Long Term Effect of Muscle Transplantation in Large Angle Esotropia and Exotropia

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Abstract

Background: In cases of large-angle horizontal strabismus, standard two-horizontal muscle surgery is insufficient. Utilizing supramaximal recession and resection techniques would result in limited duction. True muscle transplantations have been explored in this scenario as a potential solution for this large angle deviation.

Objectives: to evaluate the long-term effects of muscle transplantation on patients with large-angle horizontal strabismus, assessing success rate, ocular alignment improvement, and patient satisfaction post-surgery.

Patients and methods: This prospective case series with 30 cases, divided into Group A (large-angle esotropia) and Group B (large-angle exotropia). The surgical procedure involved muscle transplantation using a recession technique. Preoperative evaluations, including comprehensive ophthalmic examinations, were conducted to determine the angle of deviation, visual acuity, and ocular motility. The participants underwent follow-up visits post-surgery.

Results: In Group A, the mean preoperative distance angle of deviation, measured in prism diopters (PD), was 80.67±11.63. The mean preoperative adduction and abduction restriction was -0.07±0.26, -0.73±0.96, respectively. The amount of lateral rectus (LR) resection, and medial rectus (MR) recession ranged from 6 to 9 mm, and 2 to 5 mm, respectively.

In Group B, the mean preoperative distance angle of deviation, measured in prism diopters (PD), was 75.67±13.61. The mean preoperative adduction and abduction restriction was -1.47±1.36, -0.53±0.74, respectively. The amount of medial rectus (MR) resection, and lateral rectus (LR) recession ranged from 6 to 8 mm, and 3 to 10 mm, respectively.

Conclusion: Muscle transplantation is an effective surgical technique for large angle horizontal strabismus. It leads to significant improvements in ocular alignment and movement restrictions.

Keywords: Large angle strabismus; Autograft; Muscle transplantation.

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Introduction

Large-angle constant esotropia or exotropia can negatively impact a patient's self-perception and how others perceive them(**Fawcett et al., 2004**). Surgical treatment for horizontal strabismus in adults has been well-established, leading to improved psychosocial functioning and, in some cases, restoration of binocular vision.**(Al-Omari et al., 2022)**

Managing large-angle horizontal strabismus presents unique challenges, and recent studies have focused on two main surgical approaches: binocular or uniocular**(Currie et al., 2003).** Binocular surgery, that involve three or four horizontal rectus muscles, is chosen when both eyes have good visual acuity to avoid significant limitations in eye movement that could occur with larger uniocular surgeries. However, some patients are hesitant to undergo surgery on the healthy eye.

Uniocular surgery with a unilateral recess-resect procedure is performed if one eye has amblyopia.**(Jeoung et al., 2006)** This approach offers advantages like preserving some muscles for potential future surgeries, avoiding risks to the dominant eye, and reducing surgical time. However, there are concerns regarding disfigurement due to limited eye movement, excessive duction, narrowing of the palpebral fissure, and enophthalmos with supermaximum recession-resection surgery.

Other uniocular approaches involve additional surgery on the eye with the worse vision, but not on the eye with the better vision., using techniques like rectus muscle recessions with a central tenectomy, hangback-hemihangback recession, or muscle recession with a spacer. Attempts have also been made to elongate the muscle using materials like bovine pericardium or Gore-Tex®,(**Hedergott et al., 2014; Oeverhaus et al., 2018)** but complications like extrusion, infection, and globe erosion remain concerning.

Muscle transplantation (autogenous homograft) from the resected muscle has been used to avoid these potential complications. In a recent study, the muscle transplantation procedure was employed during the monocular recession-resection of horizontal rectus muscle in patients with large-angle exotropia and esotropia, where a conventional recession was insufficient.

Patients and methods

This prospective case series was conducted with the approval of Ethics Committee of Faculty of Medicine, South Valley University, Qena, Egypt and the ethical approval number is SVUMED- OPH 26 23-9-725 and followed the rules set out in the Helsinki Declaration. All of the people who took part gave their permission after thorough discussions regarding the surgical procedure, scheduled follow-up visits, potential benefits, and associated complications.

The study included participants selected from the Ophthalmology Department at Qena University Hospital, South Valley University, Egypt, between November 2021 and November 2022. The participants were divided into two groups: Group (A) comprised 15 cases with large-angle esotropia (>50 prism diopters), and Group (B) included 15 cases with large-angle exotropia (>50 prism diopters). Patients with previous eye procedures, high myopia, muscular paralysis, accommodative esotropias, dissociated vertical divergence, and large vertical deviations associated with alphabetic syndromes were excluded.

Before the surgery, all participants underwent a comprehensive ophthalmic examination, including a detailed medical history. Fundus examinations and cycloplegic refractions were performed on both eyes. Decimal visual acuity measurements were transformed to LogMAR for statistical analysis. Strabismus angles were evaluated using an alternate prism cover test whenever possible. For cases with lower visual acuities, the Krimsky test was conducted, involving the placement of a prism in front of the eye with better vision. An assessment of ocular motility was performed, classifying restrictions of abduction or adduction on a scale from -4 to 0. A score of -4 indicated no duction beyond midline, -3 indicated 75% restriction, -2 indicated 50% restriction, -1 indicated a 25% deficit, and zero indicated full ductions.

Surgical Procedure

Group A (Large-angle Esotropia): Fifteen patients with large-angle esotropia underwent recession with muscle transplantation. The medial rectus (MR) muscle in the medial quadrant was dissected and separated through a limbal conjunctival incision. The muscle insertion was tied with a nonabsorbable 6-0 Prolene suture and then incised. The lateral rectus (LR) muscle in the lateral quadrant was also dissected and separated through a limbal conjunctival incision. Similar to a standard rectus muscle resection, a double-armed 6-0 Vicryl suture(Ethicon Inc., Somerville, NJ, USA). was placed at a specific distance from the LR muscle insertion, and another double-armed 6-0 Vicryl suture was placed at the insertion as shown in (**Fig.1).**

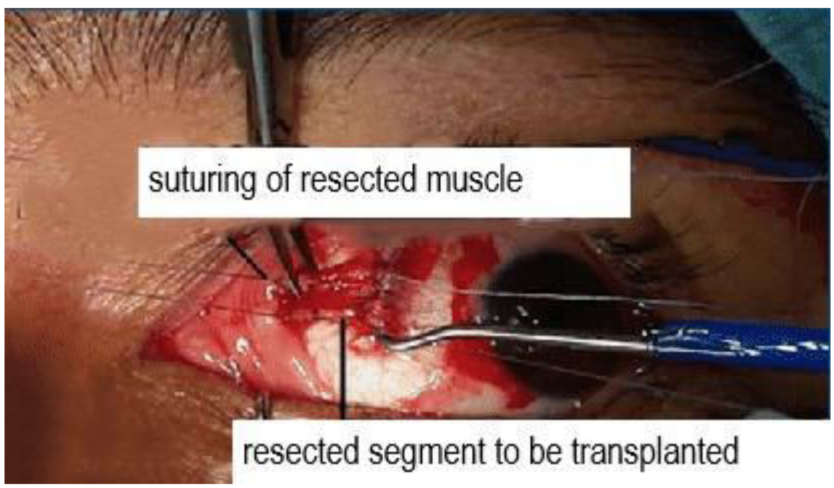

Fig.1. Intraoperative photo show suturing of the resected segment

Next, the LR muscle was hooked into two single arms, and an incision was made in the muscle from its insertion. The sutures were placed behind the incision, passing through the original insertion. The excess muscle stump was cut, and the required segment for transplantation was measured. The stump was then placed at the site of the medial rectus, and its distal end was sutured to the adjacent end of the MR using the 6-0 Prolene suture already present on the medial rectus. The elongated muscle (transplanted muscle) was sutured at the desired distance, similar to a standard rectus muscle recession as shown in (**Fig.2).** Conjunctiva suturing was performed using 6/0 Vicryl .

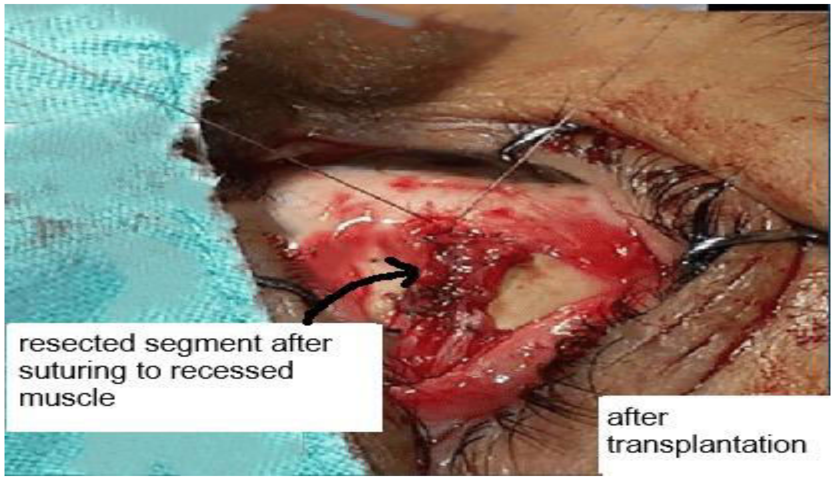

Fig. 2 intraoperative photo showing final appearance after transplantation

The resection of the lateral rectus muscle was carried out at a distance of 6 mm from insertion for 60 prism diopters (PD) and 9 mm for 100 PD. After removal from the muscle, the resected (transplanted) segment experienced 1 to 2 mm of shrinkage. The amount of recession for the MR muscle after elongation was determined based on the preoperative angle of esotropia, which was measured at 3.6±0.89 mm, with each 1 mm elongation of the MR muscle through the transplanted segment resulting in weakening by 4.5–6 PD. This effectively added 1.5-2 mm to the amount of recession required for the MR muscle without the need for additional recession beyond the equator.

Group B (Large-angle Exotropia): Fifteen patients with large-angle exotropia underwentrecession with muscle transplantation. The LR muscle was dissected and separated through a conjunctival limbal incision. Similar to Group A, the muscle insertion was tied with a nonabsorbable 6-0 Prolene suture and then incised. The MR muscle was also dissected and separated through a conjunctival limbal incision. A double-armed 6-0 Vicryl suture was placed at a specific distance from the MR muscle insertion, and another double-armed suture was placed at the insertion.

Next, the MR muscle was hooked into two single arms, and an incision was made in the muscle from its insertion. The sutures were then placed behind the incision, passing through the original insertion. The excess muscle stump was cut, and the required segment for transplantation was measured. The stump was then placed at the site of the lateral rectus, and its distal end was sutured to the adjacent end of the LR using the 6-0 Prolene suture already present on the LR. **(Tawfik et al., 2020)**The LR muscle was attached at the determined distance, similar to a standard rectus muscle recession. (**Fig.3)** shows a diagrammatic representation of the recession of the muscle after elongation by autograft of the resected muscle. Conjunctiva suturing was performed using 6/0 Vicryl .

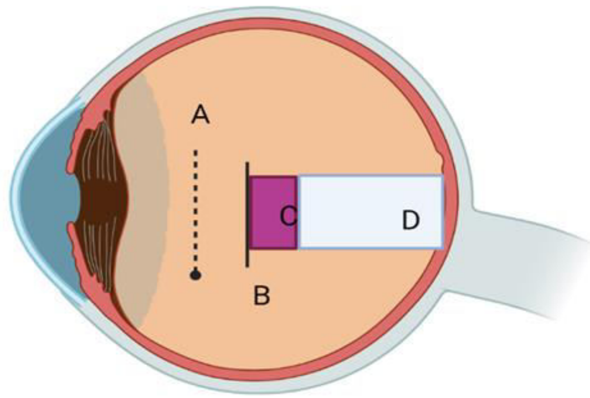

Fig.3. A: original insertion B :new insertion of the rectus muscle recession after transplantation, C :the autograft attached to the rectus muscle. D: the authentic muscle.

The resection amount of the medial rectus muscle ranged from 6 to 8 mm. After removal from the muscle, the transplantation segment experienced 1 to 2 mm of shrinkage. The amount of recession for the LR muscle after elongation was determined based on the preoperative distance angle, which was measured at 6.27±1.99 mm. Each 1 mm elongation of the LR muscle through the transplanted segment resulted in weakening by 2.25–3 PD, effectively adding 1.5-2 mm to the recession amount required for the LR muscle, with no need for additional recession beyond the equator. So the transplanted portion result in extra elongation than in traditional recession as shown in (**Fig. 4)** .

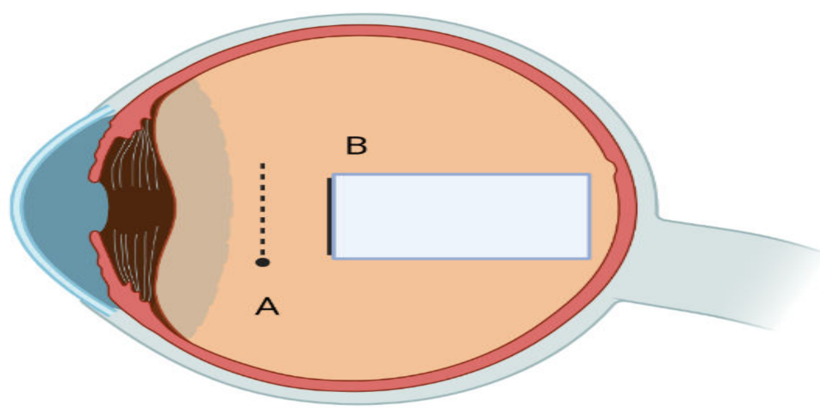

Fig.4. shows traditional recession A: original insertion B: new insertion.

Intraoperatively two cases after we resected the segment from the muscle it became friable and fragmented so we could not complete the transplantation procedure .Successful motor alignment was defined as achieving orthotropia within a deviation of 10 prism diopters (PD) while looking at a distance of 6 meters. Patient follow-ups were conducted on the 1st and 30th day, six months, nine months, and one year after the surgery. During each visit, the distance angle of deviation was assessed using Krimsky's test if a prism cover test was not feasible, and an ocular motility examination was performed. All the data were recorded, tabulated, and any limitations on adduction and abduction were evaluated and recorded. A satisfaction score is judged subjective assessment of postoperative satisfaction. At the 6-month follow-up, the patients were requested to complete a satisfaction assessment questionnaire, which included three questions about satisfaction with the degree of alignment, aesthetic appearance, and limitation of adduction and abduction. Each question has a response scale ranging from 5 (Very Satisfied) to 1 (Not Applicable / Not Sure), allowing patients to express their level of satisfaction with specific aspects of their surgery. Patients will be grouped into one of the three categories based on their total questionnaire scores, with "Unsatisfied" representing scores from 0 to 5, "Moderately Satisfied" representing scores from 6 to 10, and "Very Satisfied" representing scores from 11 to 15.

Statistical analysis

The data analysis was performed using SPSS version 18. Quantitative variables were presented as mean with standard deviation and median with range. The student t-test was utilized to compare the means of two normally distributed variables, while the Mann-Whitney test was used for comparing non-normally distributed data. Qualitative variables were represented by numbers and percentages, and the Chi-square test was employed for comparison. To analyze the changes between pre-surgery and post-surgery data, the repeated measure ANOVA (RMANOVA) test was used. Mauchly's Test of Sphericity was performed to check for sphericity. The Bonferroni post hoc test was used to assess the differences at each time point. The various time periods were considered as subject-specific factors, and a p-value of less than 0.05 was considered significant.

Results

The study involved 30 patients, divided into two groups: Group A with large-angle esotropia and Group B with large-angle exotropia. Group A consisted of 15 patients, with eight females (53.33%) and seven males (46.67%), having a mean age of 36.27±17.69 years. The best corrected visual acuity for the deviated eyes was measured using LogMAR, with a mean of .8±0.2. The preoperative distance angle of deviation was 80.67±11.63 PD. The average preoperative adduction restriction was -0.07±0.26, and the mean abduction restriction pre-surgery was -0.73±0.96.

(Tables.1and 2) show Significant improvement was observed in the distant deviation angle from the first day, first month, and after six months and nine months and one year ($p<0.0001$), as well as in adduction and abduction restrictions at the last follow-up ($p=0.001$). Successful maintenance of alignment was seen in Group A post-surgery, with pre-and post-operative images showing improved adduction and abduction in **(Fig. 5 and 6).**

Table. 1. Improvement of abduction restriction over time in Esotropia

Abduction restriction	Preoperative	First month postoperative	Six months postoperative	Nine months postoperative	One year postoperative
Mean ± SD Median (range)	-0.73±0.96 0 (-3:0)	-0.33±0.49 0 (-1:0)	-0.33±0.62 0 (-2:0)	-0.06±0.26 0 (-1:0)	0 0 0
F test	1.71				

P value	0.07			
P1 0.57	P2 0.57	P3 0.02	P4 0.008	P5 1.00
P6 1.00	P7 1.00	P8 1.00	P9 1.00	P10 1.00

P1: Preoperative and First month post operative, P2: Preoperative and Six months postoperative, P3: Preoperative and nine months postoperative, P4: Preoperative and one year postoperative, P5: First month postoperative and Six months postoperative, P6: First month postoperative and nine months postoperative, P7: First month postoperative and one year postoperative. , P8: six month postoperative and nine months postoperative, P9: six month postoperative and one year postoperative and P10: nine month postoperative and one year postoperative.

Table 2 Improvement of adduction restriction over time in Esotropia

Adduction restriction	**Preoperative**	**First month postoperative**	**Six months postoperative**	**Nine months postoperative**	**One year postoperative**
Mean ± SD **Median (range)**	-0.07±0.26 0 (-1:0)	-0.73±0.70 -1 (-2:0)	-0.4±0.63 0 (-2:0)	-0.07±0.26 0 (-1:0)	-0.07±0.26 0 (-1:0)
F test	2.92				
P value	0.001				
P1 0.001	P2 0.41	P3 1.00	P4 1.00	P5 0.41	
P6 0.001	P7 0.001	P8 0.41	P9 0.41	P10 1.00	

P1: Preoperative and First month post operative, P2: Preoperative and Six months postoperative, P3: Preoperative and nine months postoperative, P4: Preoperative and one year postoperative, P5: First month postoperative and Six months postoperative, P6: First month postoperative and nine months postoperative, P7: First month postoperative and one year postoperative. , P8: six month postoperative and nine months postoperative, P9: six month postoperative and one year postoperative and P10: nine month postoperative and one year postoperative.

Fig. 5. Left esotropia 60 PD case preoperative; A: right gaze B: Primary position, C: left gaze.

Fig.6. Left esotropia 60 PD case postoperative; A: right gaze B: Primary position, C: left gaze.

Group B included 15 patients, six females (40%) and nine males (60%), with a mean age of 33.2±11.65 years. The best corrected visual acuity for the deviated eyes was measured by LogMAR, with a mean of 1.04±0.2. The preoperative distance angle of deviation was 75.67±13.61 PD. The average adduction restriction pre-operation was -1.47±1.36, and the mean abduction restriction was -0.53±0.74.

Similar to Group A, Group B also showed significant improvement in the distant deviation angle from the first day, first month, and after six months and nine months and one year ($p<0.0001$), as well as in adduction and abduction restrictions at the last follow-up ($p=0.001$) as shown in (**Tables 3and 4).** Successful maintenance of alignment was seen in Group B post-surgery, with pre-and post-operative images showing improved adduction and abduction shown in **Figures 7and 8.**

Table 3 . Improvement of abduction restriction over time in exotropia

Abduction restriction	Preoperative	First month postoperative	Six months postoperative	Nine months postoperative	One year postoperative
Mean ± SD Median (range)	-0.53±0.74 0 (-2:0)	-0.93±0.96 -1 (-3:0)	-0.47±0.64 0 (-2:0)	-0.07±0.26 0 (-1:0)	-0.07±0.26 0 (-1:0)
F test	3.40				
P value	0.0002				

P1 0.54	P2 1.00	P3 0.25	P4 0.25	P5 0.25
P6 0.001	P7 0.001	P8 0.54	P9 0.54	P10 1.00

P1: Preoperative and First month post operative, P2: Preoperative and Six months postoperative, P3: Preoperative and nine months postoperative, P4: Preoperative and one year postoperative, P5: First month postoperative and Six months postoperative, P6: First month postoperative and nine months postoperative, P7: First month postoperative and one year postoperative. , P8: six month postoperative and nine months postoperative, P9: six month postoperative and one year postoperative and P10: nine month postoperative and one year postoperative.

Table 4 Improvement of adduction restriction over time in exotropia

Adduction restriction	Preoperative	First month postoperative	Six months postoperative	Nine months postoperative	One year postoperative
Mean ± SD **Median (range)**	-1.47±1.36 -1 (-4:0)	-0.67±0.98 0 (-3:0)	-0.33±0.62 0 (-2:0)	-0.13±0.35 0 (-1:0)	0 0 0
F test	6.07				
P value	<0.0001				

P1 0.04	P2 <0.0001	P3 <0.0001	P4 <0.0001	P5 1.00
P6 0.19	P7 0.04	P8 1.00	P9 1.00	P10 1.00

P1: Preoperative and First month post operative, P2: Preoperative and Six months postoperative, P3: Preoperative and nine months postoperative, P4: Preoperative and one year postoperative, P5: First month postoperative and Six months postoperative, P6: First month postoperative and nine months postoperative, P7: First month postoperative and one year postoperative. , P8: six month postoperative and nine months postoperative, P9: six month postoperative and one year postoperative and P10: nine month postoperative and one year postoperative.

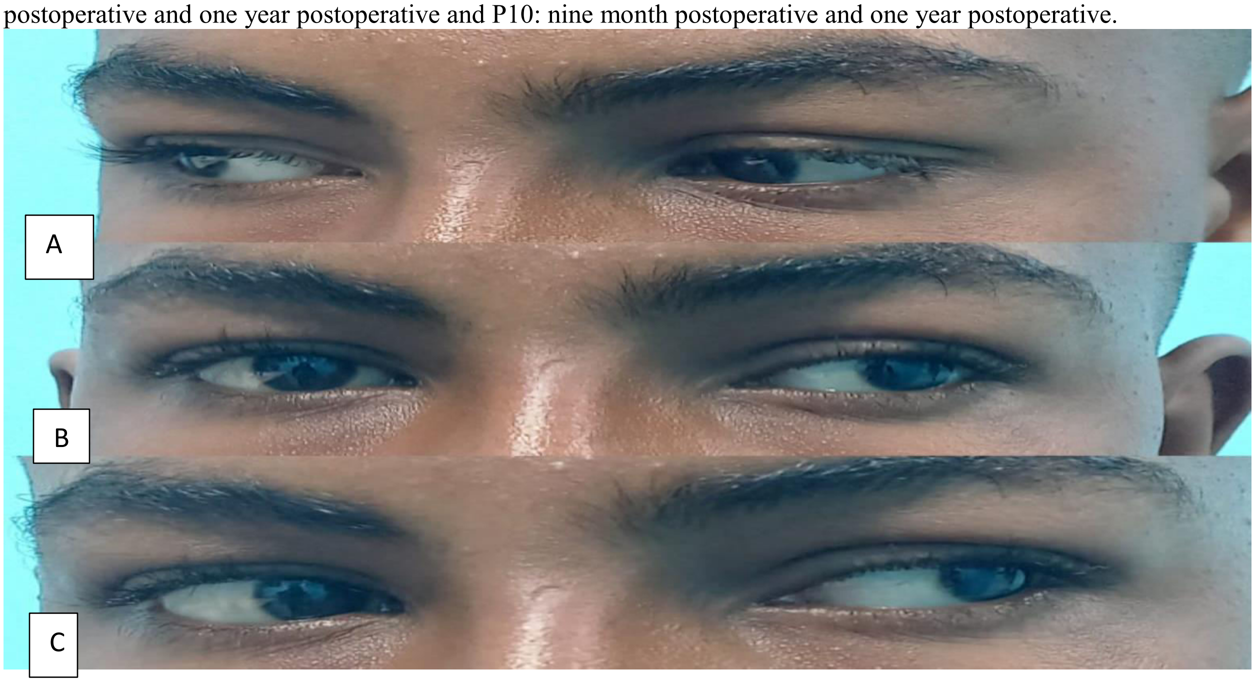

Fig.7 .Left exotropia 90 PD case preoperative; A: right gaze B: Primary position, C: left gaze.

Fig.8 .Left exotropia case postoperative; A: right gaze B: Primary position, C: left gaze.

In the comparison between the two groups, Group A (esotropia) demonstrated a significantly greater improvement in the angle of deviation than Group B (exotropia) on the first day postoperative. However, the difference in improvement between the two groups became non-significant at the one-month and six-month follow-ups, indicating similar stability of alignment. There was no statistical difference in the improvements in adduction and abduction restrictions at the last follow-up between the two groups (p=0.48) as shown in (**Fig. 9 and 10)**.

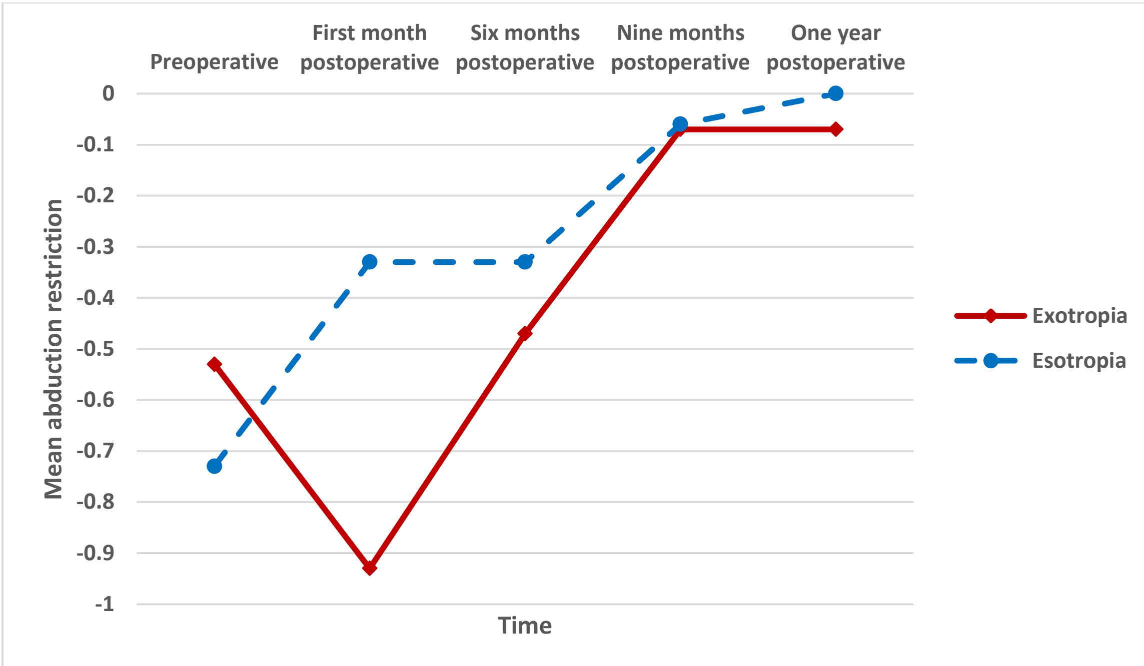

Fig.9. Comparison between exotropia and esotropia as regard abduction restriction at different time

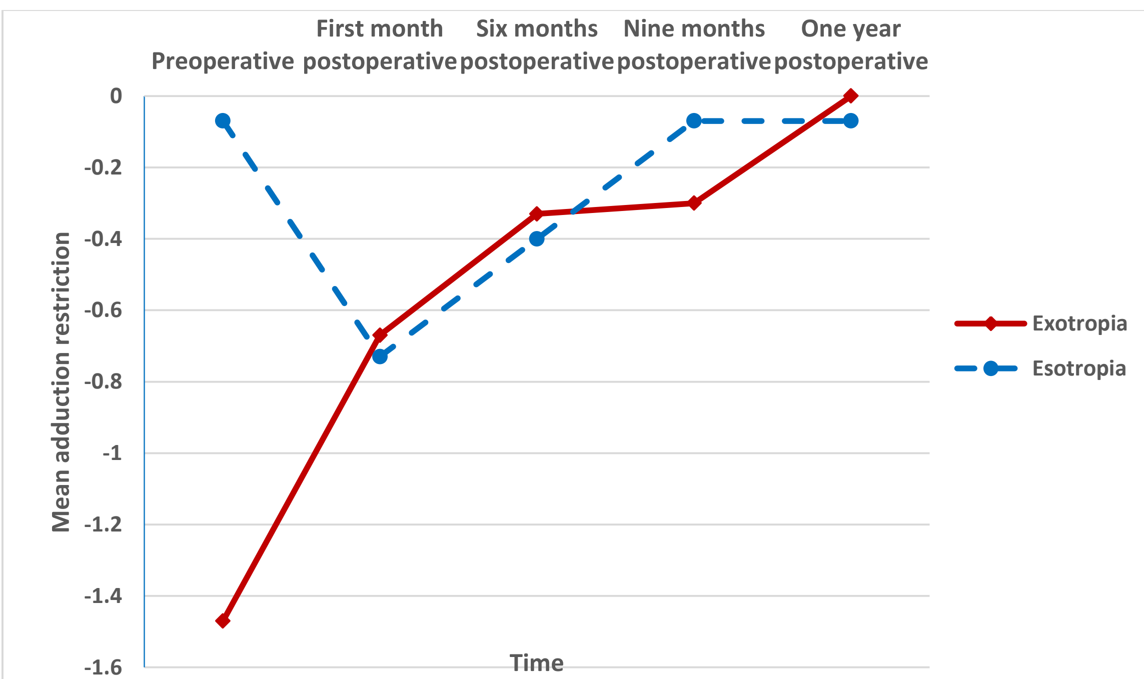

Fig.10. Comparison between exotropia and esotropia as regard adduction restriction at different time

Overall, the results indicate that both large-angle exotropia and esotropia show significant improvement after the muscle transplantation procedure, with the greatest reduction in angle of deviation observed on the first day postoperative. Subsequently, at later follow-up time points (first month, six months, nine months, and one year postoperative), the angle of deviation in both groups further improves, with no statistically significant differences between the two groups. These findings suggest that the muscle transplantation procedure is effective in reducing the angle of deviation in both types of large-angle horizontal strabismus, and the improvements are maintained over an extended period of follow-up.

Regarding patient satisfaction with the procedure, there appears to be no statistically significant difference in patient satisfaction levels between the two groups.

In the Esotropia group, 46.67% of patients reported being "Very Satisfied," indicating a high level of contentment with the surgical outcomes. An additional 40% of patients expressed being "Moderately Satisfied," suggesting a reasonable level of satisfaction. However, a smaller percentage of patients, 13.33%, reported being "Unsatisfied," indicating that a minority experienced dissatisfaction.

Similarly, in the Exotropia group, 40 % of patients reported being "Very Satisfied," while an identical percentage of 40 % indicated being "Moderately Satisfied." These results suggest that patient satisfaction in both the Esotropia and Exotropia groups was comparable, with a significant portion expressing a positive level of contentment. The statistical analysis of the data further supported these observations. The calculated P-value of 0.87 indicated that the observed difference in patient satisfaction levels between the two groups was not statistically significant at the chosen significance level.

The success rate was 93.3% in Group A, with only one case that failed, and 86.6% in Group B, with two failed cases. Among the failed cases, only one patient in Group B underwent a secondary procedure for residual angle correction after six months. Overall, the study demonstrated successful outcomes in both groups, with significant improvements in the angle of deviation and restrictions of eye movements after the surgical procedure.

Discussion

Large-angle strabismus demands a sequence of operations to be effectively coordinated. Bilateral surgery is usually required **(Amitava et al., 2005)**, However, having one eye operated on would save time, money, and allow for future surgery on the other eye. This might not address large-angle strabismus, though. Consequently, some authors have advised doing supramaximal surgery on two recti**. (Talebnejad et al., 2020)**This is the most logical option for one-eyed patients with sensory strabismus in the opposite eye. Some researchers have successfully used it on patients with normal vision in both eyes**.(ElKamshoushy, 2017)** The authors have noted that such large recessions do not produce substantial restrictions in ocular motility and cosmetically significant changes in the palpebral fissure**.(Chang et al., 2011)** Other studies have not been able to reproduce the success with two‑muscle surgery alone and have suggested adding third or fourth recti. Rayner and Jampolsky supported using large medial rectus (MR) resection and maximum lateral rectus (LR) recession in subjects with large-angle exotropia and amblyopia. The authors included 22 patients, six of whom underwent MR resections exceeding 9 mm, while LR recession ranged from 7 to 8 mm. They argued that the drawback of limited abduction could be a benefit in preventing exotropia recurrence. However, excessive recession of LR beyond the equator may lead to significant abduction reduction, resulting in late overcorrection and lateral incomitance.**(Rayner and Jampolsky .,1973)**This finding is in contrast to our study; the cases achieved favorable post-surgical alignment with insignificant duction restriction after six months.

Scott *et al*.**(Scott et al., 1986)** bimedial recessions alone succeeded in only 37.5% of patients with large‑angle infantile esotropia >50 PD. Adding a third or fourth muscle substantially increased the success rates to 64.5% and reduced the second surgery rates by four times. A study examined 92 consecutive patients who received monocular surgery with peribulbar anesthesia for significant horizontal strabismus. Successful outcomes were achieved for patients with preoperative deviations up to 60 prism diopters. However, patients with deviations exceeding 65 PD had residual misalignments of over 15 PD post-surgery. The study suggests that peribulbar anaesthesia during monocular surgery can be effective for large-angle horizontal strabismus up to 60 PD deviations but less effective for deviations exceeding 65 PD.**(Millán et al., 2009)**

An alternative approach adding to uniocular surgeries involves employing marginal myotomies, such as Botox injections, to supplement recessions with unpredictable outcomes or using hang-back sutures. However, the effectiveness of substantial hang-back recessions beyond the equator still needs to be proven.**(Repka et al., 1990)** Additionally , techniques involving elongation of the MR muscle tendon using fascia lata have been explored in cases of sixth cranial nerve palsy.**(Focosi et al., 1979)** Yet, the success rate of this method was diminished due to material shrinkage. Muscle lengthening with allograft materials like silicone bands or non-absorbable sutures,(**Wright, 1991**) has also been reported. While successful in certain scenarios, this procedure remains complex, requiring a significant learning curve and potentially leading to postoperative complications like inflammation, adhesions, and material displacement.**(Keskinbora, 2007)**

Recent application of artificial materials, such as Gore-Tex®, has shown promise in cases of restrictive strabismus with fibrosis or recurrent surgeries, enhancing eye movement, residual deviation, and double vision. However, these studies have been limited to a few patients with restrictive strabismus.**(Langmann et al., 2006)** Furthermore, the utilisation of xenograft material, such as bovine pericardium **(Oeverhaus et al., 2018)** has been investigated for elongation of extraocular muscles in cases of recurrent strabismus. Although some improvement in duction movement was observed, limitations persisted postoperatively, often necessitating additional surgery.

Muscle transplantation emerges as an effective option for addressing large angle cases while maintaining alignment in single eye surgery. This approach was first tested on rabbits, wherein the superior rectus muscle received a piece of the inferior rectus muscle with the use of cyanoacrylate adhesive. However, fragility and excessive reaction around the adhesive posed challenges. **(Dunlap et al., 1969)**Subsequently, a standardized protocol was developed, leading to the successful transplantation of extraocular muscle tissue in humans. This approach yielded results similar to artificial implants like silicone but with the added benefit of easy execution and minimal tissue reaction.

Although this procedure was suggested for conditions like thyroid orbitopathy, paralysis of the extraocular muscles, and amblyopic strabismus, transplanted muscle segments did not maintain their typical muscular characteristics over time. Healing of extraocular muscles exhibited fibrous tissue replacement. The Tenon showed only a slight reaction., with some adherence to the underlying sclera, yet without severe restrictions.**(Ganesh et al., 2020; Hiatt, 1977)**

Later on, true muscle transplantation was explored for correcting substantial esotropia, involving transplantation of resected LR muscle segments. While this method demonstrated safety and stability in the long term, its application was limited by patient numbers, Jethani et al. **(Jethani et al., 2016)** presented it as a secure and feasible alternative in 22 patients with esotropia. A recent publication indicated that transplantation is efficacious for esotropia within the range of 70 to 75 PD. Traditional single-eye surgeries were ineffective, so the researchers explored muscle transplantation as an alternative. and followed up with the patients for 2 years. The results showed that this approach was safe and stable, significantly reducing the esotropia angle. On average, each millimeter of transplantation corrected 4.1 ± 0.3 pd of esotropia. Most patients had normal eye abduction and minimal adduction restriction, demonstrating muscle transplantation as a viable and effective long-term treatment for very large angle esotropia cases. . **(Jethani et al., 2016)**

In this study, patients in esotropia group had good outcomes regard to eye alignment and mobility with a follow-up of 12 months and each 1 mm elongation of the MR muscle through the transplanted segment resulted in weakening by 4.5–6 PD, effectively adding 1.5-2 mm to the amount of recession required for the MR muscle without extra recession beyond the equator and this correction is larger than noticed by Jethani et al.

The other study **(Shafik et al., 2020)** specifically focuses on large-angle sensory exotropia and utilizes an autograft from the removed medial rectus muscle to lengthen lateral rectus tendon. It has a smaller sample size and shows significant postoperative alignment improvement and minimal motility restrictions in 81.2% of cases. The resection of the MR muscle varied based on different angle ranges: 6 mm for 50–65 PD angles, 7 mm for 70–85 PD angles, and 8 mm for angles over 85 PD.LR muscle recession after elongation depended on the preoperative angle (average 5.7±1.9). with each 1 mm elongation considered equivalent to 1.5 mm additional recession for the LR muscle. In terms of the degree to which the patient was satisfied with the procedure in this study, seven patients were moderately satisfied (43.8%), six were very satisfied (37.5%), and only three patients were not satisfied (18.8%).

In the present study patients with exotropia had good outcomes with respect to eye alignment and motility with a follow-up of 12 months. Each 1 mm elongation of the LR muscle through the transplanted segment resulted in weakening 2.25–3 PD, effectively adding 1.5-2 mm to the recession amount required for the LR muscle. Regarding patient satisfaction after surgical outcomes. In the Esotropia group, 46.67% were "Very Satisfied," 40% "Moderately Satisfied," and 13.33% "Unsatisfied." In the Exotropia group, 40% were "Very Satisfied," 40% "Moderately Satisfied.

Limited literature exists that directly compares the efficacy of authentic muscle transplantation in cases of significant esotropia and exotropia eye misalignment**(Pineles et al., 2019).**

Another case series involved 7 patients (comprising four females and three males) who had significant angle sensory exotropia (>70 prism diopters, PD) and preferred single-eye surgery. (**Yang et al.,2016**) The average angle before surgery was 77.14 ± 4.52 PD in these seven patients, who had an average age of 39.71 ± 17.38 years. Following the procedure, the average angle reduced to 4.71 ± 4.42 PD at 6 months post-surgery, and these positive outcomes remained consistent beyond the 6-month follow-up period. Furthermore, there were no observed limitations in the range of extraocular movements after the surgery, in all patients.

True muscle transplantation serves as a secure alternative and demonstrates comparable effectiveness to the hang-back technique. the position of muscle after hang back is beyond the equator therefore over the long term, this procedure maintains stability, although some limitations in eye movement during maximum adduction may be observed.**(Tawfik et al., 2020)**

The long-term effects of muscle transplantation on large-angle esotropia and exotropia after 9 months and 1 year are critical in assessing the surgical intervention's stability and efficacy. Patients' ocular alignment and motility should have stabilized at these time points, and any potential complications or adverse outcomes would likely have become apparent.

Postoperatively under correction of deviation and some redness at the site of transplanted segment were the only encountered drawbacks.

Overall, the effects of muscle transplantation on large-angle esotropia and exotropia should demonstrate long-term stability and successful outcomes.

The movement restriction in the extreme gaze on the side of the muscle transplantation is noted because of the excessive weakening of the muscle, we suppose. The muscle is still anterior to the equator, so the motility restriction is minimal.

However, individual variations exist, and some patients may require additional interventions or ongoing monitoring to ensure optimal results.

Conclusion

Muscle transplantation is an effective surgical technique for managing large angle esotropia and exotropia. The procedure leads to significant improvements in ocular alignment and eye movement restrictions. The outcomes were successful in most cases, with a high patient satisfaction rate.

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