

# Intermittent Exotropia: A Review of the Natural History and Non-surgical Treatment Outcomes

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## ABSTRACT

Intermittent exotropia of the divergence excess type is the most common form of exotropia. Given the intermittent nature of this deviation, and that it can be controlled by fusional vergence but has the potential to develop sensory anomalies such as suppression, management options include non-surgical as well as surgical means. The aims of non-surgical or orthoptic treatment are to improve fusion, eradicate suppression and or teach control of the deviation,

in order to decrease the frequency of the manifest phase and improve motor alignment for near and distance. This review focuses on the outcomes of various non-surgical treatments, including orthoptics, and discusses the natural history of intermittent exotropia which invariably has implications for management.

**Keywords:** intermittent exotropia, distance exotropia, divergence excess, orthoptics, natural history

## INTRODUCTION

Intermittent exotropia X(T), the most common form of childhood exotropia, occurs in approximately 1% of the general population and 25% of strabismic children worldwide.<sup>1</sup> It is an ocular deviation demonstrating ortho- or exophoria when controlled by positive fusional vergence, or a manifest deviation with variable sensory adaptations when it is not.<sup>2</sup> Burian's classification system (Figure 1) divides X(T) into various types (shaded), based on the size of the near and distance deviations and state of fusional control.<sup>3</sup> Unless otherwise specified, the focus of this review will be on the most common X(T), divergence excess type or 'distance exotropia', where the angle of deviation at distance fixation is greater than that at near.

Non-surgical treatment modalities for X(T) have been described throughout the literature. All aim to decrease the frequency of the manifest phase of the strabismus, improving fusion and motor alignment for near and distance.<sup>4</sup> However, conflicting and limited knowledge of the natural history of X(T) and its non-surgical treatment

outcomes hinders formulation of the best management plan for patients. The aim of this paper is to review the literature concerning the natural history of X(T) and its non-surgical management including outcomes.

## NATURAL HISTORY

The natural history of X(T) remains uncertain. Whilst some have suggested it is a progressive disorder left untreated,<sup>5,6</sup> others have reported stabilisation or even improvement of the condition over time.<sup>7-10</sup> Table 1 presents a summary of the findings of various studies examining the natural history of X(T).

Progression of X(T) can be defined as an increase in the size or frequency of the exotropia, either at near or distance, with increasing suppression and loss of stereopsis.<sup>2</sup> This process relies upon the patient's fusional reserve and is expedited by the development of abnormal sensory patterns and more widely-spaced facial features.<sup>11</sup>

Hiles, Davies and Costenbader<sup>7</sup> conducted a study on 48 patients (primarily divergence-excess type), who underwent observation, but also non-surgical treatment, for a mean period of 11.7 years. They found that the larger the deviation, the greater the reduction in measurement at final follow-up. Most patients, however, remained within 10Δ of

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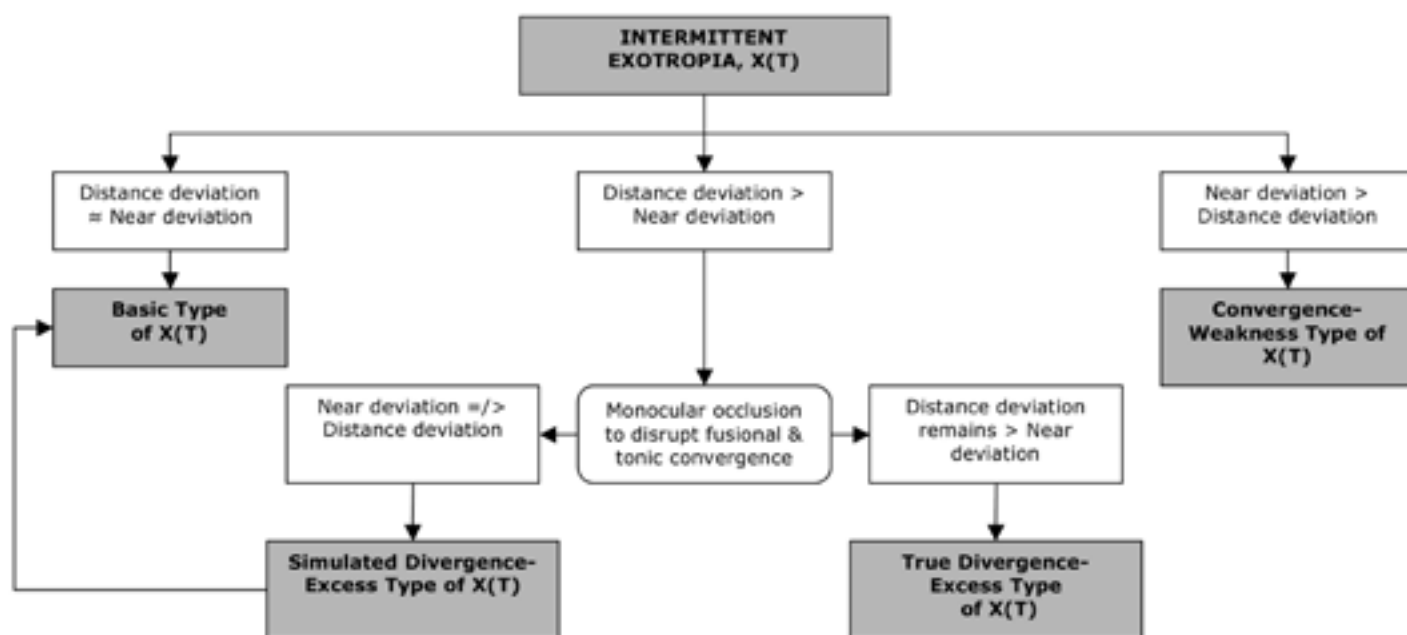


Figure 1. Burian's Classification of X(T).<sup>3</sup>

Table 1. Summary of studies on the natural course of X(T).

Study and Design	N	Mean age of onset and/or presentation	Mean follow-up	Outcomes
Hiles et al <sup>7</sup> Retrospective	48	Onset: 2.8 years Pres.: 4.8 years	11.7 years	83% stayed within 10Δ of distance deviation; 65% became exophoric in the distance
Chia et al <sup>8</sup> Retrospective	287	Onset: 3 years Pres.: 6.1 years	3 years	48% remained within 5Δ of distance deviation; 63% had stable control of distant exotropia
Clarke et al <sup>10</sup> Prospective	168	Pres.: 3.7 years	6-24 months	< 1/3 deteriorated in the control of deviation; 87% maintained or improved stereo acuities
Romanchuk et al <sup>9</sup> Retrospective	109	Onset: 33 months Pres.: 8 years	9 years	58% retained their distance deviation; 51% retained control of deviation
Rutstein & Corliss <sup>2</sup> Retrospective	73	Pres.: 20 years	10 years	36% became exo- or ortho-phoric; 67% of the deviations stabilized or decreased for distance and 81% for near
Von Noorden & Campos <sup>6</sup> Prospective	51	Pres.: 5-10 years	3.5 years	75% progressed; 25% improved or unchanged
Nusz et al <sup>5</sup> Retrospective	138	Pres.: 6.3 years	5.6 years	>50% will have distance deviation increase by at least 10Δ in 20 years; only 4% resolved

Pres. = Presentation

their initial measurements. With a mean initial distance deviation of 23Δ, 65% of patients eventually became exophoric at distance and latency was maintained at near. However, it must be noted that many patients in this series were prescribed orthoptic treatment, which is likely to have contributed to improvement.

Similar findings were reported by Chia, Seenyen, and Quah<sup>8</sup> on 287 patients, though who did not have orthoptic treatment, over a mean period of 3 years. Like the Hiles et al<sup>7</sup> study, the deviation appeared to be relatively stable showing gradual improvements in its size and control at distance, especially in older patients or those who had larger deviations initially.

In another recent study, Clarke and coworkers<sup>10</sup> found that less than one-third of their 168 patients demonstrated deterioration in the control of the deviation, and fewer still (13%) a decrease in stereoacuity (near and distance) over a period of 6 to 24 months. Rutstein and Corliss<sup>2</sup> also reported showing no progression of X(T) and even an improvement of the deviation. However, many of the participants in this study were diagnosed with a basic exotropia or had undergone previous surgery. Furthermore, because improvements could not be attributed to treatment or length of follow-up, Rutstein and Corliss postulated that their findings were due to a regression toward the mean rather than physiological processes. This is a statistical phenomenon such that very

high or low baseline measurements reduce or increase respectively by chance on a subsequent follow-up visit.<sup>12</sup>

However, some studies have suggested that X(T) has an equal chance of becoming better or worse. For instance, Romanchuk, Dotchin and Zurevinsky<sup>9</sup> reported an equal possibility of improvement or deterioration of control of the deviation despite little change in the size of the distance deviation. Despite an improvement in stereoacuity found by Romanchuk et al,<sup>9</sup> it must be noted that without a control group, it is possible that improvement was due to a maturational or learning effect. However, this study is amongst the few to assess the change in stereoacuity between visits. Many authors evaluating various treatments have not considered changes in sensory fusion and have not measured distance and/or near stereoacuity, although its usefulness in assessing control and therefore progression of X(T) has been affirmed.<sup>13</sup>

Contrarily, few studies have reported progression of X(T). Von Noorden & Campos<sup>6</sup> cited a study wherein 75% of patients who were observed without treatment for a mean of 3.5 years displayed one or more signs of progression; the remaining 25% either improved or were unchanged. More recently, Nusz, Mohney and Dieh<sup>15</sup> conducted a study of 138 patients who were followed-up for an average of 5.6 years and found that only 4% resolved in deviation size, more than half having an increased deviation (of at least 10Δ) over a 20 year period.

Most studies published on the natural history of X(T) are retrospective.<sup>2,5,7-9</sup> Retrospective studies rely on the availability and accuracy of medical records and can often be confounded by selection bias may be problematic. The lack of concurrent controls and unreported clinical data also affect such studies' internal and external validities.<sup>14</sup> Previous studies have included various types of X(T)<sup>2,7,8</sup> and/or have included patients who have been undergoing active treatment.<sup>2,5,7,9</sup> The application of treatments in the investigation of the natural course of X(T) can confound conclusions and it is also possible that different types of X(T) have different progression rates.<sup>6</sup> To adjust for potential confounding factors and prevent measurement artifacts, prospective studies with matched case-controls are needed to further understand the natural history of X(T).

## NON-SURGICAL TREATMENT

Non-surgical treatment of X(T) is indicated either pre-operatively to optimize sensory conditions or as primary management usually to delay surgery.<sup>6</sup> Such treatment includes the optical correction of refractive error and minus lens treatment, prisms and orthoptics. Table 2 provides a summary of the articles included in this review investigating non-surgical treatment for the management of X(T).

## REFRACTIVE CORRECTION & MINUS LENS TREATMENT

It is important to correct refractive errors before administering other forms of treatment as clearing blurred images provides a stimulus for fusion, facilitating control, and particularly for myopes.<sup>4</sup> However, the sole impact of refractive correction on treatment outcome of X(T) remains unknown. For hypermetropes, von Noorden and Campos<sup>6</sup> suggests correcting only hypermetropia >2 dioptres (D), the exact amount of correction being dependent on the patient's age and AC/A ratio. On the other hand, it has long been advocated that minus lenses of the strength required for fusion to be established at distance be added to the refractive correction to stimulate accommodative convergence, thereby improving the control of the X(T).<sup>4</sup> However, opponents of minus lenses suggest that treatment can cause temporary consecutive esotropia and accommodative asthenopia, particularly in older children.<sup>6</sup> In addition, myopic progression has been raised as an issue, but is refuted by studies that have found mean refractive changes similar to the general population.<sup>15,16</sup> Table 2 provides a summary of studies investigating minus lens treatment for the management of X(T).

In a retrospective study, Caltrider and Jampolsky<sup>17</sup> reported either qualitative or quantitative improvement in 72% of children who were over-minused by 2–4D for an average of 35 months. A qualitative improvement was regarded as one of increased control of the X(T) with a well-controlled exophoria; quantitative improvement was defined as a decrease in the exodeviation by at least 15Δ. Improvement was maintained in 70% of patients who were followed for at least a year after cessation of this treatment, demonstrating long-term stability in treatment outcome. Pre-treatment age and AC/A ratio did not seem to affect the outcome though.

Watts, Tippings and Al-Madfai<sup>18</sup> tested the success of minus lens treatment using a standardised scoring system – the Newcastle Control Score (NCS). Similar to Caltrider and Jampolsky<sup>17</sup>, the NCS showed that 71% of the patients improved their control of the X(T) post minus lens treatment.

The strength of the minus lenses advocated for this treatment varies.<sup>19-22</sup> Merrick<sup>19</sup> supported the careful use of weak minus lenses in relieving symptoms of X(T). Goodacre<sup>20</sup>, on the other hand, recommended stronger lenses of up to -3D, which improved the control of the deviation in 62% of their patients, especially in those with a high AC/A ratio and near deviation  $\leq 24\Delta$ . Further, 72% of patients in a study by Donaldson and Kemp<sup>21</sup> and 62% in a study by Reynolds et al<sup>22</sup> also had comparable success with minus lens treatment using a variation of -1 to -3D lenses, dependent factors being patient compliance and size of pre-treatment deviation. Hence, to date although minus lens treatment has been shown to be effective, consensus for the strength of the prescription is yet to be established.

**Table 2.** Summary of studies investigating minus lens treatment for X(T)

Authors and Study	Treatment Details	N	Mean Age	Mean Duration of Treatment	Outcomes
Caltrider & Jampolsky <sup>17</sup> Retrospective	Minus lens treatment (-2 to -4DS)	35	Onset: 1.5 years	35 months (2-156 months)	72% improved either fusion quality or both fusion quality and deviation size; 70% followed-up for 1 year maintained their improvement
Watts et al <sup>18</sup> Prospective	Minus lens treatment (-2 to -4DS)	24	6.8 years	4 months	70.8% improved control of deviation
Goodacre <sup>20</sup> Prospective	Group1: Minus lens treatment (Mean -2.50DS) Group2: Minus lens treatment + surgery	34	Group1: 3 years Group2: 4 years	Group1: 32 months Group2: 24 months	62% (of groups 1 & 2) became exophoric at all distances; 27% had at least 15Δ of reduction in deviation and exophoria
Donaldson & Kemp <sup>21</sup> Retrospective	Minus lens treatment (-2 to -3DS)	27	2-17 years	Approx 6 months or more (67%)	72% wearing lenses for at least 6 months became asymptomatic and recovered BSV
Reynolds et al <sup>22</sup> Retrospective	Minus lens treatment (-1 to -2.50DS)	74	4.8 years	3-6 months	Overall "success" rate: 61.7%; 92% with deviation <20Δ "successful"

**Table 3.** Summary of studies investigating prism treatment for X(T)

Pratt-Johnson & Tillson <sup>24</sup> Prospective	Prism (neutralising) treatment	25	2-8 years	1- 2.5 years	66% wearing prisms for at least a year were "cured"
Moore & Stockbridge <sup>26</sup> Retrospective	Prism (overcompensating) treatment or prisms + surgery + orthoptics when needed	50 (Prisms only: 5; Prisms + surgery: 45)	Not stated	Prism therapy alone: 3-18 months; Prisms + surgery: 7 months	Prism therapy: No change in deviation size or control; 13% of patients with residual exodeviation "cured"
Veronneau-Troutman et al <sup>29</sup> Retrospective	Prism treatment or prisms + exercises or prisms + exercises + surgery	37	8-9 years	3.9 months	19% improved fusion quality without surgery; 92% had a decrease in deviation

**Table 4.** Summary of studies investigating occlusion treatment for X(T)

Chutter <sup>35</sup> Prospective	Occlusion treatment (38 part-time patching; 8 full-time) + orthoptic exercises when needed	51	2-62 years	3-12 weeks	Fusion strengthened in 70% occluded part-time, 54% of them became exophoric
Spoor & Hiles <sup>32</sup> Prospective	Occlusion treatment (3-6 hrs/day)	38	29 months (7 months-7 years)	15 months (3-42 months)	90% achieved latency for near and 65% for distance; 58% no longer required surgery
Spoor & Hiles <sup>33</sup> 3-year follow-up	--	34	11 years	3 years without occlusion	78% maintained improvement in control and size of deviation
Freeman & Isenberg <sup>34</sup> Prospective	Occlusion treatment (4-6 hrs/day)	11	Onset: 18 Mths; Treatment: 23.5 months	22 months	100% became ortho- or exo-phoric initially; 27% eventually became orthophoric
Iacobucci & Henderson <sup>36</sup> Prospective	Occlusion treatment (constant)	28	--	Up to 3 months	73% (occluded) initially exotropic and 53% initially intermittent at distance became exophoric
Berg & Isenberg <sup>37</sup> Prospective	Occlusion treatment (4-6 hrs/day)	11	Onset: 28 months; Treatment: 4.7 years	9 months	100% achieved latency initially; 36% maintained control of deviation

**Table 4.** Summary of studies investigating occlusion treatment for X(T)

Sanfilippo & Clahane <sup>38</sup> Prospective	Orthoptic treatments: occlusion, red-filter, antisuppression treatment, convergence exercises etc	31	9 years and above (52%)	5-22 orthoptic sessions Follow-up: 4.5-6.5 years	97% had "excellent" or improved binocular status; 84% of them maintained their status on long-term follow-up
Altizer <sup>39</sup> Prospective	Group1: Orthoptic treatments: occlusion, convergence exercises, prisms Group2: Surgery	52 in total 1) 23 (13 X(T), 10 constant XT) 2) 29	--	1 year; Follow-up: 1-2 years	1) 69% X(T) pts became exophoric from orthoptics; 62% X(T) pts improved convergence 2) 44% exophoric from surgery
Chryssanthou <sup>40</sup> Prospective	Orthoptic treatments: occlusion, red-filter, convergence exercises	27	5-33 years	3-16 sessions; Follow-up: 6-30 months	89% improved binocular status; 67% had "excellent" or "good" status 6-30 months after
Newman & Mazow <sup>42</sup> Retrospective	Group1: Orthoptic treatments: occlusion, minus lenses, exercises, glasses Group2: Surgery	60 in total 1) 30 orthoptic 2) 30 surgical	Orthoptics: 8 years; Surgery: 6 years	Follow-up: 2 years	Groups 1 & 2: 67% with deviation <30Δ became exophoric and size of deviation reduced to <15Δ

**Table 5.** Summary of studies investigating combined orthoptic treatment for X(T)

Study and Design	Type/s of Treatment	N	Mean Age	Mean Duration of Treatment	Outcomes
Cooper & Leyman <sup>41</sup> Retrospective	Group1:Occlusion Group2: Surgery Group3: Orthoptic treatment + surgery Group4: Orthoptic treatment (anti-suppression & convergence exercises)	673 in total 1) 11 2) 264 3) 216 4) 182	--	12 weeks Follow-up: 1 year	59% of group 4, 52% of group 3, 42% of group 2 & 36% of group 1 had "good" results
Singh et al <sup>11</sup> Prospective	Orthoptic treatments: occlusion (6hrs/day), bar-reading, convergence and fusional exercises, glasses	30	Presentation: 19.8 years	8 weeks-1 year	64%-86% improved their binocular status and symptoms
Pejic et al <sup>43</sup> Retrospective	Group A: Orthoptic fusion exercises Group B: Control group with no orthoptic treatment	96	6-34 years	Group A: 12-36 weeks	Group A: 74% achieved better distance stereoacuity; 93% increased distance fusional amplitude by at least 50% Group B: No improvement in distance stereoacuity, 12% deteriorated
Moore <sup>44</sup> Retrospective	1)Orthoptic treatment + surgery 2) Surgery 3)Orthoptic treatment	180 in total 1) 106 2) 57 3) 17	3-18 years	Follow-up: 10 months- 10 years	1) 73% improved or "cured" 2) 84% improved or "cured" 3) 18% improved or "cured"
Figueira & Hing <sup>31</sup> Retrospective	1) Orthoptic treatment/ occlusion + surgery 2) Surgery 3) Orthoptic treatment/ occlusion 4) Observation	150	Onset: 2.5 years Treatment: 5.2 years	Follow-up: 3.3 years	Highest rate of "success" of orthoptic treatment & surgery at approx 85%

**PRISM TREATMENT**

Prisms are used to shift target images closer to or on the fovea, aiding in sensory fusion.<sup>23</sup> According to Coffey and coworkers,<sup>4</sup> there are three approaches to prism treatment: prisms can be demand-reducing by compensating for part of the deviation and relieving the load on fusional vergence; neutralising and fully compensating the deviation; or over compensating to increase the convergence response so that fusion is maintained when the prism strength is reduced.

There are few studies on prisms as a primary treatment for X(T) (Table 3). One of the earliest is by Pratt-Johnson and Tillson,<sup>24</sup> who investigated the effects of neutralising prisms on patients with X(T) of less than 20Δ. They had patients wearing them for more than half of their waking hours for 12–30 months. Despite most patients having reduced vision due to the prisms, 66% who wore them for at least 12 months were deemed to be "cured". Hardesty<sup>25</sup> also reported that the younger the child having prism treatment, the higher the chance of improving their fusional amplitudes. However, this study had incorporated orthoptic exercises in conjunction with prisms.

Moore and Stockbridge<sup>26</sup> purported that prism treatment should not be administered alone, but as an adjunct to surgery. In their study, only patients who underwent surgery experienced an improvement in the deviation size and control. Immediate prism treatment was more successful for a number of patients with residual deviation postoperatively.

The success of prism treatment in exodeviations, when used in conjunction with other treatments, have also been reported by other studies.<sup>27-29</sup> In these studies, not only were the size and control of the deviation improved, but convergence amplitudes and retinal correspondence were also enhanced. In a study by Veronneau-Troutman,

Shippman and Clahane,<sup>29</sup> 19% of patients receiving pre-operative prism treatment had their fusion improved to the point of no longer requiring surgery. There was also no difference in the results of those receiving prisms alone or both prisms and orthoptic exercises.

However, not all advocate prism treatment. Friendly<sup>30</sup> was skeptical regarding the usefulness of prisms due to the many disadvantages (optical distortion, weight, cosmesis and visual degrading properties), especially for patients unaccustomed to wearing glasses. Possible reliance on the prisms may also develop, causing exodeviations to increase over time.<sup>23</sup>

**OCCCLUSION TREATMENT**

By reducing binocular stimulation, occlusion treatment abolishes the abnormal sensory adaptations developed in avoiding diplopia (suppression) (see Table 4), reduces the suppression scotoma size and reinforces fusional processes after cessation of patching.<sup>31</sup> Studies have demonstrated significant improvements in exodeviation with part-time patching of the non-deviating eye (or alternate patching for those with equal fixation preference) as a passive form of anti-suppression treatment.<sup>32-34</sup> Full-time patching is generally not prescribed because of possible disruption to fusional mechanisms and subsequent manifestation of the deviation.<sup>34</sup> Moreover, part-time patching has been proven to be just as effective as full-time patching in these patients, strengthening fusion in 70%.<sup>35</sup>

Spoor and Hiles<sup>32</sup> prescribed occlusion (3–6 hours daily) over an average of 15 months, aiming to reduce patients' deviation size and increase fusional amplitudes. Control of the deviation improved substantially - the number of patients with latent deviations increased from 26% to 65% for distance fixation. Improvement in the size and control of

the deviation was such that surgery was no longer required in 58% of patients. In a follow-up study, 80% of patients were re-evaluated three years after cessation of occlusion and 78% had maintained their improvements.

In addition to the above findings, occlusion has been reported to delay the need for surgery by at least 2 years, which can greatly reduce the risk of amblyopia following surgical overcorrection in young children.<sup>34</sup> In Freeman and Isenberg's study,<sup>34</sup> all patients who were patched for 4–6 hours daily became heterophoric at least temporarily, with 27% becoming "orthophoric" after a follow-up of 22 months. Their ability to control the deviation was improved more than the reduction in size. Similarly, Iacobucci and Henderson<sup>36</sup> stated that preoperative occlusion enhanced postoperative results by inhibiting the development of suppression, thus increasing postoperative fusional amplitudes. Indeed, 86% of patients demonstrated a decrease in the size of the distance deviation; and 73% of the patients having occlusion who were initially exotropic and 53% who were intermittent at distance eventually became exophoric.

In a similar study to Freeman and Isenberg,<sup>34</sup> Berg and Isenberg<sup>37</sup> also found that similar unilateral occlusion of older children yielded favourable results. All achieved latency or control in the distance for some amount of time with occlusion and 36% maintained their control of the deviation even after cessation of patching.

## COMBINED ORTHOPTIC TREATMENTS

Orthoptic exercises (see Table 5) like anti-suppression and convergence exercises aim to make patients aware of when their deviation becomes manifest, reinforcing their control.<sup>6</sup>

Sanfilippo and Clahane<sup>38</sup> examined the immediate and long-term results of combined orthoptic treatments in exodeviations. Red-filter anti-suppression treatment and convergence exercises were prescribed. In most patients, the pre-treatment binocular status was deemed to be "poor" but improved (even to "excellent") in 97% post-treatment. This improvement was maintained in 84% after long-term follow-up.

Altizer<sup>39</sup> compared the effects of non-surgical treatment on X(T) with that of surgery (but including constant exotropia). Non-surgical management consisted of constant occlusion, convergence exercises (that trained relative fusional vergences and simple, jump and voluntary convergence), and base-in Fresnel prisms for approximately 1 year. More X(T) patients attained a "cure" than constant exotropes, especially those undergoing non-surgical treatment (69%) as compared to surgery (44%). "Cure" referred to achieving an exophoria of less than 20Δ at both near and distance that was controlled under stress. Most patients (62%) also improved their convergence ability after non-surgical treatment.

Later studies demonstrated equally favourable outcomes for

orthoptic management on X(T), each according to its own definition of success.<sup>11,40-43</sup> Chryssanthou<sup>40</sup> and Newman and Mazow<sup>42</sup> found orthoptics useful even for the treatment of moderate-sized exodeviations (25–30Δ), more than half of patients gaining control both at distance and near fixation. However, Chryssanthou's<sup>40</sup> orthoptic treatment varied from that of Newman and Mazow,<sup>42</sup> the latter including minus lenses in addition to occlusion and convergence exercises. Good results were also obtained in 59% of patients receiving only orthoptic treatment in a study by Cooper and Leyman<sup>41</sup> compared with those receiving just surgery (42%) or both orthoptics and surgery (52%).

More recently, Singh, Roy and Sinha<sup>11</sup> and Pejic and coworkers<sup>43</sup> reported that orthoptic exercises (convergence and fusion exercises) can indeed enhance the binocularity of all types of X(T), particularly convergence-weakness type. More than half of the patients receiving fusion exercises obtained significant improvement in binocularity. In the Pejic et al 43 study, 74% achieved better distance stereoacuity and 93% also demonstrated an increase in their distance fusional amplitudes by at least 50%. In the Singh et al 11 study, orthoptic treatment was found to be effective functionally in 64% and symptomatically in 86% of the patients, most having deviations of  $\leq 25\Delta$ .

While some argue that orthoptic treatment is more effective for certain X(T), others stress that orthoptics as a supplement (and not a substitute) to surgery generates better results. Moore<sup>44</sup> reported the lowest success rate for orthoptic treatment alone on X(T) children when compared to those treated with surgery or a combination of both. Figueira and Hing<sup>31</sup> also demonstrated that combined surgery and orthoptics (including minus lens treatment and convergence exercises) achieved better outcomes than orthoptics alone.

Finally, orthoptic treatment has been criticised for being time-consuming as it requires regular follow-ups, and because patient cooperation and compliance is important for its success.<sup>4</sup> Despite patient compliance being principal in determining the success of various treatments (including minus lenses, prisms and orthoptics), compliance was not evaluated or controlled in any of the above studies. Future studies must actively monitor adherence to treatment. Without any record of compliance, it is difficult to attribute findings to the prescribed treatment.

## CONCLUSION

Consensus regarding the efficacies of various non-surgical treatments remains unattainable despite their inherent ability to strengthen fusional control and diminish the size of exodeviation. The lack of uniform success criteria and outcomes as well as inconsistent definitions of treatments and lack of recording of compliance hinder the evaluation and comparison of treatment options to determine best management.

Furthermore, sub-categorisation of X(T) types are often not clearly defined even though they are likely to have a different response to treatment. Prospective randomised controlled trials with larger sample sizes and standardised definitions and scoring systems are required in order to better assess the effectiveness of various treatments. A randomised controlled trial is considered the best type of study for the assessment of healthcare interventions. By conducting such studies, clinical guidelines for the use of non-surgical treatment in X(T) could be developed more readily. Finally, further investigations on the unpredictable course of X(T) are also important as it has implications on the true value of non-surgical management, and the need for and timing of surgery.

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