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Review article

# Restrictive problems related to strabismus surgery

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ABSTRACT

Strabismus surgery may be responsible for some restrictions in ocular motility that may cause new problems after surgery. Most of the time these restrictions present as a complex motility problem after surgery that requires further treatment. There may be various reasons that cause motility restriction following strabismus surgery. Those are excessive shortening or inadvertent capture of extraocular muscles, transposition procedures and, the most challenging problem, postoperative scar tissue-adhesion formation. In this review the potential reasons for postoperative restrictive problems, preventive measures and finally the treatment options for such problems are overviewed.



## 1. Introduction

The aim of strabismus surgery is primarily to correct ocular misalignment and to keep both eyes aligned in nine positions of gaze with free ocular movements. However, in some patients that goal may not be achieved by surgical intervention and strabismus surgery itself may be the reason for ocular misalignment and restrictive ocular motility problems.

The tissue that causes a restriction may limit the rotation of the eye both in the opposite and in the same direction which is called as “leash” and “reverse leash” effect by Jampolsky [1]. Figure 1 demonstrates the schematic representation of “leash” and “reverse leash” effect.

The tissue that causes a restriction of ocular movements may be the extraocular muscle, conjunctiva, soft tissues around the extraocular muscles and orbital adhesions that possibly affect the extraocular muscle pulleys.

## 2. Diagnosis

When a postoperative limitation of ocular movement is observed, the surgeon first needs to know whether it is due to a restriction or due to weakness of an extraocular muscle. For differential diagnosis, forced duction test, forced generation test, intraocular pressure change on side gazes and saccadic velocity measurements can be used. Slit lamp examination may also give clues about excessive conjunctival scarring and the presence of orbital fat tissue under the conjunctiva at the early postoperative stage.

The forced duction test is a simple test that can be performed at the examination room with topical anesthesia in adults. Use of the forced duction test during surgery provides very important additional information if it is repeated at different stages of surgery. In order to find out which tissue is responsible for the restricted ocular movement, the forced duction test must be repeated before and after dissection of conjunctiva, Tenon’s capsule and extraocular muscles. That will allow to determine the tissue that causes the restriction. Sometimes the forced duction test may still be positive after disinsertion of the extraocular muscle, which indicates the presence of orbital fibrosis.

The forced generation test is useful to rule out a lost muscle problem after surgery. Intraocular pressure change at gaze positions also gives an idea about the presence of a restriction and any change exceeding 4 mmHg is suggestive of a restrictive motility problem. Saccadic velocity measurement gives reliable information but it is not as easy as the other methods to perform and requires some equipment which is not available in most clinics.

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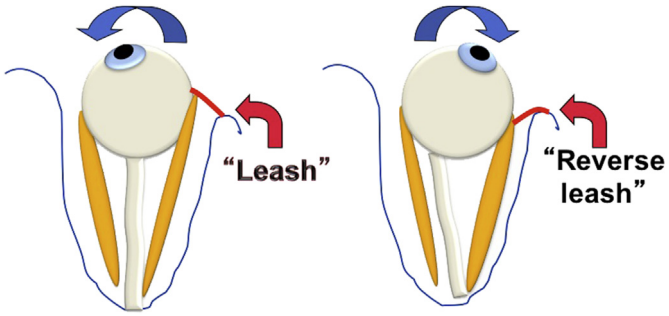


**Figure 1.** The schematic representation of "leash" and "reverse leash" effect. The tissue that causes a restriction may limit the rotation both in the opposite and the same direction [1].

## 3. Etiology — preventive measures

The problem that causes restricted ocular movement may be at the extraocular muscles, conjunctiva, Tenon' capsule, soft tissues surrounding the extraocular muscles and at the orbital structures.

Etiology of restricted ocular movements may be summarized in four groups:

1. restrictions related to excessive shortening of an extraocular muscle;
2. restrictions related to inadvertent capture of a neighboring muscle;
3. restrictions related to transposition surgery; and
4. restrictions related to postoperative scar tissue — adhesions.

### *3.1. Restrictions due to excessive shortening of an extraocular muscle*

Excessive shortening of an extraocular muscle may develop either due to excessive resection or excessive tucking-plication of an extraocular muscle. Excessive shortening of an extraocular muscle causes a restriction towards the opposite side of the functional area of the shortened extraocular muscle. In order to avoid that complication, the amount of resection must be carefully determined. In surgical tables the conventional maximum amounts of resections show some variability. The surgeon needs to consider that the elasticity of an individual muscle may have some variability and in some certain conditions even the conventional amounts of resection may cause some restrictive motility problems in concomitant strabismus. In all resections, performing forced duction test must be a routine procedure. In dysinnervational problems such as Duane syndrome and congenital fibrosis of extraocular muscles, resections should be avoided as a golden rule. There may be only rare exceptions to perform resections in Duane syndrome which should be regarded with great caution [2]. Thyroid-associated eye disease is another condition in which resections should be avoided. In cases with cerebral palsy the abnormal muscle tone may cause unpredictable postoperative restrictions.

One of the problems that troubles the strabismus surgeon is reoperation. There are no reliable surgical tables for secondary operations. It is the surgeon's subjective decision how much resection to perform in a previously resected muscle. In some cases the information on the amount of the previous resection may not be obtained. In such a situation the surgeon has to decide the amount of re-resection based on the elasticity of the muscle. A forced duction test might be a good guide before closure to decide whether the new positions of the extraocular muscles will cause any restriction or not. The use of adjustable sutures is a very useful preventive measure to avoid restrictions related to primary or secondary resection surgery.

Tucking or plication is mostly used for the superior oblique tendon in cases with superior oblique palsy. A complication of excessive tuck surgery is the development of secondary Brown syndrome. Because of the high risk of iatrogenic Brown syndrome, tuck surgery is advised to be performed in congenital cases with abnormally lax tendons. The amount of tucking must be determined depending upon the laxity of the superior oblique tendon. Before closure, the surgeon must repeat the forced duction test and if it is positive the amount of tucking must be reduced. A slight limitation in elevation on adduction is usually well tolerated and demonstrates a decrease in time.

### *3.2. Restrictions related to inadvertent capture of a neighboring muscle*

This problem may occur during superior and lateral rectus muscle surgery by inadvertent capture of superior oblique in the former and inferior oblique in the latter. The preventive measure is to hook the lateral rectus muscle from the superior site and to hook the superior rectus muscle from the temporal site. The hook must not engage the muscle far behind the insertion with blind fishing.

### *3.3. Restrictions related to transposition surgery*

Transposition of rectus muscles may cause a restriction towards the eye movement in the opposite direction with the transposition. As an example, transposition of vertical recti laterally in an abducens palsy may cause a limitation on adduction. In order to avoid that complication, the forced duction test should be performed and if any restriction is felt, transposition should be performed with a small recession of the transposed muscle [3]. The risk for a restriction increases with Foster augmentation sutures and a small restriction usually does not cause any problem in an abducens nerve palsy. However if it occurs in Duane syndrome where there is some limitation of adduction preoperatively, the restriction may cause significant problems. If there is a restriction in the preoperative forced duction test, the augmentation sutures may be placed more anteriorly, enough to allow a free forced duction test.

Transposition of oblique muscles may also cause some restrictions. Anterior transposition of the inferior oblique muscle may cause a limitation of elevation–antielevation syndrome — if it is placed too anteriorly or the posterior fibers are spread too temporally. In order to reduce that risk, the posterior fibers are recommended to be sutured in a bunched up fashion and the placement of sutures should not be placed anterior to the inferior rectus insertion.

### *3.4. Restrictions related to postoperative scar tissue — adhesions*

One of the major problems in strabismus surgery is the development of postoperative adhesions, particularly in patients who require multiple strabismus surgeries. The adhesions may develop in the conjunctiva, Tenon's capsule, intermuscular membrane, orbital fat, sclera or extraocular muscle. Such adhesions may cause limitation of ocular motility despite an appropriate amount of extraocular muscle surgery.

Adherence syndrome is described by Parks [4] and he used this term specifically for the motility disturbance secondary to hemorrhage and prolapse of orbital fat tissue following inferior oblique surgery. Later on he suggested that the fat is not directly involved and the loss of elasticity of the septae in the extraconal space that

develops as a result of the inflammation, causes the restriction of the ocular movement [5]. Adherence syndrome may develop in all types of extraocular muscle surgery but the risk is higher in oblique muscle surgery. In both inferior oblique and superior oblique muscle surgery the posterior fibers are close to the posterior Tenon's capsule and a blind hooking may end up with penetration of posterior Tenon's capsule and prolapse of orbital fat tissue. So, hooking the oblique muscles under direct view is of the utmost importance in order to avoid that problem.

### 3.5. Summary of preventive measures

The prevention of the development of restrictive problems during strabismus surgery is far more important than the management techniques. In order to prevent development of restrictions the surgeon need to consider the following parameters:

1. forced duction test must be routinely performed
   - prior to conjunctival opening,
   - following dissection of the extraocular muscle,
   - following the resection or tuck surgery, and
   - following closure of the conjunctiva;
2. gentle handling of tissues;
3. avoiding blind hooking especially during oblique muscle surgery;
4. good control of hemorrhage;
5. avoiding penetrance of the posterior Tenon's capsule and popping of orbital fat tissue; and
6. use of adjustable sutures where possible to avoid restrictions due to excessive resections.

## 4. Treatment

Postoperative restrictive problems usually require another surgery, and another surgery means possible new adhesions and restrictive factors. The surgeon must be very careful not to cause more new problems while attempting to correct the restrictive problem. Intraoperative use of some drugs such as steroids, 5-fluorouracil, mitomycine C, sodium hyaluronate (Healon), poloxamer-alginate-CaCl2 mixture and materials such as supramide, silicone sleeve, polyglactin 910 mesh, synthetic polypeptide sleeves, oxidized regenerated cellulose sleeve, amniotic membrane transplantation onto the extraocular muscles and Seprafilm may be helpful to reduce the development of further scar tissue [6–12].

In a rabbit model we investigated the role of Seprafilm on development of postoperative scar tissue [11]. In that study we demonstrated that histopathologically Seprafilm significantly reduces the development of fibrosis in strabismus surgery. The reports on the benefit of the use of mitomycine C and 5-fluorouracil demonstrate some variability [6,7,13–15]. The use of such agents should be regarded with caution as they may also decrease the reattachment of the extraocular muscle to the scleral tissue. The role of amniotic membrane to reduce postoperative scarring is studied by different groups and conflicting results are reported about the effect of reducing postoperative scarring [16–24].

Conjunctival scar tissues may be a significant problem, especially if there is loss of tissue. In order to reduce conjunctival scarring, avoiding the opening of the conjunctiva over the muscle insertion is important. During reoperation of such cases, excessive adhesions with the conjunctiva may be observed and dissection of the conjunctiva may be extremely difficult.

If closure of the conjunctiva creates a restriction on forced duction test, then the conjunctiva needs to be recessed. In patients with significant loss of tissue, conjunctival grafting or amniotic membrane transplantation may be helpful.

Restrictive motility problems cannot be solved without the release of the tissues that cause the restriction. If it is the extraocular muscle itself that causes the restriction, it is relatively straightforward to release that restriction. If the problem is excessive resection, then the resected extraocular muscle needs to be recessed. In patients where excessive resection is responsible for motility restriction, botulinum toxin A (BTXA) may be very helpful, especially during the acute phase by allowing a reorganization of the length tension properties of the extraocular muscles. In our clinical practice our first-line treatment is to inject BTXA into the excessively resected muscle. If this fails, surgery may be considered. The following case represents an unusual example of the effect of resection in a case with cerebral palsy [25].

### 4.1. Case 1

A 7-year-old girl with Parinaud syndrome, right esotropia (20 prism dioptres) and cerebral palsy underwent bilateral superior transposition of horizontal recti, right medial rectus recession (3 mm) and right lateral rectus (5 mm) resection (Figure 2A). On the 1st postoperative day she had a large-angle exotropia (45 prism dioptres) with severe limitation of adduction (Figure 2B). She was reoperated with a preoperative diagnosis of a disinserted medial rectus muscle but the extraocular muscles were found in the appropriate position. A forced duction test was positive on adduction. The lateral rectus muscle was recessed for 5 mm in an attempt to neutralize the resection of the lateral rectus muscle. On the next day the exodeviation was slightly better but the severe limitation of adduction persisted (Figure 2C). These findings suggested that the patient has an abnormal muscle contractility problem, as is the case in skeletal muscles of patients with cerebral palsy. Two weeks later, BTXA was injected into the previously operated lateral rectus muscle and she became stable in the orthophoric position (Figure 2D). Her eyes remained stable over the following 5 years. In this case, BTXA allowed a reorganization of the mechanical contractile forces and eliminated the abnormal contractility of the lateral rectus muscle [25].

If the problem is excessive tucking of superior oblique tendon, the treatment depends upon the severity. A mild to moderate amount of Brown syndrome resolves in time if tuck surgery is performed in a lax superior oblique tendon and does not require any correction. However if iatrogenic Brown develops in an acquired superior oblique palsy with normal tendon, it does not resolve in time and requires treatment if the patient is symptomatic.

If the restriction is due to the soft tissue scarring, such as orbital fat tissue prolapse, the problem is much more complicated because prolapse of orbital fat tissue causes a development of excessive adhesions and fibrosis among all of the tissues in the field. When adherence syndrome is developed, it is not possible to 'cure' it and all treatment attempts aim to make it 'better'.

If the development of adherence syndrome is recognized during the acute phase, release of the antagonist muscle by BTXA injection may be helpful [26]. The mechanism of BTXA is similar with a traction suture where the globe is aimed to be kept in a certain position during the healing period. Injection of BTXA during the acute phase allows the eye to move towards the opposite side of the injected muscle, which keeps the eye in the primary position during the development of fibro fatty inflammatory reaction (Figure 3). Figure 4 demonstrates a sample case (Case 2) of the use of BTXA in a case with adherence syndrome and also a lost muscle.

### 4.2. Case 2

A patient was referred for lost lateral rectus muscle 7 days after her first surgery. She had a previous esodeviation, medial rectus

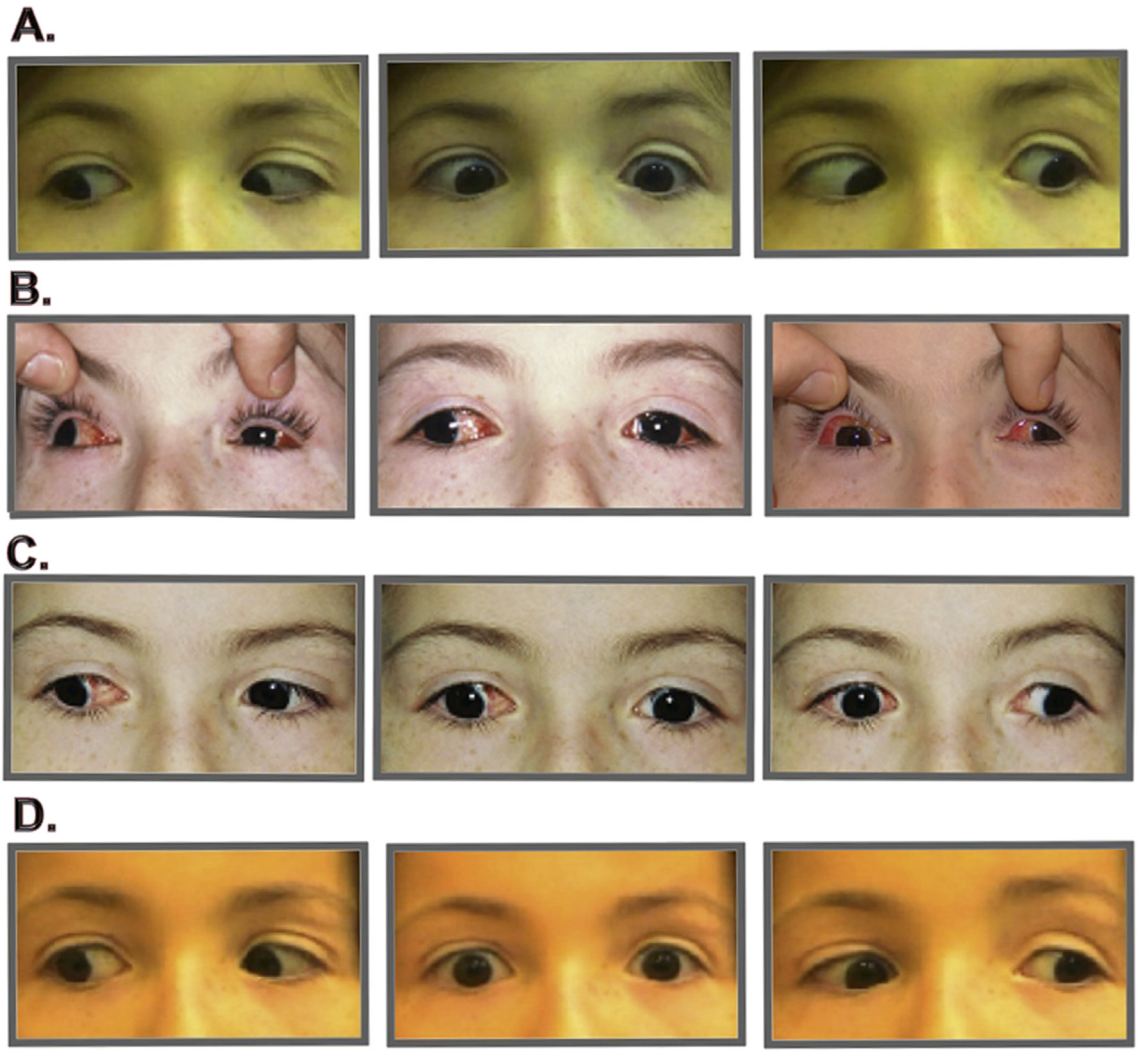


**Figure 2.** Case 1. (A) Parinaud syndrome, right esotropia and cerebral palsy. (B) Consecutive exodeviation with severe limitation of adduction on the 1st postoperative day, following bilateral superior transposition of horizontal recti, right medial rectus recession (3 mm) and right lateral rectus (5 mm) resection. (C) Consecutive exodeviation and limitation of adduction persisted after second surgery. Preoperative forced duction was (+) on adduction, MR muscle was found in the correct location, LR was recessed for 5 mm. (D) No horizontal deviation 3 months later following botulinum toxin injection into the right LR muscle.

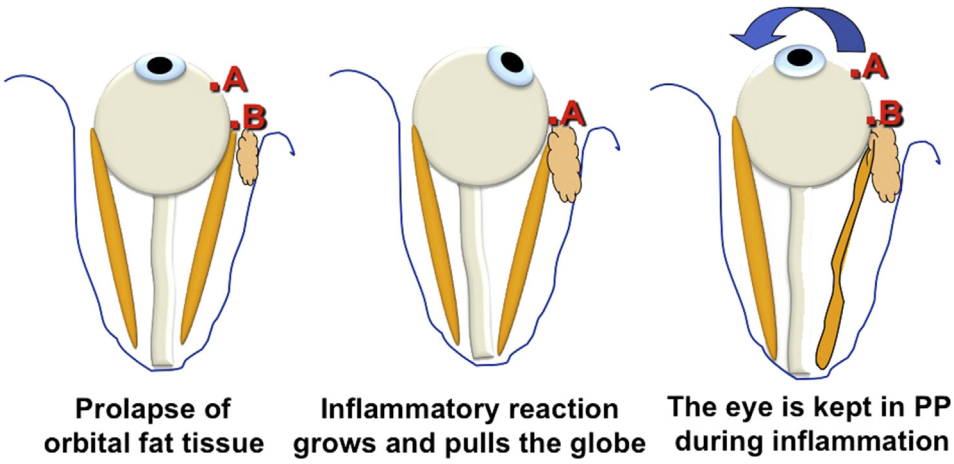


**Figure 3.** The schematic representation of the effect of BTXA in adherence syndrome. The prolapse of orbital fat tissue induces an inflammatory reaction which pulls the globe and attaches to the point 'A'. The injection of BTXA allows the eye to be kept in primary position (PP) and the fibro-fatty tissue attaches the globe at a more posterior point.

was recessed, lateral rectus was resected and then lost. At presentation she was found to have excessive inflammatory reaction and conjunctival eudema. Orbital fat tissue was recognized under conjunctiva and the diagnosis was fat-adherence syndrome in combination with a lost lateral rectus muscle (Figure 4A). Because of the excessive inflammatory reaction we preferred to wait for 6 weeks. In order to keep the eye in the primary position during this period, BTXA was injected into the left medial rectus muscle. Orthophoria was achieved on the 1st postinjection week with limited abduction related to lost lateral rectus muscle and with limited adduction related to the BTXA effect (Figure 4B). Six weeks later she underwent operation. Forced duction test was severely positive both on adduction and abduction. Lateral rectus muscle was found within the orbital fat tissue and it could be reattached to the globe with some recession as it could not be possible to pull the muscle to the original insertion. Excessive scar tissue was also found at the medial rectus area and these tissues were excised. Two months after reattachment of lateral rectus muscle to the globe the eyes were well aligned but there is a limitation of both adduction and abduction related to fat-adherence syndrome (Figure 4C).

After the development of fibrosis BTXA cannot be effective and the problem can only be reduced with another surgery. In such

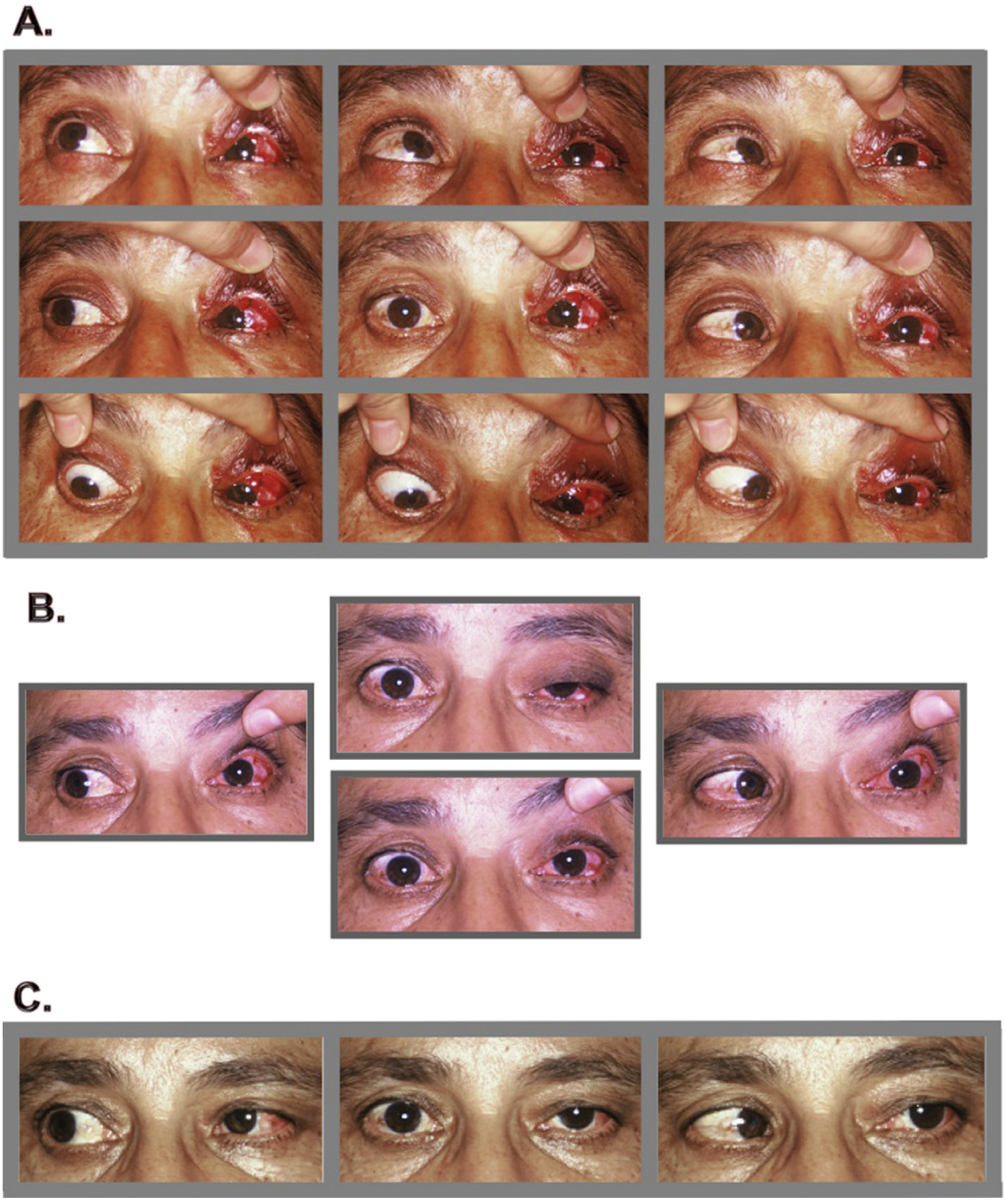


**Figure 4.** Case 2. (A) The patient was referred for lost lateral rectus muscle 7 days after her first surgery. Orbital fat tissue was recognized under the conjunctiva with excessive inflammatory reaction. Abduction was severely limited. (B) Botulinum toxin A is injected into the left medial rectus muscle and orthophoria was achieved on the 1st postinjection week with limited abduction related to lost lateral rectus muscle and with limited adduction related to the BTXA effect. (C) Two months after reattachment of lateral rectus muscle to the globe. Note that the eyes are well aligned but there is a limitation of both adduction and abduction related to fat-adherence syndrome.

cases the aim is to achieve orthophoria in primary position. Some limitation of ocular motility remains in all cases. A satisfactory improvement in primary position is reported in a series of 11 patients, with extensive 180° conjunctival peritomy and recession of conjunctiva in combination with inferior rectus recession [27]. The authors emphasized that the expectation of the patients must be realistic and it is not possible to obtain free ocular movements. It is important to remember that once the integrity of fascial system is lost and once the orbital soft tissue scarring occurs it is not possible to eliminate it in total with any type of treatment.

## 5. Conclusions

Restrictive problems related to strabismus surgery represent a challenging motility problem for the strabismus surgeon. The primary goal must be to prevent the development of such problems during surgery. Nontraumatic surgery is essential to prevent excessive scar tissue. Forced duction test that is carried out routinely is an effective preventive measure to reduce the risk of postoperative restrictive motility disorders and forced duction test must be repeated before, during and at the end of the surgery as a routine in all types of strabismus operations. BTXA may be very helpful to “rescue” a restriction if it is performed during “acute” phase of the problem.

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