Strabismus Surgery

Continuing Nursing Education (CNE) Article

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The primary goals of strabismus surgery are to restore ocular alignment and single binocular vision. Surgery is indicated when nonsurgical treatments are unsuccessful in eliminating the misalignment. The rationale for strabismus surgery usually has little to do with the etiology of the strabismus; rather it is a balancing of the extraocular muscles. The timing of surgery is important and controversial. The surgeon must consider the variables and treat each patient individually before determining which of the extraocular muscles to operate on and the degree of surgical intervention to perform.

Goals

The most crucial goal of strabismus surgery is to restore ocular alignment. A second important goal is to restore, if possible, normal single binocular vision with a full range of movement. Single binocular vision is the blending of the separate images seen by each eye into one composite image. This is also known as "fusion." It is important for the patient to be able to maintain fusion when looking up, down, left, and right. Having "straight" eyes does not mean the patient can fuse. Some patients have their strabismus eliminated entirely and still are unable to fuse. Strabismus surgery enables fusion only when it is possible; it does not produce fusion. However, fusion cannot develop without straight eyes.

Indications for Strabismus Surgery

Strabismus treatment can be classified as nonsurgical or surgical. The nonsurgical techniques include patching, glasses, prisms, and orthoptic exercises. These nonsurgical techniques will treat amblyopia (poor vision in one eye), promote fusion, and straighten ocular alignment. If the results of nonsurgical treatment are unsuccessful or only partially help to restore alignment, then it is time to consider surgery.

Along with having straight eyes while looking straight ahead, it is also important to have straight eyes in downgaze (the position used for reading). If these conditions already exist, there is usually no indication for surgery. For example, a patient with Duane's syndrome (a congenital miss-wiring of the medial rectus to the lateral rectus) who sees single straight ahead and when reading should not have surgery to try to improve eye movements. Consider surgery only when straight eyes with a straight head does not exist. For example, if a Duane's syndrome patient must adopt a significant head turn in order to fuse, then surgery can be considered to try and align the eyes with the head straight.

Nonsurgical treatment of strabismus should always be the first treatment of choice. Patients with esotropia who are fully corrected with glasses are not candidates for surgery. There is no ocular deviation present when the glasses are on, thus there is no indication for surgery. When glasses only partially correct the crossing (partially accommodative esotropia), surgery can be done to correct the residual crossing. Patients with partially accommodative esotropia will still have to wear their glasses after surgery. Surgery corrects only the amount of crossing that is not corrected with the glasses.

Strabismus surgery is always an elective procedure. The patient's overall health should be as good as possible. The patient should avoid taking anticoagulants such as acetasalicylic acid (ASA) for two weeks prior to surgery. It is important to note any allergies to medications or problems that the patient has experienced with anesthesia in the past.

Timing of Strabismus Surgery

There is some disagreement among ophthalmologists as to the optimal timing of strabismus surgery. It is generally agreed

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Fig 1. Patient looking in the nine diagnostic positions of gaze. The yoke muscles are shown for specific fields of gaze. In up and right gaze the yoke muscle are the right superior rectus (RSR) and the left inferior oblique (LIO). In right gaze the yoke muscles are the right lateral rectus (RLR) and left medial rectus (LMR). In down and right gaze the yoke muscles are the right inferior rectus (RIR) and the left superior oblique (LSO). In up and left gaze the yoke muscles are the right inferior oblique (RIO) and the left superior rectus (LSR). In left gaze the yoke muscles are the right medial rectus (RMR) and the left lateral rectus (LLR). In down and left gaze the yoke muscles are the right superior oblique (RSO) and the left inferior rectus (LIR).

that reliable, consistent measurements are necessary. Measurements should be made after the correction of any significant refractive error. Some believe that early surgery (within the first year of life) offers the best chance of achieving fusion, while others feel that such early surgery is not beneficial.[1] Accurate exams are critical to the development of a surgical plan and may be difficult to obtain in young children. The ocular deviation should remain stable throughout the exam and on follow-up examinations. In a study conducted by the Pediatric Eye Disease Investigator Group (PEDIG), infants with an onset of esotropia between four and 20 weeks of age were examined. Forty-six percent of the infants had a variable or intermittent deviation. Only a minority of the infants who were diagnosed with esotropia before 20 weeks of age had the large-angle constant esotropia classically described for congenital esotropia.[2]

One limiting factor to early surgery is amblyopia. The classical teaching is that for the best surgical result you must completely treat the amblyopia prior to strabismus surgery; the first priority is to treat the amblyopia. Fusion cannot be achieved in the presence of significant amblyopia.

Strabismus resulting from an extraocular muscle paresis (partial loss of movement) needs time to allow for spontaneous recovery. Most patients with a third-, fourth-, or sixth-nerve palsy (complete or partial loss of movement) will demonstrate some recovery.[1] If recovery is to occur, it will usually occur within six months following the onset of the paresis. These patients may need frequent assessment of their ocular alignment to monitor recovery or determine cessation of recovery.

The optimal time to operate is when the ophthalmologist has all the necessary information. The ophthalmologist should be able to answer "yes" to the following questions:

1. Have all the preoperative measurements been done to help achieve straight eyes and fusion?
2. Does the ophthalmologist have a plan as to what surgery to perform and why?
3. Has the ophthalmologist clearly explained to the patient the goals, the plan, the risks involved in surgery, and the risks involved in not operating?
4. Has the ophthalmologist explained the possibility that more than one operation may be necessary?

Rationale of Strabismus Surgery

To better understand the rationale of strabismus surgery, it is important to understand some of the features of extraocular movement as well as the anatomy of the oculomotor system.

The globe and the orbit can be thought of as a specialized form of a ball-in-socket joint.[3] The globe rotates around three principle axes (horizontal, vertical, and torsional). These rotations are made possible by the action of six extraocular muscles, four rectus muscles, and two oblique muscles. The innervation of these muscles comes from three different cranial nerves. Innervation to four of the extraocular muscle (medial rectus, inferior rectus, superior rectus, and inferior oblique) comes from the third cranial nerve. The fourth cranial nerve innervates the superior oblique muscle, and the sixth cranial nerve innervates the lateral rectus muscle.

The six extraocular muscles work as three opposing pairs: medial rectus-lateral rectus (MR-LR), superior rectus-inferior rectus (SR-IR), and inferior oblique-superior oblique (IO-SO). When one member of the pair receives information to contract, the other member is told to relax the same amount, allowing the eye to move (Sherrington's law). Our two eyes are able to move together because of Hering's law of equal innervation. Each muscle in the right eye is innervationally paired with a muscle (yoke muscle) in the left eye. For example, the right medial rectus is paired to the left lateral rectus, the right inferior oblique is paired to the left superior rectus, and the right superior oblique is paired to the left inferior rectus (Fig 1). Changes in innervation are similar for both members of a yoked pair. Thus, when the right medial rectus contracts, the left lateral rectus contracts the same amount keeping the eyes together as they look to the left. These relationships are guided, in part, by associated sensory feedback mechanisms. To maintain normal single binocular vision (fusion) when we move our eyes, the movements must be tightly coordinated and symmetric.[3]

The extraocular muscles are located on the exterior of the globe under the conjunctiva (clear membrane lining the inner eyelids). A small incision is made through the conjunctiva, Tenon's capsule, and intermuscular septum down to the sclera.[4] The surgeon does not remove the globe. He rotates the eye to expose the muscle that is undergoing the surgery.

Viscous, elastic, and inelastic forces in the orbit oppose the active forces of the extraocular muscles. These passive forces of the orbit arise from the biomechanical properties of the extraocular muscles as well as the connective and supporting tissues. The orbit has a complex and intricate structure. The path of each extraocular muscle is fixed by pulley-like concentrations of orbital tissue.

The orbit also contains a specialized fat that acts as a cushion to protect the globe against injury and is well suited to facilitate eye movement. All of these features play an important bearing on the mechanics of eye movement.

The cause of strabismus in many patients remains unknown. There is usually nothing wrong with the extraocular muscles, and in many cases the third-, fourth-, and sixth-nerve innervation to these muscles appears to be normal.

In some cases the cause of the strabismus is known. For example, trauma can cause paresis of an extraocular muscle, or a systemic disease such as thyroid disease can cause muscle infiltration resulting in restriction of extraocular movement. Even though the cause of the strabismus is known, surgery cannot eliminate or reverse the cause. The aim of strabismus surgery is to change the position of the globe within the orbit by altering the position of the extraocular muscles. By changing the insertion location of an extraocular muscle or adjusting the tightness of a muscle, ocular position and movement can be affected. Surgery does not directly affect the innervation reaching the eyes.[5] This can only happen indirectly when the eyes adjust to the newly created position.

Choice of Surgery

When the need for surgery has been established, the ophthalmologist must determine which muscle or muscles to operate on. This is where the experience and expertise of the ophthalmologist are critical. There is no one surgery for every patient. Surgical results depend on the operative plan. Each surgeon must establish the effectiveness of the procedure he or she routinely chooses to use. Even when the technical aspects have been standardized, mechanical, sensory, or innervational factors for each individual remain as variables that influence the outcome of the operation. Thus, the identical surgery performed on several patients may have different results in each patient.

Even with all these variables, there are empirical rules that are helpful in determining the type and amount of surgery to perform on each patient. There are essentially three types of procedures that can affect the action of the extraocular muscles. The action of a muscle can be weakened, strengthened, or transposed.

Weakening Procedures

There are several procedures that fit into this category. The most commonly used weakening procedure is the recession.[5] For a recession, the surgeon disinserts a muscle from the globe and reattaches it with sutures posteriorly to its original insertion. By changing the tension of the muscle and where it pulls on the eye (arc of contact), the effective action of the muscle is reduced. The surgeon can measure the amount the muscle is moved, thus grading its effect.

A complete tenotomy is a procedure where the surgeon disinserts the muscle tendon from the globe and allows it to retract. The muscle reattaches to the globe at an undetermined location posterior to its original insertion. A tenectomy is a similar procedure in which the tendon is disinserted and a section of the tendon is removed and allowed to attach posterior to its original insertion. It is not possible to grade these weakening effects. The tenotomy and tenectomy are usually reserved for oblique muscle surgery.

For a Z tenotomy, the surgeon makes two incisions partially across the tendon or muscle. The surgeon does not disinsert the muscle from the globe. A weakening effect results due to the lengthening of the muscle. This procedure is usually reserved for muscles that previously have been recessed.

Strengthening Procedures

A common strengthening procedure is the resection or shortening of the muscle. During a resection a portion of the tendon and/or muscle is removed and the remaining muscle is resutured to the original insertion. The surgeon can measure the amount of resection, thus grading its effect. There are limits to the amount of resection that can be done. Excessive shortening of the muscle may restrict movement of the globe in the opposite direction.

An advancement can be made on a previously recessed muscle. The surgeon can disinsert the muscle from the globe and reattach it more anteriorly toward the limbus, strengthening the muscle. The surgeon can measure the amount of advancement.

A muscle can also be strengthened by making a pleat or fold in the muscle without disinserting it from the globe. Commonly referred to as a "tuck", this procedure shortens the muscle and therefore strengthens it. A tuck is most commonly performed on the superior oblique muscle.

Transposition Procedures

Muscle transposition procedures may be broadly defined as procedures in which the insertion of the muscle is moved to a new position on the globe. These procedures are not usually classified as strengthening or weakening procedures. The

Fig 2. Patient with orbital cellulitis, left eye. Note the proptosis, severe swelling of upper and lower lids, and chemosis.

intent of a transposition procedure is to alter the field of action of the transposed muscle. Many transposition procedures have been described, and new techniques continue to develop. Unfortunately, it is not within the scope of this paper to describe these techniques. Transposition procedures are most commonly used in the treatment of paretic strabismus and A- or V-pattern strabismus.

Single Versus Multiple Procedures

The patient should avoid repeated exposures to general anesthesia. Therefore having the eyes aligned with a minimum number of operations is optimal. With this in mind some surgeons will operate on more than one muscle in more than one eye during a single operation. However, the patient and/or parents must be made aware of the possibility of future surgeries.

Preparation for Surgery

To avoid a great deal of fear, the surgeon should take the time to talk with the parents and patient. Briefly explain the operation. This will help dispel any fears that the eye is to be removed from the orbit or that laser beams are used. Make sure it is clear which eye is having the surgery, but explain to the parents and patient that sometimes in the course of surgery a different approach becomes necessary and the other eye may have to be operated on as well. In some cases, where it doesn't matter which eye is operated on, the surgeon should make a choice and inform the patient (or parents, when appropriate) before surgery. It is difficult for patients to understand the surgery when they feel the problem is in the left eye and the surgeon says he is going to operate on the right eye. Explain that it is not always possible to operate on the eye that appears to have the problem. The eyes are linked or yoked together; thus changing the alignment of one eye will affect the alignment of the other eye. Make sure to explain possible complications, specifically the possibility of over- and undercorrections. This will help maintain confidence in the surgeon if the need for further surgery arises. Be sure to discuss postoperative care and discomfort and the importance of follow up.

Fig 3. Patient with a conjunctival cyst, right eye.

Complications of Strabismus Surgery

Complications of Anesthesia. Complications arising from anesthesia during strabismus surgery are extremely rare, even though anesthesia is never entirely without danger. However minimal, the possibility of life-threatening situations should never be ignored. The incidence of mortality during general anesthesia for strabismus surgery is not exactly known. The mortality has been estimated to be 1.1 per 10,000 cases, which indicates that more people die as a result of tooth extraction (17.42 per 10,000) than as a result of strabismus surgery.[5] When taking the patient's history, be sure to note any unusual reactions to an anesthetic by the patient or a family member.

Postoperative Complications. Infections following strabismus surgery are rare. Endophthalmitis may be related to scleral perforations during strabismus surgery. Such complications can be prevented by good surgical technique.

Orbital cellulitis is even less common than endophthalmitis (Fig 2). Very few cases have been reported. Patients should be informed of possible signs such as proptosis, swelling of the eyelids, chemosis, and restricted eye movement. Patients respond well to intravenous and topical antibiotics.

Conjunctival cysts can develop when small sections of conjuntival epithelium become buried in the wound during closure (Fig 3). The cyst is filled with clear fluid and can be evacuated with a needle puncture under local anesthesia. If the cyst recurs, excision becomes necessary.

Corneal dellens (dry areas) occur with interruptions of the corneal tear film and local dehydration of the cornea. This results from the swelling of the conjunctiva next to the cornea. It is a benign complication that occurs in the postoperative phase. Dellens respond well to treatment.

Diplopia (double vision) can occur due to the change in ocular alignment. Postoperative diplopia can last from a few minutes to a day or a week but rarely forever. How long the double vision lasts depends on the ability of the patient to suppress, ignore, or fuse the second image. Since these abilities decrease with age, constant diplopia is more common in adults. Scott et al found that only 1% of adult patients had

diplopia at their last exam after strabismus surgery.[6] Even though this is a rare complication, the possibility of postoperative diplopia must be discussed with all patients, especially adults.

Overcorrections and undercorrections can occur even in the hands of the most experienced surgeons. They can occur days, weeks, months, or even years after the surgery. In most situations it is advisable to wait at least six weeks or longer before considering reoperation. In some patients, the goals of straight eyes and single binocular vision are best achieved with mild, temporary surgical over- or undercorrection. For example, mild overcorrection is desirable in patients with intermittent exotropia. Patients with a vertical deviation with vertical fusional amplitudes might have best results by being mildly undercorrected. The amount of correction depends on several factors and varies among different patients. The surgeon not only has to choose which muscles to operate on but also how much surgery to do on each muscle.

Conclusion

The surgical treatment of strabismus is possible in patients of all ages. In order to meet the goals of straight eyes and single binocular vision, the surgeon must perform a detailed preoperative diagnostic workup. The physician should view each case on an individual basis, assessing the optimal time for surgery, the operation of choice, and the surgical technique for each patient. An attempt should be made to first correct amblyopia. It is paramount to inform the patient and parents. Do not overlook a review of surgical complications, the need for future surgeries, and the importance of follow up. When everyone works together and has a clear understanding of the goals, strabismus surgery can be successful.

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CNE Test

Strabismus surgery

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1. List the goals of strabismus surgery.
2. Describe the indications for strabismus surgery.
3. Name the extraocular muscles.
4. Explain the rationale of strabismus surgery.
5. List the types of strabismus surgery.
6. List the complications of strabismus surgery.

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1. A B C D	3. A B C D	5. A B C D	7. A B C D	9. A B C D
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General Evaluation: "Strabismus Surgery" Please use the scale below to evaluate this educational activity. Circle your response.

As a result of completing this offering, I am able to:	4 Very well	3 Moderately well	2 Fairly well	1 Not at all
1. List the goals of strabismus surgery.	4	3	2	1
2. Describe the indications for strabismus surgery.	4	3	2	1
3. Name the extraocular muscles.	4	3	2	1
4. Explain the rationale of strabismus surgery.	4	3	2	1
5. List the types of strabismus surgery.	4	3	2	1
6. List the complications of strabismus surgery.	4	3	2	1
7. The content matches the objectives.	4	3	2	1
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The time required to complete this offering (in minutes) and take the test was:	60	75	90	>90

CNE Test

Strabismus Surgery

1. The goals of strabismus surgery include all of the following except
   A. To restore ocular alignment
   B. To restore innervation
   C. To restore single binocular vision
   D. To restore fusion

2. Which of the following patients have indications for strabismus surgery?
   A. Patients with a recent onset of fourth cranial nerve palsy
   B. Patients with good vision in both eyes and diplopia only in extreme right gaze
   C. Patients with a right head-turn to establish fusion
   D. Patients who have esotropia only when their glasses are removed

3. When should strabismus surgery be performed?
   A. When the ophthalmologist feels the patient is ready.
   B. When the angle of the strabismus is stable.
   C. When all nonsurgical treatment has been completed.
   D. All of the above.

4. Which cranial nerves innervate the eye?
   A. One, two, and three
   B. Three, four, and five
   C. Two, four, and six
   D. Three, four, and six

5. The sixth cranial nerve innervates
   A. The medial rectus
   B. The inferior oblique
   C. The lateral rectus
   D. The superior oblique

6. When looking to the left, Sherrington's law applies to which pair of muscles?
   A. The left lateral rectus and right medial rectus
   B. The right lateral rectus and left lateral rectus
   C. The right lateral rectus and right medial rectus
   D. The left lateral rectus and left medial rectus

7. The two eyes are able to move together because of
   A. Hering's law
   B. Sherrington's law
   C. Donder's law
   D. Prentice's law

8. Which of the following is a strengthening procedure?
   A. Myectomy
   B. Resection
   C. Tenotomy
   D. Recession

9. Transposition procedures are used most commonly to treat
   A. Restrictive strabismus
   B. Paretic strabismus
   C. Congenital strabismus
   D. Comitant strabismus

10. Which of the following is the most uncommon complication of strabismus surgery?
    A. Endophthalmitis
    B. Mortality
    C. Corneal dellen
    D. Diplopia