Treatment of Younger Patients with Accommodative Esotropia

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Research article

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Abstract

Background: Accommodative esotropia (AET) is a common disease during childhood. In this literature review, we analyze and discuss the different methods of treatment for Accommodative esotropia. Methods: Articles about accommodative esotropia from 2007 to 2017 were retrieved from the PubMed database. We study the articles by title/abstract/all fields, after applying the inclusion and exclusion criteria, finally 9 articles were retained. We compared the effectiveness between these approaches to treatment. Results: All the refraction methods had an effectivity rate of > 50%. The bifocal lenses group showed a higher failure rate (15.58%) than the single-vision lenses group (5.19%). Extraocular muscle surgery can significantly decrease deviation in patients who have AET with a high AC/A ratio (95.24%,71.30%,78.40%). After Botulinum toxin injection, the residual deviation was significantly lower than that before the injection (90.44%) and this rate held stable until 12 months after the injection (85.71%) and then decreased to 71.43% at 18 months. The effectivity rate in the prism builders group (surgery with prism group) was significantly higher than that in the prism non-builders group 100% vs. 56.25%). In this review, the average rate of Amblyopia in the accommodative esotropia patient is 41.36%. Conclusions：All the treatment were full or partly effective for accommodative esotropia patients. Early intervention using effective methods of treatment can improve accommodative esotropia patients' alignment and improve their quality of life. Amblyopia is common in patients with partly accommodative esotropia. Keyword: Accommodative esotropia, Treatment, High AC/A (accommodative convergence to accommodation ratio), Amblyopia.

Background:

Esotropia is the commonest type of strabismic deviation,[1] manifesting as an esodeviation that cannot be controlled using fusion.[2] Specifically, when the visual axes cross in front of the point of fixation, the eyes over-converge and become misaligned.[3] Several studies have shown that almost half of all esotropia cases can be attributed to accommodation.[3] Other studies have shown that 36% of patients with esotropia have accommodative esotropia (AET), and that almost half of them have the convergence-excess type.[4,5] Untreated AET can cause amblyopia; effective treatments are therefore urgently needed.

AET is an acquired esotropia that is associated with activation of the accommodation reflex.[6] For this reason, it can also be classified as refractive accommodative esotropia (RAE), non-refractive accommodative esotropia, and partly accommodative esotropia. AET can present at any time during childhood, but it most often appears between the ages of 2 and 4 years. In patients with AET who have uncorrected hyperopia, the error increases until the age of 6–7 years and then decreases until the child is 14 years old. This differs from the pattern in the general hyperopia population.[5,7,8] Furthermore, the incidence of hyperopia in patients with esotropia is larger than that in the normal population. RAE is associated with hyperopia,[9,10] and the refractive error generally ranges from 2 to 6 diopters (D). The angle of deviation can be canceled at both distance and near after full hyperopic correction. The deviation is caused by an abnormal activation of the accommodation reflex that is required to correct the blurred vision caused by the uncorrected hyperopia.[11] To date, the relationship between the amount of hyperopia and the angle size has not been determined. However, the deviation in RAE is related to the size of the AC/A ratio.[3] RAE comprises three factors: uncorrected hyperopia, accommodative convergence, and insufficient fusional divergence. The condition usually begins as intermittent RAE, but if treatment is delayed, the deviation can become constant.

Non-refractive accommodative esotropia is usually manifests in an corrected patient with a high AC/A ratio and showing orthotropia at distance fixation, but more than 10 prism diopters (pd) of esotropia at near fixation. It can be corrected using an add-on lens at near.[12] The refractive errors of patients with non-refractive accommodative esotropia can range from myopia to high hyperopia. Patients with partly accommodative esotropia show a reduced angle of esotropia upon full refractive correction, as well as residual esotropia, despite treatment of their amblyopia and full hyperopic therapy.

The basic treatment for RAE is restraint of accommodation (by the full amount of hyperopia measured under cycloplegia) and treatment of concomitant amblyopia. More specifically, some common treatments include single focal spectacles, bifocal spectacles, progressive-addition lenses (PALs), contact lenses, vision therapy ,[3] pharmacologic agents, and/or observation. In patients with non-refractive AET, the most common treatment is bifocal spectacles. When an increase in bifocal power does not eliminate the angle of deviation, base-out prisms may need to be used.[3] Strabismus surgery may also be necessary. In patients with partly accommodative esotropia (PAE), the most common treatment comprises full correction of the hyperopic refractive error measured under cycloplegia. The use of prisms and surgical correction for residual deviation may also be warranted.[1,2,13,14] In addition, treatment of any amblyopia should be considered.

There are several treatments for different type of AET. So analyze and discuss the difference among those treatments, and choose an effective method is very important.

Methods

An article search was performed on PubMed database (https://www.ncbi.nlm.nih.gov/pubmed/). The following keywords were used: "accommodative esotropia", "refractive accommodative esotropia", "non-refractive accommodative esotropia", "partly accommodative

esotropia", "high AC/A ", "high accommodative convergence to accommodation ratio", "treatment", and "therapy" . The search included all articles published before June 2017 and yielded a total of 162.

Inclusion criteria were as follows: (1) All patients had AET; (2) Studies or reports discussed the treatment of AET; (3) Published in English.

Exclusion criteria were as follows: (1) Studies or reports published more than 10 years ago; (2) Subjects (participants) were over 18 years old; (3) Patients had undergone prior strabismus surgery (except in prism studies); (4) Patients had a chromosomal anomaly; (5) Study involved a follow-up period of < 5 months.

After applying the inclusion and exclusion criteria, finally 9 articles were retained. The basic information of the nine articles is listed in Table 1.

Table 1. Basic information of the nine articles

First author	Published year	Title
Quigley,C	2017	A retrospective evaluation of bilateral medial rectus recession for management of accommodative esotropia according to prism-adapted motor response preoperatively
Gerling, A	2013	Single-vision lenses: a comparison of management of high AC/A esotropia and refractive esotropia
Mohan, K	2014	Long-term treatment results of accommodative esotropia
Mezer, E	2015	Progressive-Addition Lenses for Accommodative Esotropia with a High Accomodative Element
Whitman, M. C	2016	Bifocals Fail to Improve Stereopsis Outcomes in High AC/A Accommodative Esotropia
Flores-Reyes, E. M.	2016	Botulinum toxin type A as treatment of partially accommodative esotropia
Wabulembo, G	2012	Long-term outcome of medial rectus recession and pulley posterior fixation in esotropia with high AC/A ratio
Akar, S.	2013	Medial rectus Faden operations with or without recession for partially accommodative esotropia associated with a high accommodative convergence to accommodation ratio
Chun, B. Y.	2007	Reduction of deviation angle during occlusion therapy: in partially accommodative esotropia with moderate amblyopia

*Only Quigley (2017) included patients who had undergone prior strabismus surgery (because a prism is a supplementary method in strabismus surgery.)

Results:

The 2015 report by Flores (2015)[15] was a prospective study; all other reports were retrospective studies. Mohan (2014)[16] discussed RAE, while the remaining eight articles all covered partly accommodative esotropia or high AC/A ratio AET. The main parameters of the nine reports are listed in Table 2.

Table 2. Summarized overview of the main parameters of the nine reports

Author	Quigley	Gerling	Mohan	Mezer	Whitman	Flores	Wabulembo	Akar	Chun
Published year	2017	2013	2014	2015	2016	2016	2012	2013	2007
Sample size	26	37	107	32	180	21	21	473	22
Follow up(year)	0.42±0.08	>5	12.02±2.25	>6	4.2±2.1/ 4.4±2.1	1.5	3.5±2.5	4.8(1-6)	4.30±1.58
Age (year)	5.5 (4-6)***	2.9(0.5-8) /4.2(1.5-7)	4.81±2.64	5.36±2.68	5.1±2.1/ 5.4±2.2	6.43 (2-12)	4.3±1.6	2.9±1.3*	4.78±0.94/ 3.38±1.36
Type	PAE	PAE	RAE	PAE	PAE	PAE	PAE	PAE	PAE
Treatment method	Prism+ surgery	single-vision lenses	full cycloplegic hyperopic correction lenses	progressive addition lenses	bifocal or single-vision lenses	botulinum toxin type A	Extraocular muscle surgery	Extraocular muscle surgery	occlusion therapy
Effective rate	100% (10/10)/ 56.25% (9/16)*	65.21% (15/23)/ 85.71% (12/14)	79% (85/107)	56% (14/25) / 100% (7/7)	only has failure rate**	71.43% (15/21)	95.24% (20/21)	71.3% (77/108)/ 78.4% (286/265)	59% (13/22)
Amblyopia rate		51.35%	32.71%		32.78%	33.33%	66.67%	45.03%	

*Akar (2013) provided only the age of strabismus onset, not the age range of treatment initiation.
**Whitman (2016) only recorded the failure rates: bifocals group (study group)—15.6% (12/77); single vision group (control group)—3.9% (4/103).

***The Quigley study (2017) only gave the interquartile range of age.
Because the different reports had varying standards of effectiveness, the effectivity rate of the reports in the chart has no real practical significance. Quigley (2017)[18] defined effectiveness as a horizontal deviation angle of ≤ 10 pd at distance fixation. Gerling (2013)[19] defined effectiveness as a decrease in angle size of > 5 pd, improved control, improved stereopsis, and a refraction decrease of > 0.5 D. Mohan (2014) defined effectiveness as orthophoria or esotropia of < 10 pd at both near and distance fixation. Mezer (2015)[20] defined effectiveness as orthotropia or phoria of < 8 pd with lenses. Whitman (2016)[17] defined failure as has the need for additional surgery. Flores (2016) defined effectiveness as esotropia of ≤ 12 pd. Wabulembo (2012)[21] defined effectiveness as a post-operative overcorrection of < 8 pd, or as the lack of late undercorrection in cases of additional surgery. Akar (2013)[22] defined effectiveness as post-operative orthotropia or esotropia of < 10 pd at near and distance fixations with available optical correction and an elimination of near-distance disparity. Chun (2007)[23] defined effectiveness as a deviation angle of < 15 pd after occlusion therapy and no further surgery. We have listed the articles' differing effectivity rates to provide a sensory understanding. Additionally, the Whitman study (2016) only provided the failure rate data; thus, to facilitate statistics in the present review, we defined its effectivity rate as 1 - failure rate (Figure 1).

Among these nine reports, Gerling (2013), Mezer (2015), and Whitman (2016) all discussed AET with high AC/A ratio. All the refraction methods had an effectivity rate of > 50%. The bifocal lenses group showed a higher failure rate (15.58%) than the single-vision lenses group (5.19%). Gerling (2013) and Mohan (2014) discussed full cycloplegic hyperopic correction for RAE. The effectivity rate was high in both reports (85.71%,79.00%). They also mentioned the problem of decompensation. The decompensation rate was similar and low in both reports (4.35%, 4.67%).

Wabulembo (2012) and Akar (2013) discussed extraocular muscle surgery for treating high AC/A AET. The most common surgical methods are as follows: (1) medial rectus (MR) recession with pulley posterior fixation (PF), and (2) PF on the MR muscles without recession. Detailed data are provided in Table 3. Both surgical techniques can significantly decrease deviation in patients who have AET with a high AC/A ratio(95.24%,71.30%,78.40%). The PF with MR recession surgery had a higher effectivity rate than the PF without MR recession surgery. The incidence of residual esotropia was significantly higher than that of secondary exotropia in both studies. PF with MR recession surgery was more often associated with secondary exotropia, while PF without MR recession surgery was more often associated with residual esotropia. Before surgery, the patients in the PF with MR recession group had a bigger angle size than those in the PF without MR recession group at both

near and distance. There was no significant change in either group after surgery. Akar (2013) reported that the PF without MR recession group showed that PF was associated with a slight decline from the early to late post-operative periods.

Table 3. Deviation and results data in patients treated surgically

	pre-operative exotropia distanceΔ	pre-operative exotropia nearΔ	early postoperative exotropia distanceΔ	early postoperative exotropia nearΔ	late posterative exotropia distanceΔ	late posterative exotropia nearΔ	effective rate	secondary exotropia	residual esotropia
PF with MR recession (Wabulembo 2012)	19.6 ± 10.5 (0-38)	36.9 ± 18.9 (16-80)	1.3 ± 3.3 (-8-8)	2.8 ± 5.2 (0-10)	0.1 ± 5.8 (-6-14)	1.0 ± 6.2 (-10-16)	95.24%	4.76%	14.29%
PF with MR recession (Akar 2013)	44.9±5.1 (15-65)	69.7±6.3 (50-90)	6.1±3.2 -14-18	8.3±4.4 -15-20	4.7±0.05	7.5±0.5	78.40%	7.90%	13.70%
PF without MR recession (Akar 2013)	8.5±1.1 (0-10)	36.7±4.1 (20-45)	2.6±0.7 (-8-4)	6.9±2.9 (15-4-)	3.3±0.2	8.7±0.5	71.30%	4.60%	24.07%

Flores (2016) discussed Botulinum toxin as a treatment for partly accommodative esotropia. They injected Botulinum toxin type A into each MR muscle: 5 IU for a residual deviation angle of > 18 DP and 2.5 IU for a deviation angle between 14 and 18 DP. The deviation angle before Botulinum toxin type A injection was 22.3 ± 7.99 pd after full cycloplegic hyperopic correction. After Botulinum toxin injection, the residual deviation was significantly lower than that before the injection. The highest effectivity rate (90.44%), defined as “satisfactory,” occurred at 6 months; this rate held stable until 12 months after surgery (85.71%) and then decreased to 71.43% at 18 months. The secondary exotropia rate after Botulinum toxin injection decreased over time, and the condition was eliminated at 6 months. In the first 3 months, the secondary exotropia rate was significant, especially during the first week (71.43%; Figure 2).

In the Quigley study (2017), the total effectivity rate of surgery with or without a prism was 73.08%. The effectivity rate in the prism builders group (study group) was significantly higher than that in the prism non-builders group (control group; 100% vs. 56.25%, respectively).

In the Chun (2007) study, the researchers found that, after occlusion therapy, the deviation angle decreased while visual acuity increased in the amblyopic eye. They also found a statistically significant relationship between the two ($Y = -19.359X - 1.0545$; $R2 = 0.2498$). Before occlusion therapy, 82% of patients were considered as indicating surgery, defined as a deviation angle of ≥ 15 pd within surgical limits. However, after occlusion treatment, that ratio decreased to 41% ($p = 0.003$). They also found that, before occlusion therapy, deviation in the non-surgery group was significantly lower than that in the surgery group (15.62 pd vs. 25 pd, respectively). While the deviation angle decreased in the non-surgery group (from 15.62 pd to 2.46 pd, respectively) during the occlusion period, it was slightly increased in the surgery group (from 25 pd to 26.11 pd).

In the present review, seven of the nine studies mentioned amblyopia. The Chun (2007) study required that all patients have moderate amblyopia. Therefore, it was not used in the present review to analyze the effectiveness of amblyopia treatment. There were six articles remaining that analyzed the amblyopia rate among patients with AET. We found that amblyopia was common in AET, with an average rate of 41.36%. All six of the articles had an amblyopia rate of > 30% (Figure 3).

Discussion

The patients with partly accommodative esotropia showed only a reduced angle of esotropia with complete refractive correction. In other words, partly accommodative esotropia is a combination of both RAE and non-refractive accommodative esotropia. The major treatment methods for high AC/A ratio or partly accommodative esotropia are summarized in Figure 4.

1.Refractive correction method

1.1. Single vision lenses

Single vision lenses are the major method of full cycloplegic hyperopic correction to treat hypermetropic refractive error. Single vision lenses have the advantage of being economical, effective, easy to fit, simple to prescribe, and easy to access.

In the Gerling study (2013),[19] the authors found that no patients in either study group—the high AC/A ratio or control group (refractive esotropia group)—showed deterioration in the size of deviation. Both groups showed a significant decrease in deviation. The effectivity rate in the experimental group (65.21%) was lower than that in the control group (85.71%), indicating that single-vision lenses are effective at treating deviations, even in patients with a high AC/A ratio. However, the effectivity rate in patients with a high AC/A ratio was lower than that in patients with a normal AC/A ratio. In both groups, there was a decrease in the participants' hyperopic refraction error.

In the Mohan study (2014),[16] which had a long term follow-up of > 10 years, the authors found no statistically significant difference in the mean interval between presentation and prescription of full hyperopic correction. The study by Watanabe-Numata et al.[24] found that the patients' age at the start of hyperopic correction was not a risk factor for treatment of RAE. Therefore, it is never too late to treat AET. Mohan (2014) showed that, even after a longer follow-up period (> 10 years), full cycloplegic hyperopic correction had a high success rate (79%) in the treatment of RAE and a low rate of further strabismus surgery (only 6%). We found a similar result in some of the other papers.[24] Full cycloplegic hyperopic correction is the first line AET treatment, especially in patients who have AET with a normal AC/A ratio. Therefore, patients can benefit from both alignment and hyperopic control.

Both the Gerling (2013) and Mohan (2014) reports mentioned the problem of decompensation, and the decompensation rate of RAE was similar in both studies (4.35% and 4.67%). The mean time over which decompensation occurred varied from 3.8 years to 6 years after prescription of full hyperopic correction. Many risk factors for decompensation have been found in past studies, such as abnormal distance–near relationship,[24] high AC/A ratio,[25] moderate hypermetropia (2.75–4.0 D), oblique muscle dysfunction,[10, 25] failure to fully correct hypermetropia,[10] and lack of compliance in wearing glasses. When using single-vision lenses to treat RAE, ophthalmologists should be aware of the problem of decompensation.

In the Gerling study (2013), after a long-term follow-up period (> 5 years), compared with the control group, the experimental group had almost twice as many patients who were still tropic and had deviations that were more difficult to control at near. Additionally, in the same study, the researchers found that, after the 5-year follow-up visit, single-vision lenses had no negative impact on the development of stereopsis, while the control group had more patients with stereopsis, whether gross or fine. In patients who had a high AC/A ratio, it may be necessary to use other treatment modalities to improve the effectivity rate of treatment. Conversely, the study was limited because there was no comparison group comprising patients with high AC/A esotropia who had been treated using bifocals, so there were not enough data to allow comparison of the effectivity rate between single-vision lenses and bifocal lenses.

1.2. Bifocal lenses

In patients who have AET with high AC/A ratio, full hyperopic correction often controls alignment at distance while allowing a deviation to persist at near. To reduce or eliminate the residual angle at near, bifocal lenses with an add-on near lens have been recommended. Bifocal lenses that correct the full cycloplegic refraction with the addition of between +2.00 D and +3.00 D are the commonest treatment method for high AC/A AET.[1,2,26]

In the present study, bifocal lenses were somewhat controversial in the treatment of high AC/A ratio AET. The Whitman study (2016) reported that, although bifocal lenses were widely used to treat AET, there was no evidence to suggest that they showed better outcomes in children with high AC/A ratio AET than single-vision lenses or surgery.[27] In the same report, the group of children with bifocals had higher rates of surgery (15.6%) and a smaller improvement in near deviation over time than the single-vision lenses group. Surgical patients tended to be younger and have higher initial angle size. The authors believed that patients (especially children) often have difficulty using bifocal lenses properly. Some patients who have worn bifocals for long periods will adjust their head position to use the bifocal lens. Thus, they lose some fusional divergence and require the bifocal lens to retain binocular vision at near. This can cause them to lose accommodative capacity. However, single-vision wearers learn to control their deviations more effectively over the range from near to distance, possibly reducing the risk of decompensation to the point of requiring further extraocular muscle surgery.

The Whitman study (2016) showed that patients in the bifocal group who remained esotropic at near after prescription of a +3.00 D add-on seemed to have a higher risk of poor outcome than those in the single-vision group. They demonstrated that control of esodeviation at distance (< 10 pd) using full hyperopic correction is adequate for development of stereopsis, even if a large residual deviation persists at near. In Arnoldi's study, only 20% of patients who were assessed as good candidates for bifocals were long-term successes. In this regard, there are economic factors to consider as well. The cost of bifocal lenses is significantly higher than that of single-vision lenses. Therefore, in future clinical practice, doctors should more stringently restrict the indications for bifocal lenses.

1.3. Progressive-addition lenses

The use of PALs to treat AET has also been mentioned in many studies,[28] usually as an alternative to conventional bifocals. PALs add near and intermediate distances, so they are better for sports. Additionally, patients have no esthetic problems with PALs, such as the line that is visible in bifocal lenses.[3]

In the Mezer study (2015), the PAL-only group showed a significantly higher effectivity rate than the group that used bifocals first and then switched to PAL (100% vs. 56%). Additionally, there was no statistical significant between the two groups in terms of stereopsis.
PALs also had several disadvantages. They cost more than bifocal lenses and single-vision lenses. They required frequent changing due to changes in the prescription or lens breakage.[3] Opticians usually have limited experience in fitting children with PALs, and the process is more challenging than fitting an adult with a PAL.[20]

1.4. Contact lenses

Contact lenses have been used as an alternative approach to treating AET. Monovision contact lenses, bifocal contact lenses, and the uni-lens RGP(Rigid Gas Permeable) aspheric multifocal contact lens have been mentioned in several studies.[29] Children with hyperopic refractive error who wear contact lenses requires less accommodation per unit distance than those who wear spectacle corrections. Additionally, contact lenses avoid the base-out effect at near that happens with high-plus glasses.[3] Unfortunately, contact lenses put patients at a higher risk of developing infections than glasses do. This requires patients with contact lenses to practice good compliance and good hygiene habits.

Morton et al.[29] showed that, in esotropia patients with a high AC/A ratio, neither bifocal nor multifocal contact lenses sufficiently control near deviation. Few studies discussed contact lenses in the treatment of AET. More clinical trials regarding the use of contact lenses in the treatment of AET are required to elucidate the efficacy of this modality of treatment.

2. Surgical methods

2.1. Extraocular muscle surgery

Extraocular muscle surgery is not necessary in patients with RAE. It is an option when the residual deviation exceeds 15 pd after full cycloplegic hyperopic correction that is cosmetically displeasing.[3] The traditional surgical procedures for high AC/A ratio AET patients include augmentation of MR recession, slanted MR recession, and MR recession with Faden operation/scleral PF.[30-31] The Ghali study (2017) also mentioned recession-retroequatorial myopexy of the MR muscles. However, they found that this type of the surgery was less safe and less effective than the traditional surgeries.[32] Past studies have demonstrated that scleral PF does not progressively reduce peak saccadic velocity in the MR muscles' field of action.

Wabulembo (2012) and Akar (2013) both mentioned extraocular muscle surgery as a major treatment for high AC/A ratio AET, and the effectivity rate was satisfactory in both studies. Both types of surgery can significantly decrease the deviation at near or distance. Indeed, the deviation angle is close to zero even in the later post-operative period. In a recent study, Inal (2017) also came to the same conclusion.[33]
Wabulembo (2012) and Akar (2013) found that the pre-operative deviation angle in the PF with MR recession group was larger than that in the PF without MR recession group—both at near and distance. After the surgery, they found no significant difference in deviation between the two groups. However, in the PF with MR recession group, the effects of the PF slightly declined over time. Some researchers found during the secondary surgery of some Faden operations that the scar between the muscle and the sclera had gradually moved anteriorly.[34] This discovery may explain why the effects of PF slightly decline over time.

Both extraocular muscle operations are effective methods for treating high AC/A ratio AET. However, PF with MR recession confers a larger correction of the deviation. Specifically, the PF with MR recession surgery group showed a higher incidence of secondary exotropia (7.9% vs. 4.6%) and a lower rate of residual esotropia (13.7% vs 24.7%) than the PF without MR recession group. The residual esotropia rates were similar in the both studies (14.29% and 13.70%, respectively). Additionally, residual esotropia rates in both groups were lower than those of other non-surgery operations, which have reported rates of 12%–30%.[22]

Akar (2013) agrees that operations based on the level of deviation at distance fixation often lead to unacceptably high degrees of undercorrection, and some of the disadvantages and complications of such operations were discussed in both studies, including difficulty with suture placement behind the equator and near to the vortex veins, perforation when the muscles are sutured posteriorly,[30] late undercorrection necessitating further surgery, possibility of infection, and potential for granuloma. Some studies have also mentioned slipped MR muscle, which is a serious and rare potential complication of extraocular muscle surgery.[35] Nonetheless, the complications of extraocular muscle surgery were rare and mild in the studies. However, the surgeon's surgical technique, patient compliance, and a strict follow-up procedure were important.

2.2 Botulinum toxin

Injecting Botulinum toxin into the extraocular muscles alters ocular alignment, producing temporary palsy and an overcorrection of strabismus, which in turn leads to a shortening of the antagonist muscle. Histology studies have shown that density changes in the sarcomeres enhance permanent ocular alignment.[36] Indeed, the deviation before botulinum toxin type A injection was significant lower than in extraocular muscle surgery studies.[21,22]

The Flores study (2016) showed a significant decrease in deviation after Botulinum toxin injection. The toxin's most effective period is from 6 months to 12 months. Because Flores (2016) did not report a long term follow-up period in their study, we only found a downward trend in effectivity rate, implying that some patients may require extra injection in the future. The secondary exotropia rates decreased over time. The main observed side effects in the study were reversible ptosis, temporary diplopia, and the development of a vertical deviation. The authors also had to consider that the recovery time from adverse effects was between 2 and 3 weeks, perhaps reflecting Botulinum toxin metabolism.[37]

The advantages of Botulinum toxin were that it is cost effective and a good choice for patients in whom surgery is contraindicated. The main disadvantage was that it may not remain stable over a long period; thus, further treatment may be required. Additionally, there are potential side effects, such as reversible ptosis, diplopia, and vertical deviation. Flores' study was prospective in design. However, the sample size was not large enough and the follow-up period was not long enough.

3. Complementary methods

3..1. Prism

Some studies reported that the prism adaptation test can improve surgical outcomes, showing that a small angle of residual esotropia can be managed using non-surgical treatment such as prism glasses.[38]
Quigley (2017) showed a significantly higher effectivity rate of surgery (100%) in the prism builders group than in the surgery without prism group (56.25%). The authors also found that prism builders were younger than prism non-builders (median age: 4.5 vs. 6 years), which may influence surgical outcome. Patients with a high AC/A ratio have an increased requirement for prisms, and post-operative outcomes were better than those of patients with a lower AC/A ratio.[39] The prism adaptation test as a pre-operative tool can fine-tune surgical dosage and reduce undercorrection and overcorrection in pediatric patients with partly accommodative esotropia. However, to date, not enough studies have demonstrated the benefits of the test. Prism can be an alternative choice for the patients with contraindications to surgery. Prism can also help to control the uncomfortable feeling of diplopia. However, some investigators believe that further addition of prisms may cause an increase in the deviation.[3]

3.2. Occlusion therapy

Amblyopia is usually associated with anisometropia or unilateral and constant esotropia. Partly accommodative esotropia usually involves a constant and unilateral deviation. Therefore, amblyopia is common in patients with partly accommodative esotropia. Occlusion therapy is recommended in patients with partly accommodative esotropic moderate amblyopia.[40] Current clinical guidelines recommend initiating amblyopia treatment before surgical correction of strabismus.[41]

Chun (2007) showed a statistically significant relationship between increases in visual acuity in amblyopic eyes and decreases in the deviation angle ($p = 0.024$). This may have occurred because increases in visual acuity in patients with amblyopic eyes confer better fusional divergence and thus better control of deviation. The same study showed a significant decrease in angle size in the non-surgery group, whose deviation with glasses was almost lower than 20 pd during the occlusion period. In the surgery group with a higher deviation before occlusion therapy, the deviation was slightly increased, suggesting that occlusion therapy is more beneficial in those with lower deviation AET.

4. Amblyopia treatment

Amblyopia is defined as a best corrected visual acuity of less than 20/20 in the absence of any obvious structural or pathological disease, but with one or more of the following amblyogenic factors occurring before the age of 6 years: anisometropia, constant unilateral strabismus, amblyogenic bilateral isometropia, amblyogenic astigmatism, or image degradation. Amblyopia can cause decreases in visual acuity, saccades and pursuits abnormality, accommodative status problems, spatial distortion, performance with reduced illumination and contrast sensitivity, crowding phenomenon, laser interferometry acuity, or electrophysiological testing deficiencies compared with the dominant eye.

The prevalence of amblyopia is 1%–5% worldwide. Among patients with this condition, 91% have unilateral amblyopia with strabismus, hyperopia of ≥ 2.0 D, astigmatism of ≥ 1.0 D, or anisometropia of ≥ 0.5 D, while 76% of children with bilateral amblyopia have bilateral hyperopia of ≥ 3.0 D or astigmatism of ≥ 1.0 D. Hyperopia (usually greater than +2.00) is a common risk factor for developing AET. Amblyopia is common in patients with AET, especially in those with partly accommodative esotropia. In the present review, we found that the average amblyopia rate was 41.36%. Amblyopia rates were above 30% in six articles. Clinically, we need to carefully consider the diagnosis of amblyopia in patients with AET, and amblyopia treatment must be considered during treatment of accommodative esotropia with amblyopia.

The treatment of amblyopia includes correction of refractive error, occlusion therapy, vision therapy, and treatment of strabismus. In the present review, correction of cycloplegic refractive error, followed by occlusion therapy, was the commonest method for treating patients who had accommodative esotropia with amblyopia. Other methods were mentioned, such as atropine-only treatment, patching followed by atropine

treatment, and cycloplegic refraction. However, several studies reported abruptly developed esotropia after full-time occlusion treatment. The studies authors' speculated that this phenomenon was caused by disruption of peripheral fusion.[42]

5. Limitations

This literature review had some limitations: (1) Most reports included were retrospective; (2) There were no uniform standard criteria to define effectivity rate, inclusion, or exclusion; (3) None of the nine articles were large randomized controlled trials; (4) Some studies' sample sizes were not large enough, which may have generated a higher rate of random error.

6.Future studies

More large sample-size, randomized controlled trials are required. In particular, investigators need to form a unified standard of inclusion and exclusion criteria, as well as choose comparable treatment methods. Negative results should also be analyzed and considered, and long-term follow-up periods are needed.

Conclusion

Full cycloplegic hyperopic correction is the first line of the treatment for AET. Single-vision lenses have satisfactory results in the treatment of RAE. However, they may result in decompensation.Bifocal lenses are one of the most common effective treatment methods for high AC/A AET. However, children often have difficulty using bifocal lenses properly. Therefore, optometrists and parents need to monitor children's behavior carefully. PALs can be an alternative to lined bifocals in the treatment of AET. They can be beneficial for athletes and patients who really care about esthetics. However, because they are expensive, require frequent changes, and are more difficult to fit, PALs should not be used in younger patients.Contact lenses have a theoretical advantage over spectacle lenses in the treatment of AET. They require less accommodation per unit distance and avoid the base-out effect at near. However, to date, few clinical studies have been carried out in this regard.

Extraocular muscle surgery is an option in patients whose deviation angle is over 15 pd after full cycloplegic hyperopic correction. The Faden operation, with or without MR muscle recession, is an effective method for the treatment of AET with high AC/A ratio. Alternatively, PF with MR recession can confer a larger correction of deviation, while PF without MR recession has a lower rate of secondary exotropia development. Botulinum toxin treatment of AET is effective for at least 18 months. It is a good choice in patients who have contraindications to surgery. However, such patients may not remain stable for a long time and may therefore require further treatment.

Prism treatment is a complementary method that improves surgical outcomes after extraocular muscle surgery. Prisms can be used to fine-tune surgical dosage and reduce undercorrection and overcorrection in partly accommodative esotropia. However, further addition of prisms may increase deviation.

Occlusion therapy has been recommended in patients who have partly accommodative esotropic with moderate amblyopia. This method can improve visual acuity and decrease the deviation angle in patients with accommodative esotropia whose initial deviation angle with glasses is lower than 20 pd.

Amblyopia is common in patients with partly accommodative esotropia. Therefore, amblyopia treatment must be considered when treating patients who have accommodative esotropia with amblyopia. In this regard, correction of cycloplegic refractive error followed by occlusion therapy is the most common method.
Early intervention using effective methods of treatment can improve AET patients' alignment, control their refraction error, and improve their quality of life. It is never too late to treat AET.

List Of Abbreviations

AET	accommodative esotropia
AC/A	accommodative convergence to accommodation ratio
RAE	refractive accommodative esotropia
D	diopters
pd	prism diopters
PALs	progressive-addition lenses
PAE	partly accommodative esotropia
MR	medial rectus
PF	posterior fixation
RGP	Rigid Gas Permeable

Declarations

Ethics approval and consent to participate

Not applicable. This article does not touch upon ethical issues.

Consent for publication

All authors consent for publication.

Competing interests

The authors declare that they have no competing interests.

Availability of data and material

We reviewed all 9 articles which analyzed and discussed different treatments for accommodative esotropia from the PubMed database. Data is available.

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Authors' contributions

All authors participate in literature search and analysis. Xianjie Liu wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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Refference

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Figures

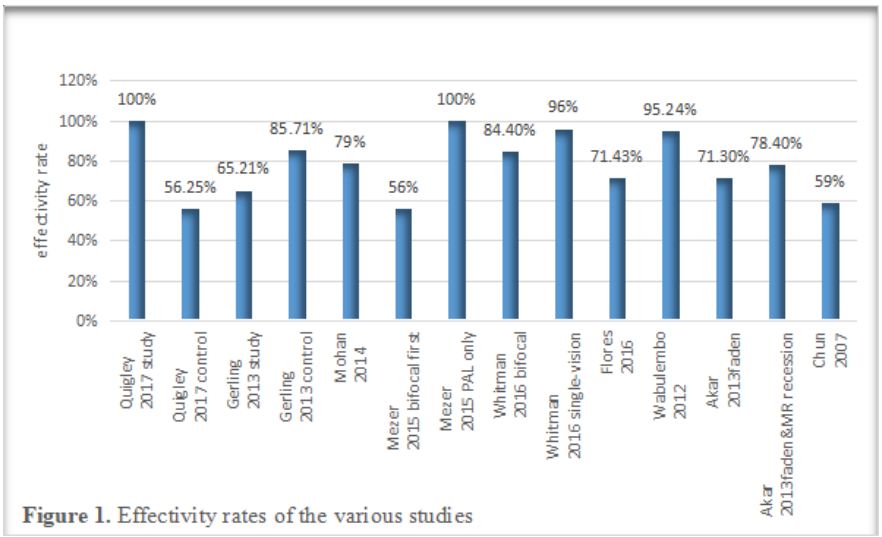

Figure 1

Effectivity rates of the various studies

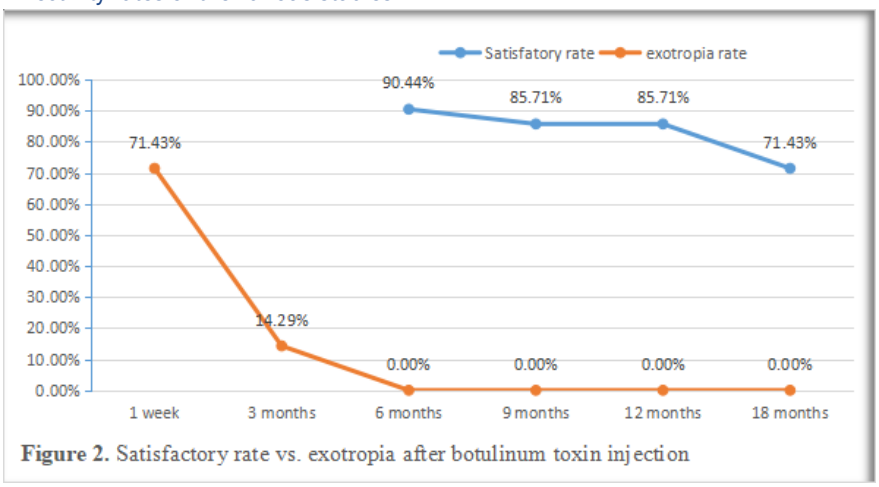

Figure 2

Satisfactory rate vs. exotropia after botulinum toxin injection

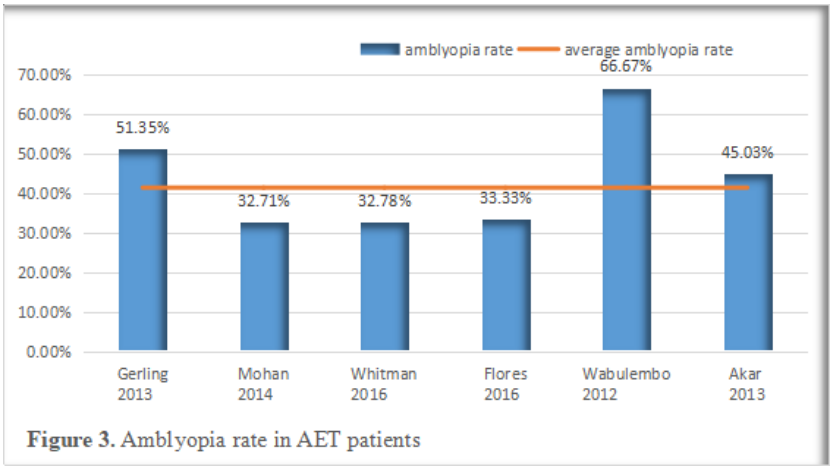

Figure 3

Amblyopia rate in AET patients

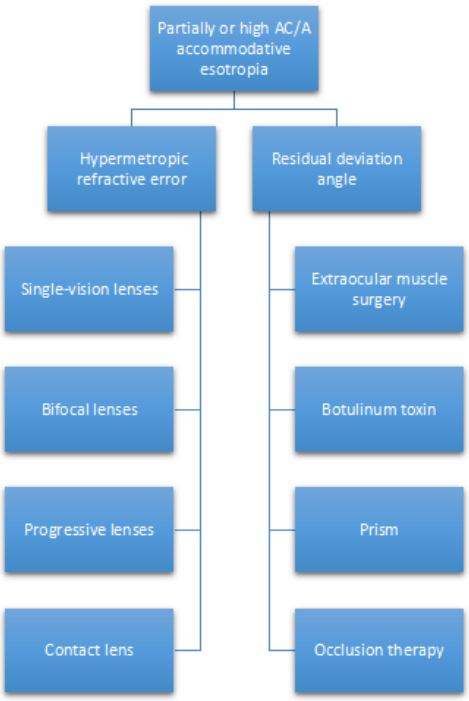

Figure 4. Various treatments for patients who have accommodative esotropia with high AC/A ratio

Figure 4

Various treatments for patients who have accommodative esotropia with high AC/A ratio