Review Article

Non-surgical Management Options of Intermittent Exotropia: A Literature Review

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Abstract

Purpose: To review current non-surgical management methods of intermittent exotropia (IXT) which is one of the most common types of childhood-onset exotropia.

Methods: A search strategy was developed using a combination of the words IXT, divergence excess, non-surgical management, observation, overcorrecting minus lens therapy, patch/occlusion therapy, orthoptics/binocular vision therapy, and prism therapy to identify all articles in four electronic databases (PubMed, Web of Science, Google Scholar, and Scopus). To find more articles and to ensure that the databases were thoroughly searched, the reference lists of the selected articles were also reviewed from inception to June 2018 with no restrictions and filters.

Results: IXT is treated when binocular vision is impaired, or the patient is symptomatic. There are different surgical and non-surgical management strategies. Non-surgical treatment of IXT includes patch therapy, prism therapy, orthoptic sessions, and overcorrecting minus lens therapy. The objective of these treatments is to reduce the symptoms and the frequency of manifest deviation by decreasing the angle of deviation or enhancing the ability to control it.

Conclusions: Evidence of the efficacy of non-surgical management options for IXT is not compelling. More comprehensive randomized controlled trial studies are required to evaluate the effectiveness of these procedures and detect the most effective strategy.

Keywords: Divergence excess, Intermittent exotropia, Non-surgical management

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Introduction

Strabismus is one of the most frequent ocular problems among developmentally normal children.[1] The prevalence of strabismus varies among different regions, ranging from 0.06% in Japan to 5.65% in China.[2-9] Exotropia is reported to be the most prevalent type of deviation in many of these studies.[5-8] About 48–92% of the exotropic patients have intermittent exotropia (IXT).[6,10-12] Jenkins reported that the prevalence of exodeviation was higher in countries near the Equator.[13] Its prevalence is also higher in subequatorial Africa, the Middle East, and East Asia (where there is plenty of sunshine) in comparison to the USA and Central Europe.[14,15]

IXT is an outward deviation of the eye that is not constant and is intermittently controlled by fusional mechanisms. Unlike a pure phoria, IXT breaks down spontaneously into a manifest

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exotropia.[16] It is one of the most frequent types of childhood-onset exotropia. In many subtypes of IXT, the deviation is more obvious on distance vision, which is the reason why it is also referred to as intermittent distance exotropia.[12,13,17,18] Since the deviation usually manifests when the person is tired, sick, or daydreaming, it is also known as periodic or inattention exotropia.[19] The etiology of IXT is not clear, but many factors, including neuro-mechanical factors,[20] insufficient fusion, a high accommodative convergence to accommodation ratio (AC/A),[21,22] refractive errors,[23] and genetic factors[10,24] were cited in previous reports.

There are two classification systems for IXT: the Burian's classification and Kushner's classification. The Burian's system is based on the distance and near measurements of exodeviation. According to this system, IXT may occur during distance fixation (divergence excess [DE]), near fixation (convergence insufficiency [CI]), or both (basic exotropia [BE]). Therefore, limiting the use of IXT to DE is not correct, and each type of exodeviation can be latent, intermittent, or constant. DE IXT is also divided into true and simulated forms. A patient has true DE if there is no change in near deviation after the relaxation of proximal fusion and accommodation, while simulated DE is present if near measurements approach or exceed distance measurements in this situation [Table 1].[25] Kushner's classification system is more complex and is based on the effective mechanism of distance and near deviation disparity [Table 2].[26]

It is unclear whether this type of deviation changes over time, and there are different hypotheses in this regard. A decompensated exophoria is sometimes converted to IXT, which ultimately becomes constant. Suppression, increased distance between the eyes, and decreased accommodation and tonic convergence with age are risk factors of IXT progression.[20] However, studies have shown that not all IXT deviations are progressive as some of them remain constant for years, and a lower percentage of patients improve over time.[16,27-29] Examination of the magnitude of deviation, stereo-acuity, and the ability of the patients to control their deviation can help the examiner predict the severity of the deviation and the possibility of deterioration in future. However, quantification of its severity has been poorly standardized. Different scales are used to assess the ability to control the deviation based on the speed and recovery movements of the eyes from a dissociated state such as the Newcastle Control Score (NCS) [Table 3][30] and the Mohney and Holmes score [Table 4].[31]

Management decisions in IXT patients still present a challenge to many clinicians. IXT is treated when binocular vision is impaired, or the patient is symptomatic. The objective of treatment is to reduce the symptoms and the frequency of manifest deviation by decreasing the angle of deviation or enhancing the ability to control it. There are different surgical and non-surgical management strategies. Non-surgical methods are non-invasive and can reduce the symptoms and postpone surgical interventions.[20,32] Current non-surgical management strategies of IXT are discussed in this research.

Table 1: Burian's classification of intermittent exotropia

Type	Description
CI	Amount of deviation: Near > far (amount of difference between near and far measurement > 10 PD)
True DE	In both first measurement and 30 min after monocular patch, amount of deviation: Distance > near (amount of difference between far and near measurement >10 PD)
Pseudo DE	In first measurement, amount of deviation: Far > near After 30 min of monocular patch, amount of deviation: Near=far (or amount of difference between far and near measurement <10 PD)
Basic	Amount of deviation: Near=far (or amount of difference between far and near measurement <10 PD)

CI: Convergence insufficiency, PD: Prism diopter, DE: Divergence excess

Table 2: Kushner's classification of intermittent exotropia

Type	Description
High AC/A ratio	Amount of deviation: Distance > near AC/A ratio is high
Proximal convergence	Amount of deviation: Distance > near even after 30-60 min of occlusion AC/A ratio is normal
Tenacious proximal fusion	Amount of deviation: Distance > near at first measurement After 60 min monocular occlusion near measurement increases
Basic	Amount of deviation: Near=far
Low AC/A ratio	Amount of deviation: Near > distance AC/A ratio is low
Fusional CI	Amount of deviation: Near > distance Fusional convergence amplitude is poor
Pseudo CI	Amount of deviation: Near > distance But distance measurement increases with 60 min of monocular occlusion

AC/A: Accommodative convergence to accommodation ratio, CI: Convergence insufficiency

Methods

A search strategy was developed using a combination of the words IXT, DE, non-surgical management, observation, overcorrecting minus lens therapy, patch/occlusion therapy, orthoptics/binocular vision therapy, and prism therapy to identify all articles in four electronic databases (PubMed, Web of Science, Google Scholar, and Scopus). Two authors (S.H. and A.O.) searched and extracted the articles. Then, they scanned the titles and abstracts of the retrieved articles for relevance. To find more articles and to ensure that the databases were thoroughly searched, the reference lists of the selected articles were also reviewed from inception to June 2018 with no restrictions and filters.

Results

Management decisions in IXT patients are presently guided by both the angle of deviation and the ability to control it. Although

non-surgical management options are not very effective for the treatment of IXT, they are rarely associated with adverse outcomes. These options are believed to be more appropriate in many patients with a small angle of deviation (<20 prism diopter [PD]). Moreover, these methods may be preferred in very young children who may become amblyopic or lose their binocular fixation due to the possibility of overcorrection in surgical procedures.[33,34] A summary of some previous studies that investigate different non-surgical management strategies of IXT is reported in Table 5.

Correction of refractive errors

According to the literature, one of the etiologies of IXT is high hyperopia and/or low-to-moderate myopia, which can cause deviation through decreased accommodative convergence.[23,48-51] Anisometropia can also impair sensory fusion and thus result in deviation due to the relationship between sensory and motor fusion.[52,53] Therefore, correction of these types of refractive errors may resolve the problem by improving the sensory and subsequently, the motor fusion and enhancing the ability to control the deviation.[54] According to a recent study by Han *et al*., uncorrected refractive errors impair stereo-acuity, and since impaired stereo-acuity may worsen IXT in the long-term, its treatment may improve the patient's status over time.[55]

Table 3: Newcastle Control Score method

Score	Component
Home control	
0	Exotropia or monocular eye closure never reported
1	Exotropia or monocular eye closure seen<50% of time in far fixation
2	Exotropia or monocular eye closure seen over 50% of time in far fixation
3	Exotropia or monocular eye closure seen over 50% in both far and near fixation
Clinical control	
Near	
0	Exotropia occur only after cover test and fusion recovered perfectly (without any need for blink)
1	Realignment of eye from dissociated condition with support of blink or re-fixation
2	Exotropia stays obvious after cover test or prolonged fixation and recovery not happened with blinking
3	Manifest exotropia spontaneously
Distance	
0	Exotropia occur only after cover test and fusion recovered perfectly (without any need for blink)
1	Realignment of eye from dissociated condition with support of blink or re-fixation
2	Exotropia stays obvious after cover test or prolonged fixation and recovery not happened with blinking
3	Manifest exotropia spontaneously
Total NCS=Home control score + near score + distance score	

NCS: Newcastle Control Score

Table 4: Mohney and Holmes Office Control Scale

Score	Component
5	When the observer seen constant exotropia during a 30s observation time (without any dissociation)
4	Exotropia seen over 50% of the examination time (30s) without any dissociation
3	Exotropia seen less than 50% of the examination time (30s) without any dissociation
2	Exotropia not seen unless after dissociation, realignment over 5 s
1	Exotropia not seen unless after dissociation, realignment between 1-5 s
0	Exotropia not seen unless after dissociation, realignment in <1 s (phoria)
Total score=Distance + near	

In myopic cases, full correction is suggested due to its effect on accommodative convergence. In hyperopic patients, although some clinicians believe that hypermetropia will increase both the frequency and the angle of deviation, this is not always correct. Many patients with high hyperopia and IXT improve after optical correction.[56] Age, degree of hyperopia, and amount of AC/A should be considered in prescribing this type of refractive error. In general, mild-to-moderate hyperopia is not usually corrected due to the possibility of accommodative convergence relaxation and worsening of the angle of deviation. However, in hyperopia >4 D or anisometropia >1.5 D, refractive error correction usually improves the deviation control. Moreover, in these cases, due to the lack of accommodative effort, the retinal image is blurry, and deviation becomes manifest; hence, correction of hyperopia can enhance the retinal image and improve deviation control.[56,57]

Chung *et al*. evaluated the changes of the angle of deviation after refractive correction in IXT patients and reported a mild increase in exodeviation following hyperopic correction (more than 10 PD in one-third of the hyperopic cases). By contrast, in their myopic cases, the angle of deviation remained constant or decreased following wearing spectacles for at least 6 months. The authors concluded that optical correction in cases with exotropia was useful before strabismus surgery, and considering a new angle of deviation after spectacle correction should produce better results.[35]

Although findings related to the effect of refractive error correction on IXT are controversial, it is widely accepted that correcting even insignificant amounts of refractive error (especially astigmatism and myopia) may result in a better deviation control and should be considered prior to surgical intervention.

Observation

Studies in this field have reported different results that can be categorized into three groups: no change in deviation over time,[19,27,29,58] improvement in the course of time,[16,59] and deterioration of deviation over time.[20,28]

A study conducted by the Pediatric Eye Disease Investigator Group showed that observation did not result in IXT deterioration in the age range 12–35 months.[36] Buck *et al*. indicated a very low risk of deterioration within 2 years after a diagnosis of IXT.[19] However, these studies were conducted

Table 5: Summary of some previous studies that investigate different non-surgical management strategies of intermittent exotropia

Authors (year)	Number of patients	Age of the patients	Treatment method	Follow-up	Mean results
Chung *et al*.[35]	114		Optical correction alone	6 months	In hyperopic cases a narrow increase in exodeviation following hyperopic correction was seen In myopic cases, the angle of deviation remained constant or decreased following wearing eyeglasses Optical correction in cases with exotropia is useful prior to strabismus surgery and considering a new angle of deviation after spectacle correction should result in better results
Mohney *et al*.[36]	177	12-35 months	Part-time occlusion versus observation alone	3 h daily for 5 months, followed by 1 month of no patching	Observation does not result in the deterioration of IXT in the age range 12-35 months Deterioration over 6 months was uncommon, with or without patching treatment
Buck *et al*.[19]	460	<12 years	Observation	2 years follow up	There is a very low risk of deterioration within 2 years after a diagnosis of IXT
Chen *et al*.[37]	58	3-6 years	Minus therapy versus observation alone	8 weeks	Minus therapy has a better effect on IXT control than no intervention at all
Cotter *et al*.[38]	358	3-10 years	Part-time occlusion versus observation alone	3 h daily for 5 months, followed by 1 month of no patching	A low rate of deterioration was observed in both groups (6.1% in the observation group and 0.6% in the occlusion group) No significant difference between observation and patching
Alkahmous and Al-Saleh[39]	21	4-10 years	6 h a day alternate occlusion	6 months	Alternate occlusion improved the sensory status and strengthened the fusional amplitudes at near and distance. Moreover, alternate patching could also improve IXT control but did not improve the angle of deviation
Bayramlar *et al*.[40]	19	3-14 years	Over-minus lenses therapy	Median period of 18 months (6-33 months)	Overcorrecting minus therapy could decrease deviation and improve the patient's status and should be considered as the first line of treatment
Mangad *et al*.[41]	53	1-5 years	Over-minus lenses therapy	1 year	Over-minus correction improves IXT control (lowers the NCS score) and decreases the angle of deviation at distance and near
Samy *et al*.[42]	100	5-7 years	Inverse prism addition versus conventional prism addition	12 months	The two types of prism therapy showed comparable improvements in NCS This study highlights the potential role of inverse prism therapy as a non-invasive method for enhancing basic IXT control
Hardesty *et al*.[43]	100	2-24 years	Surgery alone versus surgery and orthoptic therapy	Six and one tenth years (1-10 years)	Improvement in 50% of the subjects who underwent both surgical intervention and orthoptic therapy while only 32% of the patients who only underwent surgery improved
Asadi *et al*.[44]	74	4-54 years	Office and home-based training exercises	8 weeks	Orthoptic treatment seems to be effective in reducing symptoms and improving signs of intermittent exotropia Combination of in-office and home-based therapy tends to produce better results than does home-based therapy alone
Peddle *et al*.[45]	2	30 and 32 years	Binocular vision therapy/orthoptics	30 weeks	Vision therapy was highly successful in patients with childhood intermittent exotropia of the basic type Vision therapy can eliminate the patients' symptoms of asthenopia and diplopia without the need for surgery Using vision therapy exotropia at distance and near was reduced, patients achieved required fusion at all distances, and their symptoms improved
Spencer *et al*.[46]	32	3-12 years	Bilateral injections of 2.5 units botulinum toxin injection to the lateral rectus muscles	12-44 months	Botulinum toxin is at least as effective as surgical outcomes reported previously for the treatment of intermittent exotropia in children This treatment method is particularly effective in children between 2 and 4.5 years of age irrespective of the initial strabismic angle and is not associated with any secondary abnormalities
Etezad Razavi *et al*.[47]	21	5-18 years	Botulinum toxin injection to the lateral rectus muscles	6 months	Botulinum toxin injection to lateral rectus muscles seems to be a promising procedure in the management of fusional control, far and near deviations in patients with intermittent exotropia in short time

IXT: Intermittent exotropia, NCS: Newcastle Control Score

in children (<12 years) and followed the patients for a short period, while it is possible that IXT will deteriorate at older ages considering its risk factors and etiologies. There are no recent reports indicating IXT improvement with observation.

However, symptoms (functional and cosmetic) are important factors in decision-making regarding the start of treatment. If the patient is able to control the deviation, the angle of deviation does not worsen on several follow-up visits, and the patient or parents are not concerned about functional or cosmetic issues, the patient may be followed at short intervals to start treatment interventions if deviation becomes worse.[37]

Patch therapy

There are different methods for occlusion therapy, also known as anti-suppression therapy, including monocular or alternate occlusion and part-time versus full-time occlusion. Monocular occlusion (patching the dominant eye) is applied if there is a dominancy relationship between the eyes, and alternate occlusion is done when there is no dominant eye.[60] The aim of this approach is to eliminate visual adaptation (suppression), induce diplopia, and consequently motivate motor fusion. Nonetheless, diplopia may not be induced in all patients.[61] It is also suggested that occlusion may reduce the amount of deviation and change the deviation from exotropia to exophoria.[62] Some researchers believe that this method is useful in younger children and in patients who wish to postpone surgical treatment.[61,62] Cotter *et al*. evaluated the effect of alternate occlusion for 3 h daily versus observation on the deterioration of deviation (worsening of stereopsis or deviation becoming more constant) in children aged 3–10 years who were not previously treated. The cases were randomly allocated to observation (no treatment) or intermittent occlusion. After 6 months, a low rate of deterioration was observed in both groups (6.1% in the observation group and 0.6% in the occlusion group). Although the deterioration rate was lower in the occlusion group, there was no significant difference between observation and patching.[38]

Moreover, according to the results of the recent clinical trials conducted by the Pediatric Eye Disease Investigator Group to evaluate the effect of part-time occlusion in children aged 12—35 months, deterioration over 6 months was uncommon with or without patching treatment. In other words, there was insufficient evidence to recommend part-time patching for the treatment of IXT in children in this age group.[36,38]

Alkahmous and Al-Saleh[39] conducted a study to assess the efficacy of occlusion therapy in controlling IXT and degree of deviation in children aged 4–10 years. In this study, three variables, including stereopsis, deviation size, and positive fusional vergence, were examined at far and near. Binocular visual acuity and the Mohney and Holmes control scale were also assessed. After about 6 h a day alternate occlusion for about 6 months, all variables improved markedly except for deviation angle at distance. The authors concluded that alternate occlusion improved the sensory status and strengthened the fusional amplitudes at near and distance. The authors reported that alternate patching could improve IXT control but did not improve the angle of deviation.[39] Although there are no reports of the deviation angle improvement in the above studies, some earlier reports showed changes in the amount of deviation after occlusion therapy.[61,63]

Akbari *et al*. investigated the effect of 2 h of alternate occlusion on control of IXT in children 3–8 years old and found a significant improvement in control of deviation both in near and far.[64]

In general, part-time occlusion for 2–6 h was recommended in previous studies. However, we could not find a clear rationale for the duration of patching recommended in these studies or sufficient evidence to support the optimum patch time for IXT treatment in different age groups of children. An important point to remember when using this method is that since fusion control improvement resulting from occlusion therapy is temporary, it should not be used alone for IXT treatment.[65,66] In fact, this method is mostly used to postpone surgical treatment.

Overcorrecting minus lens therapy

In this method, the patient wears over-minus spectacles compared to their cycloplegic refraction at all times. The aim of this method is to improve deviation control and reduce the angle of deviation to delay surgical correction. This temporary method is also used when children are not old enough to start orthoptic therapies.[67] Minus lens therapy is usually used in preschool children (aged 2–7 years old);[37,41] however, there are reports of its efficacy in older ages, too.[40,68] It was previously believed that the minus lens was effective only in patients with a high AC/A; however, more recent evidence suggests otherwise.[20,40,56,57] On the other hand, recent studies found that a high AC/A ratio was not detrimental to a good outcome, and it appears that even children with low and normal AC/A ratios may respond well to overcorrecting minus lens therapy.[69,70] It is reported that even a slight accommodative effort can trigger a surprisingly large vergence response that can be enough to permit the child to keep the exodeviation latent by using large fusional convergence amplitudes.[69]

A widely held mechanism for the efficacy of a minus lens is that it stimulates accommodation, resulting in the stimulation of accommodative convergence and IXT reduction.[71] Another theory that accounts well for the efficacy of minus lens therapy is the fusional convergence mechanism.[72] Horwood and Riddell proposed that the use of "over-minus" lenses in IXT could eliminate blur that is secondary to excess accommodation resulting from disparity-driven convergence and thereby could promote fusional convergence at near.[73] Moreover, many other investigators have discussed the role of disparity-induced vergence in controlling intermittent exodeviations.[72,74-76] Indeed, the use of fusional convergence to reduce the deviation angle results in the stimulation of convergence accommodation causing a distance blurred vision. Therefore, over-minus spectacles improve the distance vision and therefore, sensory fusion.[73]

Two methods are used to determine the required overcorrection: (1) using a constant amount of over-minus lens according to the refractive error and age, and (2) using a primary lens and

applying gradual additions until IXT control is achieved.[37] The overcorrecting minus power is −0.5 D to −5.00 D in most studies (more routinely −1.00 to −3.00).[67,68,70,77,78] Indeed, the minimum minus power that a child can tolerate and does not compromise the child's vision while providing the best control over the deviation at the same time is usually considered. The first minus lenses are placed in a trial frame starting at −0.50 D strength and working up in −0.50 D steps until the patient controls his/her deviation at near and distance fixation.[70]

Chen *et al*. investigated the effectiveness of short-term minus therapy in children 3–6 years of age with IXT. In this study, IXT patients were randomly allocated to either observation or 2.5 D over-minus spectacles, and the results were compared after 8 weeks. The mean distance exotropia control score was better in the over-minus group compared to the observation group (2.0 vs. 2.8 points), and 59% of the patients in the over-minus group showed >1 point improvement in distance control (59% vs. 39%).[37] Bayramlar *et al*. conducted a study to investigate the effectiveness of minus therapy in IXT. In this study, 2.00–4.00 D of overcorrecting minus power was added to the patient's cycloplegic refraction, considering the maximum tolerable lens to read 20/25 at near and distance. Two methods were used to assess the success of minus therapy:[69] (1) a method described by Caltrider and Jampolsky[69] and (2) the NCS method. In the first method, qualitative and quantitative changes were evaluated after treatment. Qualitative changes included improved ability to control the deviation from poor control to good control, and the quantitative change included a decrease of at least 15 PDs in the exodeviation on the alternate cover test. Qualitative and quantitative changes were considered if neither the parents nor the physician noticed any manifest deviation while the overcorrecting minus lenses were worn. A classification of no change was used if manifest exotropia persisted while wearing the minus lenses, even if the ability to control the deviation improved in that patient.[69] After 1 year, the results showed that 84% of the children had an NCS score of 2 or less, indicating a significant improvement. According to the Caltrider and Jampolsky method, qualitative and quantitative improvement in the size of deviation was observed in 48% and 37% of the children, respectively. The authors found that overcorrecting minus therapy could decrease deviation and improve the patient's status and should be considered as the first line of treatment.[40]

A very recent study of the effectiveness of minus therapy in IXT in 2018 showed that over-minus correction improved IXT control (lowers the NCS score) and decreased the angle of deviation at distance and near.[41] However, it should be noted that the majority of these studies assessed the results of short-term minus therapy, and there is no sufficient information regarding the long-term effects of this treatment method after discontinuing the use of the minus lens. Moreover, because excessive accommodation has been implicated as a cause of myopia, there is a theoretical concern that overcorrecting minus lens therapy for exotropia may cause myopia. However, despite this concern, many previous studies found that this treatment did not seem to cause myopia.[70,78-80]

Moreover, over-minus therapy can cause esotropia in near. Hence, after beginning therapy, the first examination should be performed 3–4 weeks later to evaluate alignment in near.[69]

Prism therapy

Prism therapy is another intervention that can be applied either alone to neutralize the deviation or in combination with orthoptic therapy.[81] Prism therapy is mainly used in patients with a deviation <20–25 PD. Higher prisms are required in higher deviations, resulting in increased weight of the spectacles and distortion.[82] There are different strategies for prism prescription, including a neutralizing prism (a prism is prescribed according to the deviation magnitude to neutralize its angle), a relieving prism (a prism is prescribed to decrease the deviation to some extent in order to reduce the fusional vergence demand), and an overcorrection prism (used to induce diplopia and stimulate fusional convergence).

Some authors recently found the effectiveness of base-out prism addition, also known as inverse prism addition, for improving NCS in patients with basic IXT. Inverse prisms are used to increase fusional vergence ability since they increase the demand for controlling fusional vergence.[42] Theoretically, base-out prisms increase the demand by shifting the image to where the eye is supposed to look. This shift will provoke diplopia, stimulate fusion, and encourage the visual system to improve sensory perception and motor control.[83]

Coffey *et al*. reviewed the studies related to different IXT treatment modalities. The overall pooled success rate of different treatment modalities reviewed in this article was 28% for prism therapy, 28% for over-minus therapy, 59% for vision therapy, and 37% for occlusion therapy.[71] It was suggested that a combination of relieving prism and orthoptic therapy may be more successful than most of the above strategies.[84]

Orthoptics/binocular vision therapy

The main objective of binocular vision therapy/orthoptics is to remove suppression, stimulate diplopia awareness, improve sensory fusion and fusional reserve, and restore binocular vision.[85] A combination of anti-suppression therapy and accommodation and vergence therapy is recommended. Vision training should initially address vergence skills by modifying fusional vergence amplitudes and vergence facility at near fixation for CI and at distance, intermediate, and near for DE and BE.[86]

There is no consensus on the effectiveness of this treatment method. For example, Sanflippo and Clahane found that orthoptic therapy improved the deviation in 64% of the subjects.[87] Hardesty reported improvement in 50% of the patients who underwent both surgical intervention and orthoptic therapy, while only 32% of the patients who only underwent surgery improved.[43] In general, there are three opinions about binocular vision therapy: some studies suggest that it has no effect on the deviation,[88] some have shown

that binocular vision therapy/orthoptics alone can reduce deviation,[87,89] and some others have found that it should be accompanied by surgery.[21]

According to Lavrich, binocular vision therapy/orthoptics is more effective in adults that are more cooperative and mostly suffer from CI,[57] although, it also has some effects on other types of exodeviation as well.[90] Asadi *et al*. found that the most frequent complaints of the patients were intermittent deviation in one eye (67.2%), eye strain (23%), and diplopia (9.8%). Of 74 patients, 43 (58.1%) had BE, 22 (29.7%) had CI, and 9 (12%) had DE exodeviation. The results showed improvement in the angle of deviation (at distance and near depending on the type of deviation) and symptoms in 88.3% of the patients with BE, 100% of the patients with CI, and 88.8% of the patients with DE. In this study, office and home-based training exercises including prism exercises, pencil push-ups, 3D stereogram tests, and suppression therapy like dominant eye occlusion were applied for 8 weeks.[44] Researchers usually categorize vision therapies into some general categories for comparison, including home-based computer therapy, office-based therapy, and pencil push-up treatment. It has been shown that a combination of in-office and home-based therapy produces better results than does home-based therapy alone.[91-93]

Peddle *et al*. found that binocular vision therapy/orthoptics could be even effective in adults who received no treatments for exodeviation at all. In their study, two adult patients with BE were subjected to weekly office-based and frequent home-based therapies for 30 weeks. At the end of treatment, exotropia at distance and near reduced, the patients achieved the required fusion at all distances, and their symptoms improved.[45]

In general, it can be concluded that binocular vision therapy/orthoptics is very effective in children or even in adults who are cooperative and willing to do the therapies.

Botulinum toxin

Studies have shown the effectiveness of botulinum toxin injection for the treatment of IXT.[46,47,94] The therapeutic principle of botulinum toxin in IXT is to paralyze the injected muscle (lateral rectus muscle). According to the literature, it is at least as effective as surgery irrespective of the initial strabismus angle.[46] Significant improvements in fusion control and improved stereovision have been reported 6 months after botulinum toxin injection to the lateral rectus muscles.[46]

Discussion

The first step in the treatment of IXT patients is refractive correction to improve the sensory and subsequently, motor fusion and to enhance the ability to control the deviation.[54,55] In the next step, other methods can be applied according to the patient's status, severity of the deviation, and age.[37] According to the results of recent studies, observation does not result in improvement, and it is better to use observation together with other treatment interventions as an assessment method rather than applying it as a treatment option. Another point is that observation may be used as a temporizing measure in uncooperative children whose deviation is not severe.[36]

Overcorrecting minus lens therapy is an appropriate method for patients with good accommodative power. It may be considered the first treatment option after refractive correction because it is more convenient and acceptable compared to other methods such as occlusion therapy and orthoptics.[37,41,70]

Since occlusion therapy is used to achieve anti-suppression, it can be included in the category of binocular vision therapy/orthoptics and prescribed for children whose accommodative system is not yet normally established to improve deviation and prevent deterioration. However, it should always be remembered that occlusion therapy has short-term effects and should be accompanied by other methods.[60-62]

In patients with <20–25 PD deviation, another intervention that can be applied is prism therapy. This technique can be used either alone to neutralize the deviation or in combination with orthoptic therapy.[81]

Kushner in a study on the effect of combination therapy consisting of part-time alternate occlusion followed by over-minus spectacles with base-in prism in children 2–10 years of age with IXT found that this conservative management could delay or eliminate the need for surgery.[95]

Binocular vision therapies, including fusion, accommodative, and anti-suppression therapies, can affect all systems involved in deviation and are therefore very useful. Another advantage of orthoptic therapy is that it can also be used in adult patients.[45,86,87]

Another non-surgical temporary treatment method is botulinum toxin injection to paralyze the lateral rectus muscle. It is supposed that this method can be at least as effective as surgery irrespective of the initial strabismus angle.[46]

In conclusion, evidence supporting the efficacy of non-surgical management options for IXT is not compelling. More comprehensive randomized controlled trial studies are required to evaluate the effectiveness of these procedures and identify the most effective strategy. Studies with longer follow-ups are also recommended to investigate the long-term effects of different treatment options, especially after the cessation of interventions.

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Conflicts of interest

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