67] Goldstein,[68] and Hess and Stegall.[69]

Daum applied a statistical approach in an attempt to identify prognostic factors and induced changes in visual function associated with VT in exodeviations. Each of his three retrospective papers[70–72] addresses one particular type of exodeviation; all three types are considered together in a later paper.[73] In his papers, Daum does not consistently separate patients with latent, intermittent, or constant deviations, and his findings for treatment success represent a composite rate independent of initial frequency of deviation. In all the studies, the therapy procedures were similar, well documented, and nearly all home-based. Office sessions were scheduled every 1 to 2 weeks for review of the home activities. The criteria for total success were attainment of Sheard's criterion at near and far (magnitude of exodeviation is less than half the reserve fusional convergence range), freedom from subjective complaints, absence of any sensory adaptation, and establishment of normal amplitude of accommodation. Partial success was attained if either the objective or subjective deficiencies were alleviated, but not both, or some relief was obtained in either or both categories.

Daum's study of convergence insufficiency[70] included 22 IXT's among 110 reported cases. Subjects averaged 20 years of age (range 2 to 46 years). Duration of therapy averaged 4.3 weeks (range 1 to 34 weeks). For the entire convergence insufficiency sample (20% were IXT's), Daum reported total success in 41% and partial success in 56%. He found that older subjects required a shorter therapy period and that significant post-therapy positive changes occurred in the following areas: decreased near angle of deviation, increases stimulus AC/A ratio, increased blur and recovery divergence ranges, increased convergence ranges at near and far, increased NPC, and amplitude of accommodation. He found no significant change in the distance phoria.

Daum's study of basic exodeviations[71] reported 24 cases of IXT among 49 patients. Twelve of those with IXT also had vertical deviations. Subjects averaged 20 years of age (range 4 to 56 years). Duration of therapy averaged 7.6 weeks (range 1 to 56 weeks). For the entire basic exo sample (49% were IXT's), Daum reported total success in 56% and partial success in 40%. Better results were obtained with subjects who initially had good stereopsis, better NPC values, and less frequent deviations. Subjects who initially experienced blur as a symptom also had better outcomes.

Daum's study of divergence excess cases[72] reported 13 IXT's among 18 patients. Subjects averaged 14 years of age (range 4 to 34 years). Duration of therapy averaged 5.5 weeks (range 1 to 16 weeks). For the entire divergence excess sample (72% were IXT's), Daum reported total success in 33% and partial success in 61%. Better results were obtained by those subjects who initially had smaller distance deviations, lower AC/A ratios, and no vertical deviation.

Ludlam's[65] study was the first major optometric investigation of the efficacy of VT in the treatment of all types of strabismus. Included in his retrospective analysis of 149 patients were 58 IXT's, most of whom were under 15 years of age. The patients had no prior surgery, could not be cured via refractive lens prescription alone, were concomitant, had completed at least 8 sessions of orthoptic therapy, and had angles of deviation up to 60$^{\Delta}$ with most less than 30$^{\Delta}$. Therapy sessions were conducted in groups (usually 2 or 3 patients with 1 clinician) twice weekly for 45 min and were administered by different clinicians in a university clinic. Duration of therapy ranged from 10 to 76 in-office sessions (mean=23) which were supported by daily home training. Therapy activities were well detailed and included various forms of occlusion, ocular motility training, overminus lens application, fusion training, eye-hand coordination, and accommodative-convergence training. Ludlam slightly modified the Flom criteria[1] by adding the requirement that normal binocular function be present in all positions of gaze for a case to be considered a complete success. Flom's original criteria for complete success included: clear, comfortable binocular vision at all distances up to the NPC, normal NPC, stereopsis and normal motor fusion ranges, a 1% frequency of tropia is allowed provided that diplopia is noticed at these times, and up to 5$^{\Delta}$ prism may be worn in spectacles. The criteria for partial success were: may lack stereopsis, may exhibit strabismus with diplopia awareness up to 5% of the time, and may need larger amounts of prism to maintain comfortable binocular vision. Based upon these criteria, Ludlam's study revealed complete success in 52% of subjects and partial success in 40% (total success rate = 92%). He found greater success with subjects who attended their therapy sessions regularly, and poorer success in subjects with early onset strabismus, ARC, and angles of deviation greater than 30$^{\Delta}$. In a 3-year follow-up of 32 of the originally successful subjects, Ludlam and Kleinman[74] found that 63% remained in the complete success category.

Treatment of convergence insufficiency exodeviations was considered by Pantano.[75] She administered 1 month of 20-min-per-day home VT to 207 adults (mean age 26 years) who could demonstrate normal bifoveal fusion. She did not differentiate success rates for patients with latent exodeviations from those with IXT, and reported that 53% of the sample attained her success criteria of no symptoms, normal motor fusion ranges at near and far, and NPC inside 8 cm. Among those who were initially cured, 100% maintained their improved status without further VT during a 2-year follow-up period.

Goldrich[67] reported the results of VT for 28 divergence excess IXT's between the ages of 5 and 35 years who were treated in a university clinic setting. He excluded subjects who had prior surgery, amblyopia, vertical deviations greater than 4$^{\Delta}$, and angles of horizontal deviation greater than 35$^{\Delta}$. VT included training for ocular motility, accommodation, fusion, antisuppression, and stereoscopic skills. Monocular abilities were trained before commencing binocular therapy. Therapy sessions were scheduled weekly, lasted 45 min, and were supported by home therapy. Treatment duration varied relative to the defined outcome category. *Excellent* outcomes were defined as: phoric on distance and near cover test, no asthenopia, normal Keystone Skills tests, normal fusional ranges at distance and near, stereopsis at all distances, and ability to attain fusion through ±2.00 lenses within 3 s. *Good* outcomes were the same as *excellent* outcomes except that one or more deviant Keystone Skills tests were allowed. *Fair* outcomes were defined as: IXT observed on distance cover test, no asthenopia, Keystone Skills tests show one or more deficiencies, improved but below normal fusional ranges at distance and near, improved stereopsis at all distances, and satisfactory monocular and binocular accommodative facility. The number of treatment sessions in the excellent outcome category averaged 20.2 with a 71% success rate; in the good outcome category, 28.3 with an 11% success rate; and in the fair category, 40 with a 14% success rate (82% total success rate in the excellent and good outcome categories). He found better success with children over 6 years of age.

In a subsequent prospective study, Goldrich[76] studied the efficacy of auditory biofeedback in the treatment of exotropia. He constructed an infrared eye position monitoring system which emitted a tone when the patient's eyes moved toward the exotropic position. Seven IXT patients were included in his sample of 12 exotropes, and he attained an identical success rate (71% in the excellent category) with the IXT patients as he had in his earlier study which used conventional VT procedures. Success criteria were similar to those in

the 1980 study.[67] Subjects underwent 8 to 17 weekly treatment sessions. Goldrich concluded that the auditory biofeedback technique was effective and suggested that it had advantages over conventional VT because it improved patient motivation and decreased treatment time.

Kertesz and Kertesz[77] used computer-generated anaglyphic wide-field conventional and random dot stimuli presented at 1 m on a video monitor. Their subjects (N=38) had 30-min treatment sessions twice weekly for a total of 8 to 25 sessions. They attained 76% success using the criteria of Cooper and Leyman[36]: heterophoria at all distances, ample positive fusional ranges at both distance and near, NPC inside 5 cm, 40 sec arc stereopsis on the Titmus test, good recovery of fusion when lost during cover testing, normal Worth 4-Dot test at 6 m, no asthenopia or other symptoms, and only occasional tropia when fatigued. They were successful with young children (4.5 years) and found "plasticity of the fusional mechanism, even in adults."

Sanfilippo and Clahane[78] reported a similar success rate (78%) in a retrospective study which included 23 patients with IXT. Follow-up examination at 54 to 78 months after completion of treatment showed 78% had maintained their original success. They concluded that incomitancy and vertical deviations adversely affected the response to treatment, but that the presence of these conditions did not necessarily preclude successful treatment.

Chryssanthou[79] studied 27 young patients with IXT who underwent 3 to 16 weeks of primarily home-based VT. She used stringent success criteria which were very similar to those employed by Cooper and Leyman[36] and reported a 78% success rate. The success rate was 50% in patients whose exodeviation exceeded 30$^{\Delta}$. Follow-up examination revealed that 86% of the initial successes maintained their improvement over 6 to 30 months.

Etting[80] reported retrospectively on the efficacy of VT for strabismus. His study included 15 IXT's among an overall sample of 86 stabismic patients. They were at least 6 years old (range 6 to 40 years), demonstrated strabismus while wearing the best spectacle prescription, were seeking treatment specifically for strabismus, and completed at least 24 in-office treatment sessions. Treatment sessions were administered twice weekly for 30 min and were supported by daily home treatment activities. Subjects completed approximately 42 treatment sessions. Specific treatment procedures were not reported. He used the Flom criteria[1] as modified by Ludlam[65] in categorizing success, and reported a success rate of 87% for his IXT patients.

Hoffman et al.[81] reported upon 22 IXT's (in a sample of 55 strabismus cases) selected in accordance with Ludlam's[65] criteria: the subjects had no prior surgery, did not improve via refractive prescription alone, were concomitant, had completed at least eight sessions of VT, and did not have ARC. All but one of the IXT subjects had exodeviations less than 30$^{\Delta}$. The specific therapy activities, duration, and frequency of sessions were not reported. Complete success based upon Flom's criteria was attained by 95% of the IXT patients.

VT Success Rate

VT treatment for IXT, pooled across the 9 studies reviewed above and including subjects from the 4 direct comparison studies reviewed below, has an overall calculated success rate of approximately 59% (433 of 740). This pooled success rate is better than virtually all other treatment modalities reviewed and is essentially identical to the highest other reported pooled success rate, 61% for surgical treatment in studies which used cosmetic alignment success criteria. The use of generally stringent functional success criteria in the VT studies makes the pooled success rate for this modality all the more meaningful. A summary overview of the success criteria used in each VT study is included in Table 7.

Advocates of VT cite certain advantages for this treatment modality relative to other treatments for IXT. Primary among these advantages is that VT is viewed by its proponents as a more "complete" treatment for IXT in that successful treatment not only eliminates the strabismus, but frequently results in an overall improvement in the quality of binocular vision and task-related visual function. The treatment is noninvasive and relatively risk-free. Critics point out that VT for treatment of IXT is time-consuming (usually requiring daily training periods for the duration of treatment), often requires repeat visits to the treatment facility, and requires commitment and motivation on the part of the patient and, with young children, the patient's family. Pooling data across studies which report failure rates indicates that VT does not improve IXT in 8% (53 of 655) of cases.

STUDIES DIRECTLY COMPARING IXT TREATMENT MODALITIES

As has been emphasized throughout this review, the comparison of results pooled between studies is fraught with scientific risk because of the lack of standardized definitions of treatment and success, as well as possible biases. These objections can be somewhat alleviated by considering the four retrospective studies that compare surgery and VT directly. Although these studies are discussed separately in this section, their results are included in the tables and pooled results presented in the sections relating to surgery and VT.

Moore[82] reported the lowest success rate for VT among the studies reviewed. She compared success rates of 180 IXT children who were treated with VT (N=17), surgery (N=57), or a combination of surgery and pre- and/or postoperative VT (N=106). The training approach involved 2 months of constant occlusion. During the second month of occlusion, patients practiced two diplopia awareness activities at home and attended four in-office sessions

devoted to antisuppression training. No training designed to improve motor fusion ranges was conducted. Good outcomes were defined as attainment of phoric status at distance and near (including through ±3.00 D lenses), presence of ample positive and negative fusional ranges at distance and near, diplopia awareness when tropic, and minimal foveal suppression. The success rates for each treatment condition with a good outcome were: VT, 0%; surgery, 33%; and surgery and VT, 30%. A fair outcome was designated for subjects who had occasional diplopia awareness, foveal suppression, and peripheral fusional amplitudes, and was attained by 18% in the VT group, 51% in the surgical group, and 43% in the combination group. She concluded that VT "does not appear to increase likelihood of a cure."

Newman and Mazow[44] retrospectively studied 60 IXT children who were equally divided into surgical and VT treatment groups. Their sample was limited to exodeviations in the range of 16 to 50$^{\Delta}$, and included 8 subjects who had prior strabismus surgery and 9 with vertical components (mean = 5$^{\Delta}$). VT included alternate occlusion, convergence exercises, and overminus lens therapy. For those in the VT group, 40% became phoric and 27% had a decreased angle of 15$^{\Delta}$ or more; in the surgery group, 47% became phoric and 20% had a decreased angle. They found better results in both groups among children over 4 years of age, and suggested that central fusion was not essential for a cure. The authors concluded with a recommendation that VT should be the treatment of first choice in IXT for exodeviations less than 30$^{\Delta}$.

The largest study including VT when comparing success among different treatment modalities is the retrospective study of Cooper and Leyman.[36] They reviewed results of 182 IXT's who had undergone VT, 264 who had surgery, and 216 who received both. They excluded subjects with large vertical deviations, significant A or V syndromes, anisometropia greater than 1.50 D, prior surgeries, and angles of deviation greater than 24$^{\Delta}$. VT consisted of antisuppression and convergence training which was administered in 4 to 5 sessions over approximately 14 weeks and was supported by home training. Functional outcomes were defined to include heterophoria at all distances, ample positive fusional ranges at both distance and near, NPC inside 5 cm, 40 sec arc stereopsis on the Titmus test, good recovery of fusion when lost during cover testing, normal Worth 4-Dot test at 6 m, no asthenopia or other symptoms, and only occasional tropia when fatigued. The group that received only VT attained a success rate of 59%, whereas the group receiving only surgery attained a success rate of 42%. An intermediate result (52%) was achieved by the group receiving both treatments.

Altizer[66] used a well documented VT program, base-in prism, and constant occlusion to treat 52 exotropic patients, 29 of whom had IXT. She compared the treatment efficacy between orthoptic vision therapy (N = 13) and surgery (N = 16). She found functional cure rates of 69 and 44%, respectively, for each treatment modality. The VT program extended over a 1-year period and the author emphasized the need for periodic "maintenance" VT after the formal treatment period had ended.

Direct Comparison Success Rate

VT treatment for IXT, pooled across the direct comparison studies, indicates an overall calculated success rate of approximately 53% (128 of 242), whereas surgical treatment using the same success criteria had a calculated success rate of 41% (151 or 367). Again, the advantage of considering these studies separately is that the success criteria used for comparison of the outcome within the studies were the same for each treatment. Although the comparison might be questioned because of possible bias in assignment of patients to treatment groups, a Mantel-Haenszel Chi Square statistic (which combines the results from the four studies) indicates that VT was more effective than surgery ($p = 0.001$).

SUMMARY

Management of IXT by means of extraocular muscle surgery has been the most frequently reported treatment modality (28 studies, 2530 patients), followed by VT (17 studies, 740 patients), prism therapy (8 studies, 201 patients), occlusion therapy (7 studies, 170 patients), and overminus lens therapy (3 studies, 215 patients). The pooled success rates of the treatment modalities reviewed in this paper are: overminus lens therapy, 28%; prism therapy, 28%; occlusion therapy, 37%; all surgical studies, 46%, and VT, 59%. These pooled relative efficacy rates are summarized in Fig. 1.

In the face of the data presented in the preceding sections, one could wonder why many practitioners do not treat IXT, or treat the condition using only corrective lenses. The answer may lie in the problems that plague the entire IXT treatment literature: almost all studies have been retrospective, lacked the controls necessary to determine whether

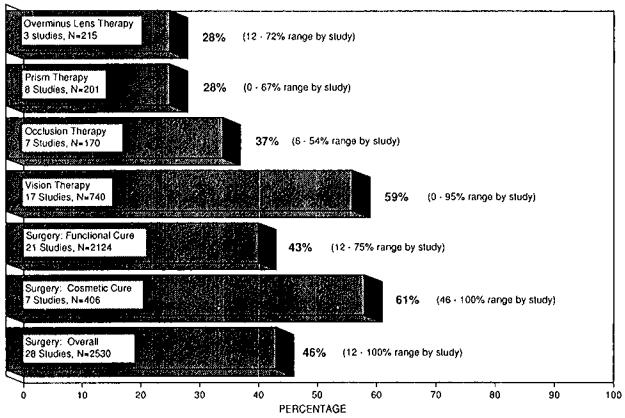

Figure 1. Comparison of efficacy of treatment modalities in intermittent exotropia.

the conclusions were valid, contained such small sample sizes that interpretation of the results is questionable, suffered from selection bias in the way the patients were chosen for treatment, or reported results in such a manner as to make interpretation difficult.

We cannot overemphasize the scientific problems with virtually all the studies cited. Any conclusions must be made with the full appreciation of the issues enumerated previously in this review. More than simply another study is needed to determine definitively the efficacy of different treatments for IXT. In order to provide a sound basis for opinion in the vision care community, we recommend that a careful, circumscribed, and well controlled clinical trial be undertaken.

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REFERENCES

1. Flom MC. The prognosis in strabismus. Am J Optom Arch Am Acad Optom 1958;35:509–14.
2. Hiles DA, Davies GT, Costenbader FD. Long-term observations on unoperated intermittent exotropia. Arch Ophthalmol 1968;80:436–42.
3. Jampolsky A. Ocular deviations. Int Ophthalmol Clin 1964;4:567.
4. Knapp P. Management of exotropia. In: Symposium on Strabismus: Transactions of the New Orleans Academy of Ophthalmology. St Louis: CV Mosby, 1971:233.
5. Parks MM. Ocular Motility and Strabismus. New York: Harper & Row, 1975.
6. von Noorden GK. Binocular Vision and Ocular Motility. 4th ed. St Louis: CV Mosby, 1990.
7. Weinstein GS, Biglan AW, Hiles DA. Postoperative residual small angle exodeviations. Ophthal Surg 1982;13:478–82.
8. Zibrandtsen P, Rindziunski E, Gregersen E. Ten years follow-up of surgery for intermittent exotropia. Acta Ophthalmol (Kbh) 1986;64:374–8.
9. Weve H. The operative treatment of strabismus. Doc Ophthalmol 1954;7–8:495–526.
10. Frandsen D. Occurrence of squint; a clinical-statistical study on the prevalence of squint and associated signs in different groups and ages of the Danish population. Acta Ophthalmol (Suppl 62) 1960.
11. Stella SL. The association of blinks and refusion in intermittent exotropia. Am J Optom Arch Am Acad Optom 968;45:465–71.
12. Romano PE, Wilson MF. Survey of current management of intermittent exotropia in the USA and Canada. In: Campos EC, ed. Strabismus and Ocular Motility Disorders. London: The Macmillan Press, 1990:391–6.
13. Romano PE, Robinson JA. Intermittent extropia: survey of current management. Paper presented at the International Orthoptic Congress, Nürnberg, Germany, June 1991.
14. Kennedy JR. The correction of divergent strabismus with concave lenses. Am J Optom Arch Am Acad Optom 1954;31:605–14.
15. Goodacre H. Minus overcorrection: conservative treatment of intermittent exotropia in the young child—a comparative study. Aust Orthopt J 1985;22:9–17.
16. Caltrider N, Jampolsky A. Overcorrecting minus lens therapy for treatment of intermittent exotropia. Ophthalmology (Rochester) 1983;90:1160–5.
17. Rutstein RP, Marsh-Tootle W, London R. Changes in refractive error for exotropes treated with overminus lenses. Optom Vis Sci 1989;66:487–91.
18. Burke MJ. Intermittent exotropia. Int Ophthalmol Clin 1985;25:53–68.
19. Worrel BE, Hirsch MJ, Morgan MW. An evaluation of prism prescribed by Sheard's criterion. J Optom Arch Am Acad Optom 1971;48:373–6.
20. Payne CR, Grisham JD, Thomas KL. A clinical evaluation of fixation disparity. Am J Optom Physiol Opt 1974;51:88–90.
21. Hardesty HH. The use of prisms in the management of nonparetic strabismus. Prisms in the management of intermittent exotropia. Am Orthopt J 1972;22:22–3.
22. Ravault AP,. Bongrand M, Bonamour G. The utilization of prisms in the treatment of divergent strabismus. In: Mein J, Bierlaagh JJM, Brummeklamp-Dons TEA, eds. Orthoptics: Proceedings of the 2nd International Orthoptic Congress. Amsterdam: Excerpta Medica Foundation, 1972:77–84.
23. Berard PV. Prisms—their therapeutic use in concomitant strabismus with normal correspondence. In: The First International Congress of Orthoptists. St Louis: CV Mosby, 1968:77–82.
24. Hardesty HH. Management of intermittent exotropia. Binoc Vis 1990;5:145–52.
25. Pratt-Johnson JA, Tilson G. Prismotherapy in intermittent exotropia. A preliminary report. Can J Ophthalmol 1979;14:243–5.
26. Hardesty HH. Treatment of under and overcorrected intermittent exotropia with prism glasses. Am Orthopt J 1969;19:110–9.
27. Hardesty HH, Boynton JR, Keenan P. Treatment of intermittent exotropia. Arch Ophthalmol 1978;96:268–74.
28. Knapp P. Use of membrane prisms. Trans Am Acad Ophthalmol Otolaryngol 1075;79:718–21.
29. Moore S, Stockbridge L. An evaluation of the use of fresnel press-on prisms in childhood strabismus. Am Orthopt J 1975;25:62–6.
30. Veronneau-Troutman A. Fresnel prism membrane in the treatment of strabismus. Can J Ophthalmol 1971;6:249–57.
31. Shippman S, Weintraub D, Cohen KR, Weseley AC. Prisms in the pre-operative diagnosis of intermittent exotropia. Am Orthopt J 1988;38:101–6.
32. Forrer HT. Retinal correspondence in intermittent exotropia. In: Moore S, Mein J, Stockbridge L, eds. Orthoptics: Past, Present, Future. Chicago: Year Book Medical Publishers (distributor), 1976;547–50.
33. Flynn JT, McKenney S, Rosenhouse M. Management of intermittent exotropia. In: Moore S, Mein J, Stockbridge L, eds. Orthoptics: Past, Present, Future. Chicago: Year Book Medical Publishers (distributor), 1976:551–7.
34. Reynolds JD, Waackerhagen M. Early onset exodeviations. Am Orthopt J 1988;38:94–100.
35. Freeman RS, Isenberg SJ. The use of part-time occlusion for early onset unilateral exotropia. J Pediatr Ophthalmol Strabismus 1989;26:94–6.
36. Cooper EL, Leyman IA. The management of intermittent exotropia: a comparison of the results of surgical and nonsurgical treatment. Am Orthop J 1977;27:61–7.
37. Chutter CP. Occlusion treatment of intermittent divergent strabismus. Am Orthopt J 1977;27:80–4.
38. Iacobucci I, Henderson JW. Occlusion in the preoperative treatment of exodeviations. Am Orthopt J 1965;15:42–7.
39. Spoord DK, Hiles DA. Occlusion therapy for exodeviations occurring in infants and young children. Ophthalmology (Rochester) 1979;86:2152–7.
40. Hurtt J. The selection of cases for orthoptics and pleoptics in the United States. In: The First International Congress of Orthoptists. St Louis, CV Mosby, 1968:83–7.
41. Dunlap EA, Gaffney RB. Surgical management of intermittent exotropia. Am Orthopt J 1963;13:20–33.
42. Paakkala AM. Surgical treatment of strabismus. A retrospective investigation of results of surgical treatment of horizontal strabismus. Acta Ophthalmol (Supp 156) (Kbh) 1982;1–107.
43. Veronneau-Troutman S. Intermittent exotropia. In Ophthalmol Clin 1971;11:114–9.
44. Newman J, Mazow ML. Intermittent exotropia: is surgery necessary? Ophthal Surg 1981;12:199–202.
45. Schlossman A, Muchnick RS, Stern KS. The surgical man-

agement of intermittent exotropia in adults. Ophthalmology (Rochester) 1938;90:1166–71.
46. Ron A, Merin S. The use of the pre-op prism adaptation test (PAT) in the surgery of exotropia. Am Orthopt J 1988;38:107–10.
47. Keech RV, Stewart SA. The surgical overcorrection of intermittent exotropia. J Pediatr Ophthalmol Strabismus 1990;27:218–20.
48. Raab EL, Parks MM. Recession of the lateral recti. Arch Ophthalmol 1975;93:584–6.
49. Windsor CE. Surgery, fusion, and accommodative convergence in exotropia. J Pediatr Ophthalmol 1971;8:166–70.
50. Capo H, Repka MX, Gutyon DL. Hang-back lateral rectus recession for exotropia. J Pediatr Ophthalmol Strabismus 1989;26:31–4.
51. Fletcher MC, Silverman SJ. Stabismus. Part I. A summary of 1110 consecutive cases. Am J Ophthalmol 1966;61:86–94.
52. Pratt-Johnson JA, Barlow JM, Tilson G. Early surgery in intermittent exotropia. Am J Ophthalmol 1977;84:689–94.
53. Clarke WN, Noel LP. Surgical results in intermittent exotropia. Can J Ophthalmol 1981;16:66–9.
54. Hardesty HH. Management of intermittent exotropia. Am Orthopt J 1984;34:87–91.
55. Hardesty HH. Management of intermittent exotropia. Semin Ophthalmol 1988;3:169–74.
56. Bedrossian EH. Surgical results following the recession-resection operation for intermittent exotropia. Am J Ophthalmol 1962;53:351–9.
57. McNeer KW. Observations on the surgical overcorrection of childhood intermittent exotropia. Am Orthopt J 1987;37:135–50.
58. Kushner BJ. Exotropic deviations: a functional classification and approach to treatment. Am Orthop J 1988;38:81–93.
59. Diamond GR. Medial rectus resection strategies for laterally incomitant intermittent exotropia. J Pediatr Ophthalmol Strabismus 1987;24:242–3.
60. Carlson MR, Jampolsky A. Lateral incomitancy in intermittent exotropia. Arch Ophthalmol 1979;97:1922–5.
61. McClintic N, McNeer KW. Postoperative drift rate of exotropia. Am Orthopt J 1980;30:60–3.
62. Mann D. The role of orthoptic treatment. Br Orthopt J 1947;4:30–4.
63. Duckman RH. Management of binocular anomalies: efficacy of vision therapy, exotropia. Am J Optom Physiol Opt 1987;64:421–9.
64. Flax N, Duckman RH. Orthoptic treatment of strabismus. J. Am Optom Assoc 1978;49:1353–61.
65. Ludlam WM. Orthoptic treatment of strabismus. Am J Optom Arch Am Acad Optom 1961;38:369–88.
66. Altizer LB. The non-surgical treatment of exotropia. Am Orthopt J 1972;22:71–6.
67. Goldrich SG. Optometric therapy of divergence excess strabismus. Am J Optom Physiol Opt 1980;57:7–14.
68. Golstein EL. Intermittent exotropia. J Optom Vis Devel 1982;13:31–4.
69. Hess JE, Stegall FW. Orthoptic treatment. In: Scott WE, Dòstino DD, Lennarson LW, eds. Orthoptics and Ocular Examination Techniques. Baltimore: Williams & Wilkins, 1983:306–16.
70. Daum KM. Convergence insufficiency. Am J Optom Physiol Opt 1984;61:16–22.
71. Daum KM. Equal exodeviations: characteristics and results of treatment with orthoptics. Aust J Optom 1984;67:53–9.
72. Daum KM. Divergence excess: characteristics and results of treatment with orthoptics. Opthal Physiol Opt 1984;4:15–24.
73. Daum KM. Characteristics of exodeviations: II. Changes with treatment with orthoptics. Am J Optom Physiol Opt 1986;63:244–51.
74. Ludlam WM, Kleinman BI. The long range results of orthoptic treatment of strabismus. Am J Optom Arch Am Acad Optom 1965;42:647–84.
75. Patano FM. Orthoptic treatment of convergence insufficiency: two year follow-up report. Am Orthopt J 1982;32:73–80.
76. Goldrich SG. Oculomotor biofeedback therapy for exotropia. Am J Optom Physiol Opt 1982;59:306–17.
77. Kertesz AE, Kertesz J. Wide-field fusional stimulation in strabismus. Am J Optom Physiol Opt 1986;63:217–22.
78. Sanfilippo S, Clahene AC. The effectiveness of orthoptics alone in selected cases of exodeviation: the immediate results and several years later. Am Orthopt J 1970;20:104–17.
79. Chryssanthou G. Orthoptic management of intermittent exotropia. Am Orthopt J 1974;24:69–72.
80. Etting GL. Strabismus therapy in private practice: cure rates after three months of therapy. J Am Optom Assoc 1978;49:1367–73.
81. Hoffman L, Cohen AH, Feuer G, Klayman I. Effectiveness of optometric therapy for strabismus in a private practice. Am J Optom Arch Am Acad Optom 1970;47:990–5.
82. Moore S. Orthoptic treatment for intermittent exotropia. Am Orthopt J 1963;13:14–20.
83. Richare JM, Parks MM. Intermittent exotropia. Surgical results in different age groups. Ophthalmology (Rochester) 1983;90:1172–7.
84. Scott WE, Keech R, Mash AJ. The postoperative results and stability of exodeviations. Arch Ophthalmol 1981l;99:1814–8.
85. Hamtil LW, Place KC. Review of surgical results using bilateral lateral rectus recession for the correction of exodeviations. Ann Ophthalmol 1978;10:1731–4.
86. Folk ER. Surgical results in intermittent exotropia. Arch Ophthalmol 1956;55:484–7.
87. Mulberger RD, McDonald PR. Surgical management of nonparalytic exotropia. Arch Ophthalmol 1954;52:664–8.
88. Johnson DS. Some observations on divergence excess. Arch Ophthalmol 1958;60:7–11.
89. Velez G. Results in intermittent exotropia. In: Moore S, Mein J, Stockbridge L, eds. Orthoptics: Past, Present, Future. Chicago: Year Book Medical Publishers (distributor), 1976:559–62.
90. Burian HM, Spivey BE. The surgical management of exodeviations. Am J Ophthalmol 1965;59:603–20.
91. Pickwell LD. Prevalence and management of divergence excess. Am J Optom Physiol Opt 1979;56:78–81.

AUTHOR'S ADDRESS:
Bradley Coffey
College of Optometry
Pacific University
2043 College Way
Forest Grove, Oregon 97116

ANNOUNCEMENT

Dr. Larry DeLucas an O.D./Ph.D. graduate of the School of Optometry at the University of Alabama is also a crystallographer. In June 1992 he will be in charge of 756 experiments aboard the shuttle Columbia for its 13-day space flight. He hopes to grow huge crystals of 32 different proteins outside the influence of Earth's gravity.