Original Article

Role of Overcorrecting Minus Lens Therapy in Intermittent Exotropia for Prevention of Constant Exotropia in Children Under the Age of 7 Years

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Abstract

Background: The basis of the overcorrecting minus lens is to induce compliance and consequently prevent constant exotropia. Some previous studies advocated early surgical therapy and others suggested over-minus treatment. Our purpose is to evaluate the success rate of the over-minus lens. **Methods:** This descriptive cross-sectional study was carried out on 106 patients under the age of 7 years with intermittent exotropia (IXT) who attended Amir-Al-Momenin Hospital at Guilan University of Medical Sciences, Iran. The data was gathered by a form including sex, age, level of cycloplegic refraction, the amount of deviation before and after using the over-minus glasses, visual acuity, the amount of the over-minus glasses, duration of treatment, recovery, and follow-up. The success rate was defined as decreasing exotropia to less than ten prism diopters or exophoria. **Results:** A total of 106 patients with a mean age of 2.25 ± 0.74 years were enrolled in this study. The mean exotropia before and after treatment was 20.96 ± 8.20 and 12.16 ± 11.04 prism diopters, respectively, and there was a statistically significant difference ($P < 0.002$). The mean refractive spherical and astigmatic errors (cycloplegic refraction) were +1.34 ± 1.07 and −0.32 ± 0.72 diopters, respectively. At the end of the follow-up, exotropia increased in 5.6% of patients, there was no change in 15% of patients with a mean deviation of 25.0 ± 6.06 prism diopters, and 79.24% of patients were treated successfully. **Conclusions:** According to the results of this study, treatment of IXT by over-correcting lenses can be a safe procedure and effective in preventing exotropia.

Keywords: *Exotropia, eye deviation, glasses, over-minus, prevention*

Introduction

Intermittent exotropia (IXT) is the most common exotropia that is seen in approximately 1% of the general population[1] and is characterized by an intermittent deviation of one or both eyes, often exacerbated by fatigue, inattention, or illness.[2,3] Both the frequency of the manifested deviation and its size are important points in deciding to treat. A 20 prism diopter (PD) or less exotropia with good binocular control for near generally is considered for nonsurgical treatment.[4] There is controversy about the method of treatment and optimal timing. Both surgical and nonsurgical management are prescribed commonly.[3] The best treatment and optimal timing for this disorder remain unclear.[5,6] Controversy exists about the success rate of over-minus treatment. Some investigations suggested the use of minus lenses,[7-14] and most generally recommended prescribing the lowest power required for fusion to prevent constant exotropia. Minus lenses have been reported to be second only to occlusion as the preferred form of IXT management, but other studies reported that the IXT relapsed to its previous level of control once the therapy was discontinued.[7,8,15,16] Nonsurgical treatment is designed to improve IXT control, prevent constant exotropia, and preserve stereoacuity, thereby potentially improving visual function. Forcing more accommodation than the patient's fusion reserve is important because possible complications such as consecutive esotropia and accommodative asthenopia can occur.[17] Furthermore, myopic progression from overcorrection has been raised as a concern.[16,18] We aimed to assess the effect of the lowest minus lens powers to control the IXT and prevent constant exotropia.

Materials and Methods

1. **Study design:** This analytic cross-sectional study was performed

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at the Eye Research Center of Guilan University of Medical Sciences, Rasht, from 2006 to 2013. This study was approved by the ethics committees of the Vice-Chancellor of Research at Guilan University of Medical Sciences (Code: 3/132/2558, date: 2014/10/25). It was conducted according to the principles of the Declaration of Helsinki. Informed written consent was obtained from the fathers of all participants.

2. **Study Population:** In this study, records of 106 IXT patients presenting in the study period were reviewed. IXT diagnosis was based on the clinical history (IXT at times of visual disinterest, daydreaming, fatigue, and eye closure in bright sunlight) and cover test. Exclusion criteria were the history of any ocular trauma and ocular surgery, congenital eye disease, irregular follow-up, continuous glasses wear, and hyperopia and myopia over 4 diopters. Patients' demographic characteristics such as age, sex, and examination results like best-corrected visual acuity (BCVA), amount of pre- and post-treatment of exotropia at 6 meters in primary gaze positions with an alternate prism and cover test, cycloplegic refraction, amount of over-minus treatment, glasses, duration of follow-up, and improvement were gathered.
3. **Measurement:** The BCVA was measured at 6 m with a Snellen E chart for children under 4 years old and a pediatric Snellen chart for above 4 years old and then converted to Log Mar and compared pre- and post-treatment. Exodeviations were measured by the prism cover test (PCT) to identify the nature and quantify the exodeviation at the pre-treatment and follow-up visits. Follow-up data were categorized at 4 months for the first year and then every 6 months for 5 years. Cycloplegic refraction was performed using cyclopentolate 0.05% (one drop and then refraction was performed 45 minutes later). All subjects received minus lens therapy to control the exotropia, which was conducted by adding the maximum tolerated minus lenses, with a minimum of −1.5 diopters to a maximum of −3.5 diopters to their full cycloplegic refraction. For the hypermetropic eyes, the prescription was reduced by a minimum of 2 diopters. Over-minus 1.5 diopters and a maximum of −3.5 diopters were prescribed in the myopic and emmetropic patients. The success rate was defined as improved exotropia to less than 10 PDs or converted to exophoria.
4. **Statistical analysis:** Data were reported by frequency, percent, mean, and standard deviation. We used the Shapiro-Wilk test to evaluate the normal distribution of quantitative variables. The mean of pre- and post-treatment exotropia was compared by paired T-test. We compared the mean of exotropia in females and males pre- and post-treatment with the independent T-test. Analysis of variance (ANOVA) was performed to evaluate the effect of over-minus glasses to improve exotropia. Linear regression was used to indicate the predictors. A P value < 0.05 was considered statistically significant.

Results

The records of 106 patients were assessed in this study. Our results are explained in seven categories.

1. **Age and sex:** The mean ages of total patients, males, and females were 2.25 ± 0.74, 2.22 ± 0.35, and 2.28 ± 0.28 years old, respectively. About 62% of patients were female [Table 1].
2. **Refractive errors:** The mean refractive spherical and astigmatic errors (cycloplegic refraction) obtained were +1.34 ± 1.07 and −0.32 ± 0.72 diopters, respectively [Table 2]. There were no significant differences between females and males in spherical and astigmatism errors (P-value = 0.689 and P value = 0.378, respectively). After treatment, the mean refractive spherical and astigmatic errors (cycloplegic refraction) were +1.03 ± 080 and −0.30 ± 0.58, respectively. There were no significant differences in spherical and astigmatism errors pre- and post-treatments (P > 0.05). The average number of prescribed glasses in patients was −1.46 ± 1.30 diopters. There was no significant shift in myopia in our follow-up.
3. **Distance Angle of Deviation:** The mean exotropia before and after treatment were 20.96 ± 8.20 and 12.16 ± 11.04 PDs, respectively, and there were statistically significant differences between pre- and post-treatment variables [P-value = 0.002, Table 3], but there was no statistically significant difference between females and males (P-value = 0.668 vs. P value = 0.907, respectively).
4. **Success rate:** At the end of the follow-up, only six patients (5.6%, including three boys and three girls) had increased eye exotropia. Also, 16 patients (15%, including 5 males and 11 females) with a mean of 25.0 ± 6.06 PD exotropia did not change deviation, and 84 patients (79.24%) were treated successfully [Table 4].
5. **Over-minus lens:** The mean of the prescribed over-minus lens was −2.86 ± 0.96 diopters. The details of the power of the over-minus lens in all patients are depicted in Table 4. Due to the taper of the patient's lens score during follow-up, the mean duration of the overcorrecting minus treatment lens was equal to the average follow-up period.
6. **Follow-up:** The mean age of the follow-up period was 4.39 ± 1.44 years (ranging from 6 months to 5 years), and the mean duration of recovery was 3.16 ± 1.35 years.
7. **Visual acuity:** The mean visual acuity at the beginning

Table 1: Mean of age and distribution of sex

Patients & sex	Average age	Patients & frequency
Male	2.22±0.35	40 (38%)
Female	2.28±0.28	66 (62%)
Total	2.25±0.74	106 (100%)

Table 2: Mean of spherical and astigmatic refractive before and after treatment

	Mean of spherical error		Mean of astigmatic error		*P*
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	
Total	+1.34±1.07	+1.11±1.07	−0.32±0.72	−0.30±0.52	*P*>0.5
Female	+1.41±1.07	+1.36±1.07	−0.21±0.85	−0.19±0.60	
Male	+1.21±1.06	+1.06±1.07	−0.50±0.55	−0.48±0.52	
P	0.689	0.675	0.378	0.377	

Table 3: Means of exotropia before and after treatment

	before treatment (prism diopter)	after treatment (prism diopter)	*P*
Total	20.96±8.20	12.16±11.04	0.002
Female	23.56±7.66	12.54±11.76	0.001
Male	19.6±9.09	11.53±10.48	0.001
P	0.668	0.907	

and after treatment was 3.32 ± 4.13 and 3.23 ± 2.12 Log Mar, respectively.

Discussion

The aim of overcorrecting minus lenses is to stimulate accommodative convergence to control intermittent exotropia. It has been shown to improve both qualitative observations and quantitative measurements.[19] Numerous research studies have shown the effectiveness of minus lens treatment for IXT. Clinicians often increase minus lens power for any deterioration in control of fusion because it is thought that stronger minus lenses induce greater accommodative convergence and thus encourage better control of the deviation.[7,10] Our study was performed on 106 patients with the diagnosis of exotropia in patients under the age of 7 years during 2006/2013. We compared our results with other studies in six categories in Table 5.

1. **Age and sex:** One hundred and six records were assessed in this study. The mean ages of total patients, males, and females were 2.25 ± 0.74, 2.22 ± 0.35, and 2.28 ± 0.28 years, respectively. About 62% of patients were female. Paula JS *et al*.[22] showed that the male–female ratio was 2.25 and the average ages in groups A and B were 4.61 ± 2.36 and 4.75 ± 2.6 years, respectively. The difference between the above study and our investigation may be related to race and the nation of the population of studies.
2. **Refractive errors:** The mean refractive spherical and astigmatic error (cycloplegic refraction) obtained was +1.34 ± 1.07 and –0.32 ± 0.72 diopters, respectively. After treatment, the mean refractive spherical and astigmatic errors (cycloplegic refraction) were 1.03 ± 080 and –0.30 ± 0.58 diopters, respectively. The mean power of prescribed glasses in patients was –1.46 ± 1.30 diopters.

   Paula JS *et al al*.[22] showed that the initial SE were OD: 0.49 ± 1.76 and OS: 0.65 ± 1.37 in group A and OD: –2.64 ± 3.99 and OS: –2.86 ± 3.98 diopters in group B. The prescribed glasses in other studies were less than –1.25 diopters in Merrick's[12] prospective study, –2 to –4 diopters in Caltrider and Jampolsky's[8] retrospective study, −2.5 diopters in Goodacre's[10] prospective study, −2 to − 3 diopters in Donaldson and Kemp's[9] retrospective study, −1 to −2.5 in Reynolds *et al*.'s[13] retrospective study, and 1–2.5 diopters in the pediatric eye disease investigator group.[20] The complete previous studies are depicted in Table 5. Approximately in all previous studies, the prescribed glasses were −1.24 to −4 diopters like our study.
3. **Distance angle of deviation:** The mean amount of exotropia before and after treatment was 20.96 ± 8.20 and 12.16 ± 11.04 PDs, respectively, and there were statistically significant differences between pre- and post-treatment variables (*P*-value = 0.002). However, there was no significant statistical differences between female and male (*P*-value = 0.668 vs. *P* value = 0.907, respectively). Konstandina[20] in his study showed that the mean angle of 20.6PD ± 6.3PD at the baseline decreased to 16.7PD ± 9.8PD, 14.0PD ± 10.1PD, and 11.4PD ± 10.1PD with −1, −2, and − 3PD lenses, respectively. With −1 D lenses, 18 children had a decrease in their distance exotropia, three had no change, and three had increased distance. With –2 D lenses, 19 had a decrease, two had no change, and the remaining three again had an increased distance. With −3 D lenses, all but one had a decrease, and the remaining child demonstrated an increase. The above results were like our results.
4. **Success rate:** At the end of the follow-up, only six patients had increased eye exotropia. Sixteen patients with an average of 25.0 ± 6.06 PD exotropia did not change deviation and 84 patients (79.24%) were treated successfully. Konstandina[23] in his study showed that with −1 D lens, 18 children had a decrease in their distance exotropia, three had no change, and three had increased distance. With –2 D lenses, 19 had a decrease, two had no change, and the remaining three again had an increase. With −3 D lenses, all but one had a decrease, and the remaining child demonstrated an increase. Kennedy[11] on 103 cases with up to − 6.5 D refractive error showed that 100% achieved cosmetically straight eyes, 18% presented constant fusion, and 54% presented fusion sometimes. Merrick,[12] in a prospective study with less than −1.25 D in four subjects and a mean age of 7.5 years and with 6 months of duration of treatment, showed different results.

Table 4: Frequency of success rate

Deviation changed	number	Pre-treatment deviation (PD)	Post-treatment PD	Over-minus (diopter)
Increased	6 (5.6%)	17.38±8.61	25.20±6.06	−2.5±1.18
No change	16 (15%)	25±6.06	25±6.06	−2.79±0.85
Decreased	84 (79.4%)	20.96±8.20	8.12±2.04	−2.89±0.79

Table 5: Summary of previous studies

Study (type)	Strength of minus lenses	*n*	Mean age	Mean treatment duration	Summary
Our study	−1.5 to−3.6 4	106	2.25Y (1.5-7)	4.39±1.44Y	79.4%
Pediatric Eye Disease Investigator r Group[20] 2016	1 to 3 D	20	1-9 Y (5)	6-48	50%
Merrick (prospective)	Less than−1.25	4	7.5 Y	6M	Results vary individually
Caltrider and Jampolsky[8] (retrospective) 1983	2 to 4	35	1.5 Y	35M	72%
Goodacre 11 (prospective) 1985	−2.5	34	3.5 Y	28M	62%
Donaldson and Kemp10 (retrospective) 1991	2 to 3	27	2-17	6M	72%
Reynolds *et al*.[13] (retrospective) 1994	−1 to−2.5	74	4.8 Y	3-6M	61.7%
Watts *et al*.[14] (prospective) 2005	−2 to−4	24	6.8 Y	4M	70.8%
Rowe *et al*.[7] (prospective) 2009	1 to 3 D	20	1-9 Y (5)	6-48	50%
Bayramlar *et al*.[21] (retrospective) 2017	−2.00 to−4.00 D	19	3-14 Y	18M	84%

Caltrider and Jampolsky,[8] in a retrospective study with a power over −2 to −4 D and age under 1.5 years with a duration of 35 months (2–156 months) showed that 72% had improved either in fusion quality or both fusion quality and deviation size. In this study, 70% of the 1 year followed-up patients maintained their fusion. Goodacre,[10] in a prospective study, divided patients into two groups: group 1: minus lens therapy (Average: −2.5 D) and group 2: minus lens therapy + surgery in 34 cases. The average age in group 1 was 3 years and in group 2 was 4 years with the duration of treatment being 32 months in group 1 and 24 months in group 2; 62% (of groups 1 and 2) became exophoric at all distances; 27% had at least 15 D of reduction in deviation and exophoria. Donaldson and Kemp,[9] in a retrospective study, assessed 27 cases with −2 to −3 D refractive error and 2–17 years' age range and showed about 67% of patients with 6 months and 72% with over 6 months of wearing lenses became asymptomatic. Reynolds *et al*.,[13] in a retrospective study on 74 cases aged 4.8 years of age with an over-minus of −1 to −2.5 D lens and 3–6 months duration of treatment, showed that the overall "success" rate was 61.7% and 92% with deviation <20 PDs, 17% maintained success after cessation of minus lens treatment. Watts *et al*.,[14] in a prospective study with over-minus −2 to −4 D in 24 cases with 6.8 years of age and duration of 4 months, showed 70.8% improved control of deviation. In a prospective study performed by Rowe *et al*.,[7] on 20 cases with an age range of 1–9 years, an over-minus of –1 to –3 D, and a duration of 6-48 months, 50% achieved control and 30% required further treatment to achieve success. Bayramlar *et al*.,[21] in their study with retrospective analysis, reported the outcomes of 19 children with IXT who were prescribed over-minus lenses (–2.00 to –4.00 D) for 18 months (6–33). The success was evaluated using two assessment methods including the Newcastle Control System (NCS) and Jampolsky's assessment. The mean age of the patients was 6.8 ± 3.3 years (range 3–14 years). After the therapy, the median NCS score significantly improved from 5 to 1 ($P < 0.001$). Sixteen children (84%) showed an NCS score of two or less after over-minus lens treatment. According to Jampolsky's assessment, 84% of the patients showed significant improvement from the baseline (47% had qualitative improvement and 37% had a quantitative decrease in the angle of deviation, and a qualitative improvement).

The differences between the above results and our results may be related to the number of patients, duration of follow-up, amount of power of over-minus, study design, and other unknown factors.

5. **Over-minus:** The mean of the prescribed over-minus was –2.86 ± 0.96 diopters. Due to the taper of the patient's lens score during follow-up, the mean duration of the overcorrecting minus treatment lens was equal to the average follow-up period. The details of the amount of power of over-minus are depicted in Table 5.
6. **Myopic shift:** There was no significant shift in myopia in our follow-up.

In a study carried out by Kushner,[18] 74 patients with IXT were treated with overcorrecting minus lens therapy for at least 6 months (6-month treatment group). A total of 34 patients in the subset received overcorrecting minus lens therapy for 5 years (5-year treatment group). The mean change in refractive error (spherical equivalent of the fixing eye) of these two groups 5 years after the initial examination was compared with the mean change in refractive error of a control group of 45 patients with IXT

who did not receive overcorrecting minus lens therapy. At the time of initial examination, the mean (± SD) refractive error was 0.00 ± 1.40 diopters (D) in the control group, 0.00 ± 1.50 D in the study group, and − 0.10 ± 1.50 D in the 5-year study group, all of which were essentially identical. Five years after the initial examination, the mean change in refractive error was − 1.40 ± 2.80 D in the control group, −1.52 ± 1.80 D in the 6-month treatment group, and − 1.54 ± 1.80 D in the 5-year treatment group. Like our results, these differences in the change in refractive error (myopic shift) were not statistically significant.

Limitations

Our study had some limitations: 1: moderate number of patients, 2: no measurement of stereopsis, 3: retrospective study, and 4: not categorizing the patients according to the over-minus amount.

Conclusions

According to the results of this study, the treatment of IXT by overcorrecting lenses can be a safe procedure for controlling the deviation that does not produce any change in refraction.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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