ASSOCIATION of SCHOOLS and COLLEGES of OPTOMETRY

Optometric Education The Journal of the Association of Schools and Colleges of Optometry

Management of Intermittent Exotropia of the Divergence Excess Type: a Teaching Case Report | 1

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Background

Intermittent exotropia (IXT) is the most common form of childhood exotropia[1, 2] with an incidence of 32.1 per 100,000 in children under 19 years of age.[1] The strabismus is characterized by an exodeviation of one eye that is interspersed with periods of ocular alignment.[3] Reliable measurement of the deviation is often hindered by the variable nature of the strabismus,[3] and without careful observation and evaluation IXT can often be missed. Divergence excess (DE) is a type of IXT that is characterized by a larger magnitude exodeviation (phoria or intermittent or constant exotropia) at distance than at near. This report is of a 5-year-old patient with IXT of the divergence excess type managed by overminus therapy. Discussion includes classification of IXT, important clinical findings, diagnostic considerations and management with an emphasis on overminus therapy. The case report is intended for third- and fourth-year optometry students.

Student Discussion Guide

Case description

Patient JT, a 5-year-old African American male presented for his first eye exam following a referral by his pediatrician for a noticeable eye turn. His foster mother of seven months reported that his left eye moved out sometimes during the day. She was unsure if she noticed an eye turn in the right eye and was unable to provide details on the duration, time and severity of the eye turn. She also reported that JT watches TV at a close distance and holds books close to his face. Past ocular history and birth history were unknown. Family ocular history was significant for accommodative esotropia in his biological sister. JT's medical history was significant for asthma and he was using Albuterol (90 mcg inhaler) as needed. He did not have any medical or seasonal allergies. JT was enrolled in preschool and was reported to have a disinterest in reading in school.

Visit 1 (in the order tested)

Entering unaided Snellen visual acuities were 20/20 in the right and left eye at distance and near. Extra-ocular movements were full in each eye. Pupils were round and reactive to light and accommodation. Screening for color vision with the HRR test showed no defect. Stereopsis with Random Dot 2 at near was 100 arc seconds (section c of the test). External observation showed an intermittent left exotropia at distance, manifesting <50% of the time during a 10-second observation. Cover test at distance (20 ft.) revealed an intermittent alternating exotropia and an exophoria at near (16"). Initial prism and alternate cover test (PACT) revealed 16 prism diopters (pd) of exodeviation at distance (20 ft.) and 10 pd of

exodeviation at near (40 cm). Average distance deviation after three consecutive measurements was 12 pd at distance and 10 pd at near. Worth Four Dot test revealed fusional response at distance and near. Dry retinoscopy was +0.50 sph in the right eye and plano in the left eye. Anterior ocular health was unremarkable and intraocular pressures measured digitally were soft and equal to touch in both eyes. Dilation was performed using two drops of 1% cyclopentolate hydrochloride instilled 5 minutes apart. Cycloplegic retinoscopy revealed +0.75-0.50×180 in the right eye and +0.75 sph in the left eye. Dilated fundus exam revealed a cup to disc ratio of 0.35 in each eye with normal retinal peripheral retinae OU. The hyperopia was minimal; the patient did not report any visual discomfort; and the chief concern was the eye turn. Correction of minimal hyperopia is less likely to treat the eye turn; therefore, glasses were not prescribed. The foster parent was educated about findings, and a follow-up visit was scheduled in 2 weeks for IXT evaluation. A summary of all visits is listed in **Table 1**.

Visit 2

An extended IXT evaluation was performed to determine the quality of control and to quantify control. IXT was quantified using the Mayo scale[5] as follows: exotropia was manifest <50% of the time during a 30-second observation period (score 3). Snellen visual acuities were 20/20 in each eye at distance and near. Stereopsis with Random Dot 2 was 100 arc seconds at near (16”, section c of the test). Worth Four Dot showed fusion at distance and near.

Table 1: Click to enlarge

Unilateral cover test revealed an intermittent alternating exotropia at distance (20 ft.) and exophoria at near (16”). PACT revealed an exodeviation of 18 pd at distance and 12 pd at near. Far distance cover test[6] (~50ft) revealed an intermittent alternating exotropia (18 pd using PACT). A patch test[7, 8] was performed by occluding the left eye for 30 minutes followed by measuring the near deviation through +3.00 lenses (gradient accommodative convergence to accommodation ratio [AC/A] was 5:1). Alternate cover test post patching[9] with +3.00 did not reveal any latent deviation at near (ruling out simulated divergence excess, discussed below). Average near point of convergence (NPC) after 4 consecutive measurements was 8 cm with accommodative target and 9 cm with penlight. Positive fusional vergence (step) at distance was x/16/10 and near was x/30/28. Push-up

accommodative amplitudes were 15D in the right eye and 14.5D in the left eye. A diagnosis of true divergence excess type intermittent exotropia was made based on the following results:

1. deviation greater at distance than near (IXT at distance and exophoria at near demonstrated by cover test) as found in two separate evaluations
2. patch test (monocular occlusion): 30 minutes of patching revealed no increase in magnitude of near deviation
3. +3.00 test at near revealed mild increase in near deviation but not equaling distance deviation; gradient AC/A was normal (5:1)

Following a discussion of various treatment options, the parent opted for overminus therapy. A predetermined minus power of -2.00 sph was chosen for the overminus trial. Factoring in JT's cycloplegic retinoscopy, a trial with -1.25 sph OU was performed (overminus-cycloplegia). Distance vision with this correction was 20/20- in each eye at distance and near. Cover test (pre-adaptation) revealed exophoria at distance and near. Following an adaptation period (30 minutes with -1.25 sph OU), unilateral cover test revealed no tropia at distance and near. PACT at distance (20 ft.) showed 10 pd exodeviation and 4 pd exodeviation at near (16"). JT maintained fusion with Worth Four Dot at distance and near.

Treatment for patient JT

Given the concern raised by the parent and the poor control of IXT demonstrated by JT, a trial of overminus therapy was chosen. It showed a significant improvement in deviation at distance and near. The patient's age was a limiting factor for vision therapy (VT) because he might have difficulty comprehending some procedures. In addition, the magnitude of exophoria at near improved. Overminus trial was performed with -1.25 sph OU (subtracting JT's cycloplegic refraction of +0.75-0.50×180 OD and +0.75 sph OS from a predetermined minus power of -2.00). Because vision with -1.25 sph was 20/20 at distance and near and cover test showed no tropia at distance and near following the adaptation period, a final prescription of -1.25-0.50×180 OD and -1.25 sph OS for full-time wear was recommended. Astigmatism in the right eye was corrected to maintain consistency with cycloplegic retinoscopy in each eye. A 6-week follow-up was recommended to monitor symptoms, adaptation, ocular alignment and vision. The goal of future visits would be to reduce the dose of minus lenses with maintenance of good control of the deviation. As JT grows older, a near add should be considered if overminus therapy is continued to meet increasing reading demands.

Visit 3

JT returned for the 6-week follow-up for treatment of IXT using overminus spectacles. He and his mother reported full compliance with glasses wear, and she noted an improvement in the eye turn with glasses. JT did not report headaches, discomfort or aesthenopia when reading

with glasses. IXT control was determined as 2 using the Mayo scale[5] (no exotropia unless dissociated, recovery in >5 seconds).

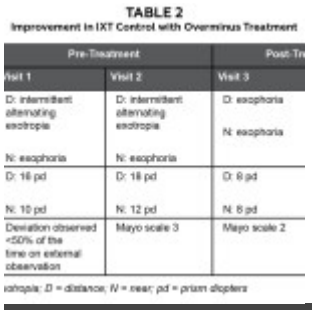

TABLE 2
Improvement in IXT Control with Overminus Treatment

Pre-Treatment		Post-Tr
Visit 1	Visit 2	Visit 3
D: intermittent alternating exotropia N: esophoria	D: intermittent alternating exotropia N: esophoria	D: esophoria N: esophoria
D: 18 pd N: 10 pd	D: 18 pd N: 12 pd	D: 8 pd N: 8 pd
Deviation observed <50% of the time on external observation	Mayo scale 3	Mayo scale 2

exotropia; D = distance; N = near; pd = prism diopters

Table 2: Click to enlarge

Snellen acuity with glasses was 20/20-3 in the right eye and 20/20 in the left eye at distance and 20/20 in each eye at near. Stereopsis with Random Dot 2 was 100 arc seconds at near (section c of the test). Unilateral cover test revealed exophoria at distance (20 ft.) and near (16”). Change in exodeviation is summarized in **Table 2**. Worth Four Dot test at distance and near revealed fusion. PACT revealed 8 pd exodeviation at distance and near. JT was recommended to continue full-time wear of glasses. His mother was educated about the possibility of weaning the prescription strength if the eye turn was well-controlled with glasses at future visits. A 2-month follow up visit was scheduled.

Visit 4

JT’s mother reported full compliance with glasses wear and denied noticing eye turn with glasses. JT reported no aesthenopia, headaches or blurred vision with glasses. IXT control was determined to be 2 using the Mayo scale[5] (stable since previous visit). Snellen acuity at distance and near with correction were 20/20 in each eye. Stereopsis was 100 seconds of arc (section c of the test plate) and local stereopsis was 50 seconds of arc with Random Dot 2. Unilateral cover test revealed exophoria at distance (20 ft.) and near (16”). Worth Four Dot test showed fusion at distance and near with correction. PACT measured 8 pd exodeviation at distance and near. JT was instructed to continue full-time wear and a 6-month follow-up visit was recommended.

Education Guidelines

Learning objectives

1. To describe the natural history of IXT
2. To describe the common signs and symptoms of IXT
3. To differentiate the types of IXT
4. To summarize the diagnostic tests and their role in accurate diagnosis of IXT
5. To be aware of the various treatment options for IXT

6. To describe the advantages and disadvantages of each treatment type

Key concepts

1. Understand the role of accommodation and vergence in distance/near differences in magnitude of IXT
2. Order of testing in the diagnosis of DE
3. Understand the rationale of each treatment type
4. Recognize when and how to treat
5. Understand the importance of follow-up care in patients with IXT

Discussion questions

1. What is the prevalence and etiology of IXT?
2. What are the common presenting symptoms and how is IXT classified?
3. What is the natural course of IXT?
4. Why are some patients symptomatic and others not?
5. What are the methods of quantifying IXT?
6. What are the components of the binocular vision exam in patients with IXT?
7. What are the factors to be considered when choosing an appropriate treatment?
8. What are the various conservative methods of management of IXT?
9. How successful is each treatment option?

Discussion

Background

To facilitate discussion of exam results, students should first be familiar with the definition, prevalence and etiology of IXT. IXT is the most common form of childhood exotropia[1,2] with an incidence of 32.1 per 100,000 in children under 19 years of age.[1] Onset of the deviation is believed to be in the first few years of life[10] with a female preponderance.[11] Patients with IXT typically have normal ocular alignment and sensory fusion during the phoric phase interrupted by periods of ocular misalignment with suppression or anomalous fusion or a combination of the two during the tropic phase.[4] Although common, the natural history of IXT remains unclear.[11-14] In addition, reliable measurement of the deviation is hindered by the variable nature of the strabismus.[15] Without careful observation and evaluation, IXT can often be missed.

TABLE 3
ıssification of Intermittent

	Charact at Dista
	D=N (within 1
	D>N by 10 pd
:I)	N>D by 10 pd

Table 3: Click to enlarge

Burian classified intermittent exotropia into three types: basic exotropia (BE), DE, and convergence insufficiency (CI).[16] In basic exotropia, the distance deviation is within 10 pd of the near deviation. In DE, the distance deviation is greater than near by 10 pd. DE can be further classified intro true vs. simulated divergence excess. In true divergence excess, the near deviation remains less than the distance deviation after a brief period of occlusion. In simulated divergence excess, however, the near deviation approaches distance deviation after occlusion. In CI type IXT, the near deviation is greater than distance by 10 pd **(Table 3)**. The difference in magnitude should be taken as a guideline. Clinicians should also look at the proportion of time the deviation occurs and the characteristic of deviation at distance and near to appropriately classify the condition.[4] This is particularly true in DE, where the larger exodeviation at distance "can either be a phoria, an intermittent exotropia or a constant exotropia."[4] Therefore, in JTs case, even though the difference in magnitude of deviation was <10 pd between distance and near, the exodeviation was an intermittent tropia at distance and a large phoria at near. This qualifies JT's condition as DE. Appropriate classification is important for making an accurate diagnosis and initiating appropriate treatment and follow-up. For example, vision therapy for basic exophoria (a normal AC/A ratio condition) is modeled differently from therapy for divergence excess (high AC/A ratio) or CI related IXT (low AC/A ratio).

It has been widely believed that a high AC/A ratio plays a major role in distance near discrepancy in divergence excess.[17, 18] Kushner showed that tenacious proximal fusion (TPF) in addition to AC/A ratio plays a role in distance/near discrepancy.[9] It is commonly believed that DE is a high AC/A ratio condition;[4] however, previous studies, such as Cooper et al.[19] (4.5:1-8.0:1) and Von Noorden[20] (3.3:1-9.0:1), have shown a wide range of gradient AC/A ratios in patients with DE. It has also been shown that calculated AC/A ratios are generally higher in patients with DE.[21] It is recommended both calculated and gradient AC/A ratios be evaluated in patients with divergence excess to sequence an appropriate treatment approach.[4] CI type IXT is caused by reduced positive fusional vergence (PFV). However in some cases, CI can be simulated by an underlying accommodative insufficiency (pseudo

convergence insufficiency).[4] In these cases, reduced accommodative convergence places a greater demand on PFV resulting in a CI diagnosis.

Because not all patients with IXT are symptomatic, students should understand the natural course of IXT in order to identify who needs treatment and when. Several studies have evaluated the change in angle of deviation (3-20 year follow-up) with conflicting results. One retrospective study found a low rate of spontaneous resolution (3.9%) during 9-year follow-up in children younger than 19 years of age.[22] In contrast, other studies have shown no deterioration of IXT when patients were followed for ≥10 years.[12, 14] A majority of these studies are observational, not prospective or population-based, and have small sample sizes. A randomized controlled trial recently has been completed that compared the effect of two commonly prescribed treatment options on the natural history of IXT.[23] The results of this study might be helpful to the clinician in deciding the right treatment approach.

Diagnosis and treatment of IXT begins with a thorough history. Pertinent history questions for an eye turn include laterality of eye turn (left eye vs. right eye vs. both), frequency (constant vs. intermittent), directionality (esodeviation/exodeviation/hyper/hypo deviation), and onset of deviation (sudden vs. gradual). Knowing the frequency of deviation is important in assessing the quality of control. Asking the parents or patient “how often do you notice the eye turn?” is a way of understanding frequency of eye turn at home. Associated symptoms include diplopia, head turn/tilt, photophobia and eye closure. Additional information about recent history of trauma, surgery or illness can be helpful. Several factors, including compensatory vergence, AC/A ratio and inattention, can contribute to symptoms. DE accounts for 25% of all intermittent exotropias,[25] the common symptoms of which include noticeable eye turn during periods of inattention, photophobia and monocular eye closure.[24, 25] Other symptoms of IXT could include headaches, eyestrain, loss of place when reading, and loss of focus while reading (more commonly reported in CI).[24] Exam findings in intermittent exotropia typically reveal normal visual acuities at distance and near, good stereopsis at near (during phoric phase), no diplopia, suppression or anomalous correspondence or combination of latter two.[4] About 25% of DE patients show covariation,[25] i.e., anomalous correspondence during the tropic phase and normal correspondence during phoric phase. To eliminate diplopia, patients with divergence excess commonly develop suppression or anomalous correspondence or a combination of the two.[4] JT’s fusional response during Worth Four Dot testing could be interpreted in the following ways: True fusion experienced during the phoric phase or anomalous fusion during the tropic phase. Evidence of fusion in the presence of a manifest deviation is indicative of anomalous correspondence. Since in JT’s case anomalous correspondence was not ruled out, it is unclear if JT’s fusional response with Worth Four Dot test represents a true fusion or anomalous fusion. Assessment of the status of

correspondence is important for sequentially planning orthoptic therapy.[4]

A higher prevalence of myopia and anisometropia has been noted in patients with DE compared to the normal population.[25] Accurate measurement of the deviation at distance and near as well as in different settings (described below) is important for monitoring progression. Students should consider several factors before choosing whether the appropriate treatment is non-surgical or surgical. These include symptoms, differences in magnitude at distance and near, proportion of time the deviation is manifest, and quality of control, as they often relate to the magnitude of the patient's symptoms. Proportion of time the deviation is manifest is as important as the magnitude of deviation as it gives information about the "quality" of control.

Diagnostic considerations for DE

Once the presence of strabismus is established through cover test, the magnitude of the deviation at distance and near can be measured using prism cover test. Cover test plays a very important role in accurate diagnosis and classification of IXT. It is important to use appropriate targets for distance and near fixation and appropriate refractive correction while testing. The student clinician should also be familiar with components of a cover test and what they identify. The results of cover test in IXT can vary from a small-large phoria at distance and/or near to a exotropia at distance and/or near between visits or even within visits. This can understandably be confusing. Useful modifications and additional techniques for performing cover test to accurately diagnose and classify DE type IXT are:

- In patients with suspected DE, cover test at distance and near should be performed using prolonged occlusion (10-15 seconds) during cover-uncover and alternate cover test to reduce the effect of tonic fusional convergence.[26, 27]
- Far distance cover test refers to a technique in which the distance cover test is performed by having the patient fixate on a target well beyond 20 ft., as this would suspend the effect of tonic fusional convergence.[6] An indication to do this test would be patient/parent reporting of eye turn at distance or during inattention while cover test findings during the exam are unremarkable. In many DE patients, typical exam room length (10 ft. or less) may not be distant enough to eliminate/reduce the effects of fusional vergence.[6] Hence, a truly distant target (20 ft. or farther) is used to evaluate strabismus at distance. This test is very effective in identifying patients with DE, in whom it may be recalled that the distance XT is greater than near. A combination of far distance test and patch test has been shown to significantly reduce surgical under-corrections.[27]
- In addition, the deviation is measured after 30-60 min. (shown to be sufficient time to unmask full deviation) of monocular patching to further reduce the effect of tonic fusional convergence.[7, 8] This procedure is called the patch test. If the deviation at near equals distance after the patch test, the patient has simulated divergence excess with high AC/A

ratio or fusional convergence or mixed mechanism as the underlying cause of this discrepancy. Kushner recommends patch testing in all intermittent exotropes in whom distance deviation exceeds near deviation.[9] It is crucial to occlude the patched eye prior to removing the patch to eliminate even brief periods of fusion. A +3.00 near add test can also be employed only after monocular occlusion if high AC/A ratio is suspected.[9] The diagnosis of true vs. simulated divergence excess is of surgical importance and its relevance in vision therapy has been questioned with the same therapy program suggested for both types.[4]

Variability in measurements between, and even within, visits often poses a challenge in accurately diagnosing IXT. Although IXT has been reported to worsen at the end of the day, a recent small-scale study showed less variability during the day. Studies have also shown that assessment of control "at a single point in time" has been shown to not truly characterize control.[15] Multiple measurements within the hour or over the course of the day (with an average score) may be necessary to reliably describe control.[15] As listed in **Table 1**, with JT, multiple measurements of the deviation were performed on two separate visits to establish overall control. Doing so enables the clinician to obtain reliable measurements and reduce variability. Until recently, there have been no quantitative methods to assess "control" in clinic. Quantitative grading of IXT is helpful in monitoring progress or deterioration over time by using standard repeatable set of measures.

Quantifying control

Two quantitative scoring methods are the Newcastle Control Score[28] and the Mayo scale.[5] The Newcastle Control Score uses an ordinal scale to grade clinic (objective scale) and home (subjective scale) control of IXT and has been shown to be repeatable and reliable, although the subjective scale relies on parental observation of deviation.[28] Mohney and Holmes developed an objective control scale to quantify the IXT at distance and near by grading phoria and tropia as well as recovery time defined as the time taken to re-establish fusion after dissociation.[5]

Intermittent exotropia control scale (Mayo scale):[5]

5 = Constant exotropia

4 = Exotropia >50% of the exam before dissociation

3 = Exotropia <50% of the exam before dissociation

2 = No exotropia unless dissociated, recovers in >5 seconds

1 = No exotropia unless dissociated, recovers in 1-5 seconds

0 = No exotropia unless dissociated, recovers in <1 second (phoria)

Total score is the sum of scores at distance and near. Levels 0-2 are graded as the worst of three consecutive measurements. Levels 3-5 are graded after an initial 30-sec. observation period and repeated at near.

Treatment of IXT

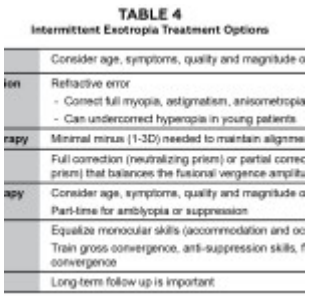

TABLE 4
Intermittent Exotropia Treatment Options

	Consider age, symptoms, quality and magnitude o
ion	Refractive error - Correct full myopia, astigmatism, anisometropia - Can undercorrect hyperopia in young patients
rapy	Minimal minus (1-3D) needed to maintain alignme
	Full correction (neutralizing prism) or partial correc prism) that balances the fusional vergence amplitu
apy	Consider age, symptoms, quality and magnitude o
	Part-time for amblyopia or suppression
	Equalize monocular skills (accommodation and oc
	Train gross convergence, anti-suppression skills, f convergence
	Long-term follow up is important

Table 4: Click to enlarge

Even though IXT is the most common form of childhood exotropia, controversy exists with regard to timing and method of treatment **(Table 4 and Table 5)**. Non-surgical interventions include:

1. Observation
2. Patching
3. Overminus lens therapy
4. Prisms
5. Vision therapy

It is not uncommon for clinicians to consider multiple treatments on the same patient, e.g., overminus therapy combined with vision therapy, or vision therapy prior to or after surgery. Few studies have reported on the efficacy of these treatment approaches. There is a lack of randomized controlled trials comparing treatment efficacy.[29,30] The effectiveness of individual treatments supported by evidence is discussed below. Students and clinicians are encouraged to contemplate the advantages and disadvantages of each treatment option.

Correction of refractive error

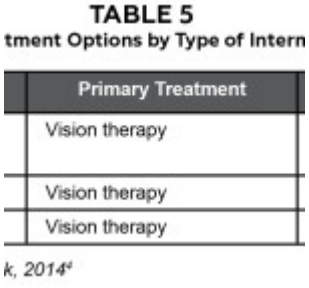

TABLE 5
tment Options by Type of Intern

	Primary Treatment
	Vision therapy
	Vision therapy
	Vision therapy

k, 2014[4]

Table 5: Click to enlarge

Correction of the underlying refractive error is the initial step towards management of IXT.[31] Providing clear retinal images may promote fusion and lead to a reduction or elimination of the deviation in some cases. Full correction of myopia, astigmatism and anisometropia has been recommended with the correction of hyperopia requiring special consideration of the degree of hyperopia.[31] In young patients, moderate to high hyperopia can be under-corrected, while in older patients this may lead to added demand on accommodation.[32] Age of the patient, symptoms, magnitude of IXT at distance and near, magnitude of hyperopia, accommodative amplitude and AC/A ratio are important factors to consider before prescribing for hyperopia.

Observation

The clinical course of IXT remains unclear with past studies reporting either improvement[33] or no improvement over time.[34] In addition, choosing the optimal treatment can be tricky when a patient has no symptoms or concerns. How does the clinician decide which patient to treat and which patient to monitor and closely follow? Is it sufficient to just monitor a patient without symptoms or other concerns? A recent multicenter randomized trial studied the effect of two commonly used treatment choices: observation vs. part-time patching (3 hours per day for 5 months) in children from 3 to <11 years of age with previously untreated IXT.[35] At 6-month follow-up, patients randomized to observation showed no significant worsening of IXT compared to the patching group. This is the first prospective randomized trial comparing treatments for patients with IXT, and the results indicate that observation alone could be a reasonable approach for some patients. Patient symptoms (cosmesis or functional) are a major deciding factor. If the magnitude of deviation remains stable and well-controlled over a few visits without patient/parental functional and or cosmetic concerns with good stereopsis at near, the patient can be monitored closely.

Patching

Monocular patching of the preferred eye or alternate patching has often been utilized as a method to delay surgery[3] in the treatment the IXT with the goal of eliminating suppression, decreasing the magnitude of deviation, or changing the character of the deviation.[3] Treatment duration varies from part-time (from 1 hour to several waking hours per day) to full-time patching. Although patching has been advocated as an economical, low-risk treatment, it can cause social stress.[34] A recent randomized clinical trial in young children (12-35 months of age) showed no evidence of deterioration during a 6-month follow-up with or without part-time patching.[36] Another study, in older children (3 to <11 years of age), reported that the deterioration rate of IXT was only slightly lower (statistically not significant) in the patching group (3 hours per day for 5 months) compared to observation during a 6-

month follow-up.[35] Although patching is commonly prescribed in young children,[33] results of this study suggest that this treatment may be just as effective as no treatment (i.e., observation) if only slightly better. When considering this option, it is important to think about the benefits (non-surgical) vs. the burden for the patient (compliance, adverse effects, social stress, etc.).

Overminus therapy

This treatment method involves prescription of intentionally overminus spectacles to improve control of IXT. The main objective of overminus therapy is to induce convergence. Conventional theory suggests that accommodative convergence (blur-induced accommodation that drives convergence via high AC/A ratio) plays a crucial role in control of the deviation at near (particularly in DE). [17,18] However, there is evidence that the amount of convergence needed to control the deviation at near causes over-accommodation (CA/C ratio) leading to reduced deviation at near.[37, 38] That is, the control of exodeviation at near might be convergence-driven rather than accommodation-driven. This alternate explanation might explain why some patients benefit from overminus therapy, which likely reduces the blur caused by excessive accommodation (driven by convergence, CA/C ratio) rather than inducing accommodation, which in turn stimulates convergence (high AC/A ratio). In clinic, AC/A ratios are generally more frequently measured compared to CA/C ratios because there are no accepted ways of measurement.[4]

Common concerns with minus lens therapy include the dose of overminus prescribed, duration of treatment and the possible adverse effects. Past studies have shown use of a wide range of treatment doses from 0.5D[39]to 5.00D[40] with a range of success rates from 12%-72%[41-42] (pooled success rate of 28%[30]) for overminus therapy. Limitations of these studies include poor study design and poorly defined treatment and success criteria. Nevertheless, a survey reported that 32% of pediatric ophthalmologists in the United States and Canada who routinely used some form of non-surgical approach used overminus therapy in the treatment of IXT.[43] Overminus therapy can be used as a temporary treatment to aid fusion in DE or BE. In CI, since patients have reduced base out vergence ranges, overminus therapy is not indicated.

Using the patient's cycloplegic retinoscopy and adding the predetermined amount of overminus to the cycloplegic refraction is one approach to determining the prescription of overminus lenses. For example, if the cycloplegic refraction is +0.50 in each eye, using a -2.00 sph overminus would result in a final prescription of -1.50 sph OU. Some clinicians use a predetermined overminus regardless of cycloplegic refraction. For example, it may be a practitioner's preference to prescribe a -2.00 overminus prescription for any IXT patient regardless of the refractive error or the accommodative status. Generally speaking, the

minimum amount of added minus, a lens that minimizes the deviation while maintaining clear single binocular vision, is prescribed.[4] Prescription of small magnitude minus lenses (-1.00D to 2.00D) for full-time wear could be considered in children younger than 6 years of age to reduce the frequency of IXT.[4] In older children who have higher accommodative demands at near, a bifocal or progressive is indicated to reduce aesthenopia when reading.[4] Other factors to consider when determining magnitude of overminus spectacles include AC/A ratio, frequency and magnitude of IXT, vergence ranges at near, and accommodative amplitude. Generally, children with a high AC/A ratio respond well to minus lenses because the added minus may provide clear single binocular vision.[4]

While there is no standard approach for determining the magnitude of overminus, it is important to consider the patient's accommodative status (amplitude of accommodation, dynamic retinoscopy and AC/A ratio), distance and near acuity with overminus lenses, fusional status and refractive status before finalizing the prescription. Ideally, the smallest prescription that provides functional visual acuity at distance and near, fusion at distance and near and acceptable improvement in ocular alignment should be prescribed. A commonly asked question about overminus therapy is whether it induces myopia. A retrospective study showed a statistically non-significant shift in myopia five years after initiation of overminus treatment.[44] Regardless, periodic follow-up and care is essential to ensure a given overminus lens is prescribed after careful consideration of the patient's refractive error and the visual demands. Overminus therapy can be considered as a viable primary treatment approach for patients with small angle IXT who are symptomatic and not keen on vision therapy or preschool children who may have difficulty with vision therapy. Overminus therapy can also be used in combination with vision therapy in older children or as a temporary treatment while a patient awaits surgery. Large-scale randomized controlled trials with well-defined treatment and success criteria are required to evaluate the optimal dose, duration and efficacy of this treatment.

Vision therapy

The main goals of VT for the treatment of IXT are to promote sensory fusion by eliminating diplopia or suppression and to improve vergence reserves in order to restore normal binocular vision. A combination of anti-suppression therapy and accommodation and vergence therapy is recommended.[4] First, any significant refractive error should be corrected, and amblyopia (although rare) if present should be treated.[30] Actual therapy can then follow, first to equalize monocular skills (i.e., accommodation and eye movements). Therapy is then focused on vergence skills by improving fusional vergence ability and vergence facility at near for CI and at far, intermediate and near for BE and DE. Diplopia awareness and anti-suppression training is a crucial part of therapy in patients with DE and BE type IXTs. In-office

therapy can be scheduled every week or every two weeks (depending on the patient's availability) with home reinforcement between appointments. Completion and successful treatment takes several sessions, typically 12-24 sessions for CI and 24-36 sessions for DE.[4] Vision therapy is generally successful in improving symptoms and restoring binocular vision in IXT.[30] Its effectiveness in treating CI has been well-established in children[45] and adults.[46] Coffey et al. reviewed previous studies that evaluated the efficacy of VT in IXT and showed that the pooled success rate of VT (59%) is "essentially identical" to the success rate of surgery (61%) and has the highest success rate compared to all other non-surgical approaches for IXT.[30] An effective therapy program in addition to patient motivation and commitment plays a crucial role in achieving success. Some disadvantages of VT include treatment duration, time commitment (office appointments and home exercises) and cost. A commonly posed question about vision therapy is how long the effects last. A recent multicenter study showed the effects of vision therapy for CI lasted up to a year after discontinuation of treatment in children age 9-17 years.[47] Pre-therapy patient education about compliance, time commitment and long-term effects is crucial for success. VT can be implemented as the preferred therapy before surgery or after other unsuccessful non-surgical treatments or used in combination with other non-surgical options before or after IXT surgery. For example, overminus lenses (usually -4.00D or -5.00D) are sometimes prescribed as "training lenses" for patients in an active VT program for IXT to stimulate accommodative convergence.

In general, VT has not been recommended for children younger than 6 years due to barriers in understanding therapy concepts and verbalizing feedback.[4] In older children and adults it could produce successful results. In summary, VT could be applied successfully to improve IXT control with motivation, commitment and compliance.

Prism therapy

Prescription of prisms for patients with IXT has varied purposes. Several types can be prescribed. A neutralizing prism reflects the exact magnitude of the deviation and is prescribed for full-time wear. In contrast, a relieving prism corrects a portion of the deviation, resulting in reduced fusional vergence demand, hence its name. Lastly, though rarely used, an over-correcting prism, as the name implies, over-corrects the exodeviation. The idea is that the resulting diplopia from the induced over-correction will stimulate fusional convergence. Relieving prisms and VT can be used successfully in combination. A review of past studies evaluating the efficacy of prism therapy for IXT reported a pooled success rate of 28%.[30] Before prescribing prisms fot IXT patients, the cost of prism glasses, cosmesis (in particular for Fresnel prisms) and prism adaptation should be considered. Because other non-surgical options (VT in particular) offer significant success in removal of symptoms, prisms

are not the primary treatment choice.[4]

Surgery

Current recommendations for surgery include worsening of the tropic phase and manifest deviation during more than 50% of waking hours.[3] Richard and Parks reported a success rate of 56% with success defined as postoperative deviation of less than 10 pd during a 4-year mean follow-up period.[48] The pooled success rate reported for surgery based on review of past studies is 61%.[30]

Assessment of learning objectives

Assessment of the learning objectives for this teaching case report can occur in the following settings. Students' understanding of signs, symptoms and types of IXT can be assessed using a problem-based approach in which small pieces of information are given out at a time and the student assimilates information provided or lists information needed. Alternatively, the same can be evaluated in a written exam situation either in the form of short essays or multiple-choice questions. Differentiation of types of IXT and knowledge of the role of diagnostic tests in IXT classification can be evaluated using real case videos of diagnostic evaluations (e.g., cover test at distance and near). Students' knowledge and proficiency with diagnostic tests can be evaluated in a clinical proficiency skills exam.

Assessment of students' understanding of treatment options and selection of appropriate treatment can be done using a case analysis-based approach where various case scenarios are presented and the students assimilate information provided and choses whether/when and how to treat. To successfully do this, students should have a clear understanding of the treatment options, pros and cons of each treatment and the natural history of IXT. In addition, a review of the literature on the efficacy of various treatment options and natural progression of IXT can also be used to assess the students' depth of understanding and critical thinking.

Summary

IXT is a common form of childhood exotropia with an unclear natural history. Divergence excess is a type of intermittent exotropia characterized by a larger exodeviation at distance than at near. Variability in measurements combined with the intermittent nature of the strabismus makes accurate diagnosis and treatment difficult for clinicians. Various types of treatment have been discussed in this case report with emphasis on non-surgical approaches. It is important to note that no single treatment approach suits all patients. The magnitude of symptoms, age, economic/social burden of the treatment, compliance and motivation are important factors in deciding the most suitable treatment for each patient.

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