

**TITLE: Surgery for Exophthalmos**

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## **Introduction**

Exophthalmos, or proptosis, occurs when there is a discordant relationship between the soft tissue and bone of the anterior orbit and the globe. The adult orbit has a fixed volume of approximately 30 ml. When the soft tissue contents of the orbit exceed this amount, exophthalmos occurs. As an example, an increase in soft tissue volume of 5 ml (16%) will result in 4-5 mm of proptosis.

Graves disease represents the most common cause of bilateral exophthalmos. This condition is generally referred to as Graves orbitopathy (ophthalmopathy).

Graves orbitopathy typically affects middle-aged women. It is 5 times more common in women than men. Peak incidence occurs in the 3<sup>rd</sup> and 4<sup>th</sup> decades of life, and is 6 times more common in Caucasians. Severe exophthalmos is more common in elderly men. In addition, there is an increased prevalence in smokers, and a genetic predisposition has been established.

Though associated with Graves Disease, exophthalmos is NOT necessarily associated with hyperthyroidism. 20% of patients with Graves orbitopathy are euthyroid.

Graves orbitopathy likely arises from autoimmune, primarily T-cell, dysfunction resulting in lymphocytic infiltration and immune complex deposition with resultant edema and proliferation of extraocular muscles, intraconal and extraconal fat, and the lacrimal gland. There is some deficit in T-cell function that results in the production of antibodies that are normally suppressed.

There are both infiltrative and noninfiltrative ocular changes in Graves. Infiltrative changes involve mononuclear cells causing activation and proliferation of fibroblasts resulting in the production of collagen and glycosaminoglycans. The end result is edema and fibrosis. Noninfiltrative changes involve spastic retraction of eyelids, an increase in palpebral fissure width, and sympathetic hypertonia.

Ultimately, thickening of the external ocular muscles, orbital fat herniation, proptosis, retraction of both the upper and lower eyelids, descent of the eyelid-cheek complex, and divergence of gaze occur. In addition, one may see eyelid edema, conjunctivitis, photophobia, chemosis, lagophthalmos, headache, gritty sensation in the eye, retrobulbar pain, and tearing. Thickening of the superior rectus muscle can result in decreased venous flow via compression of the superior ophthalmic vein. Hypertrophy of the extraocular muscles can result in ophthalmoplegia and thus diplopia, most frequently involving the inferior and medial rectus muscles resulting in limitation of both upward and lateral gaze. As inflammation of the orbital contents occurs, an increase in soft tissue volume results in increased intraorbital pressure, which causes anterior displacement of the globe and stretch (and/or compression) of the optic nerve with the potential for optic neuropathy.

The natural progression of Graves orbitopathy is from no signs or symptoms to eyelid retraction, lid lag, and edema, followed by soft tissue signs and symptoms, followed by proptosis, followed by involvement of extraocular movement, followed by corneal involvement, followed by visual loss secondary to optic neuropathy. Optic neuropathy occurs in less than 5% of Graves orbitopathy, but it is the most common cause of vision loss in this setting; the progression is usually insidious. This neuropathy usually occurs in patients with proptosis, but can occur in patients without significant proptosis. Except for cases of rapidly progressive exophthalmos (malignant exophthalmos) the eyelids are capable of closing sufficiently to protect the cornea. Thus, while approximately 50% of Graves patients experience eye symptoms, only approximately 5% of cases are severe enough to warrant intervention.

## **Patient Evaluation**

On physical exam, hyperemia over the lateral rectus muscle is pathognomonic of Graves orbitopathy. In addition, one typically sees divergence of the globes on extreme gaze (e.g., looking up or laterally).

A complete ophthalmologic exam is necessary. The amount of globe protrusion is measured using Hertel exophthalmometry. Assessment of visual acuity, visual fields, and color saturation must be performed to exclude optic neuropathy. Nasal endoscopy should be performed to diagnosis any sinonasal problems such as septal deviation or polyposis. In addition, the thyroid gland should be palpated.

Radiographic imaging is an important part of the evaluation. A CT or MRI of the orbit and sinuses represents the standard of care. This helps to rule out other pathologic conditions of the orbit, especially in a case of unilateral exophthalmos. In addition, imaging will help to establish the presence or absence of sinusitis, septal deviation, and hypoplastic maxillary sinuses – all of which will affect the approach to treatment.

MRI measurement of T2 relaxation time can be useful for detecting external ocular muscle edema. Proptotic patients with an increased mean T2 relaxation time are more likely to respond to anti-inflammatory therapy, while those without T2 relaxation time prolongation are more likely to require orbital decompression.

In Graves Disease, T3, Free T4 Index, TSH, TRH, and TSI (a type of IgG) are all

elevated. These generally return to normal after I-131 ablation of the thyroid.

## Differential Diagnosis

Graves orbitopathy may be unilateral (10-20%) or bilateral (80-90%).

Pseudotumor cerebri represents the second most common cause of bilateral exophthalmos. CT or MRI shows generalized edema of the orbital soft tissues and occasionally the brain. However, there is no specific enlargement of the external ocular muscles. The use of high dose corticosteroids will generally improve the proptosis within 24 to 48 hours.

Meningioma en plaque results in severe exophthalmos with eyelid edema. Usually, the lower lid is affected *without* lid retraction.

Axial myopia is a common cause of unilateral exophthalmos. This is diagnosed by retinoscopy and A-scan ultrasound.

Inflammatory pseudotumor mimics a neoplasm with the sudden onset of proptosis, lid edema, pain, ophthalmoplegia, and visual loss. This typically responds to steroids.

Lymphoma of the orbit typically causes eccentric proptosis. CT or MRI typically demonstrates a mass, or masses, located near the orbital apex. Other orbital masses, generally associated with unilateral proptosis, include metastasis, vascular anomalies, neurofibromas, and retinoblastoma.

In addition, congenital shallowness of the orbits, such as in Apert or Crouzon Syndromes, may be the cause of proptosis. In such cases, surgery is generally cosmetic.

## Treatment

With the exception of acute and progressive Graves orbitopathy (malignant exophthalmos), the disease is self-limited in the majority of patients. Serial testing of visual fields allows for early detection of malignant exophthalmos. If left untreated, progression to blindness from either corneal exposure or optic neuropathy will result.

Medical treatment should be the first step in addressing Graves orbitopathy. This is typically managed by the Endocrinologist. I-131 and levothyroxine are used to achieve euthyroid status. While exophthalmos generally improves with correction of hyperthyroidism, this is not always the case. Surgical treatment of Graves orbitopathy is generally delayed until both the status of the orbit and the thyroid have stabilized for 6 months.

An exception to this rule occurs in the 1-2% of patients who experience acute deterioration in visual fields or visual acuity secondary to optic neuropathy. These patients may be treated initially with prednisone 80-120 mg/day for 2 weeks. If visual dysfunction does not improve, or prolonged use of steroids is required, then decompression of the orbit is indicated.

Low dose radiation therapy to the orbits represents another non-surgical option. This is NOT appropriate in the acute or subacute setting with associated visual loss because of the early

edema associated with radiation. It is a reasonable alternative for stable Graves orbitopathy, though results are less dramatic. Usually the treatment course requires 200 cGy of fractionated photon radiation over 2 weeks. With this treatment, the condition typically arrests or improves; resolution is rare. In addition one must be very confident that the patient will not require surgery, since orbital decompression and fat manipulation becomes very difficult after the radiation.

Because immune dysregulation is thought to be at the heart of Graves orbitopathy, immunomodulation would seem a logical treatment option. Both cyclophosphamide and cyclosporine have been tried, but long term efficacy has NOT been established.

## **Surgery**

The goal of surgery is to enlarge the confining space of the orbit via removal of 1 to 4 walls of the bony orbit with incision of the periosteum to allow for prolapse of the orbital soft tissues into adjacent spaces. Theoretically, up to 15 mm of decompression can be achieved by removing all 4 walls (usually, surgery results in 3-7 mm of decompression). However, intractable strabismus and hypoglobus can result from excessive decompression.

Patients must be made aware of the risks associated with decompression of the orbit. The most common complication is diplopia. Other potential complications include injury to the optic nerve or retina from prolonged globe retraction. Retrobulbar hematoma – a potential cause of blindness – is also a possibility. Injury to the infraorbital nerve and epistaxis may also occur.

Indications for orbital decompression vary depending on time course. In the acute or subacute phase of the disease, surgery is indicated if steroids fail to improve visual disturbance OR if steroids are required for long-term maintenance of vision. Functional indications for surgery, generally present in the acute or subacute phase, include corneal exposure with keratitis, usually in patients with significant lid retraction. More commonly, functional indications are related to optic neuropathy. This may be manifested by decreased visual acuity, visual field defects, abnormal visual evoked potentials, and disk edema. Patients with optic neuropathy are usually older, usually have LESS proptosis, and usually have a shorter duration of eye disease. Globe prolapse anterior to the eyelids is another early indication.

In the late phase, decompression is generally performed for cosmesis, which is a relative indication. Again, this should occur only after orbital findings have stabilized for approximately 6 months.

In general, the more advanced the exophthalmos, the more extensive the surgery required to produce even a modest improvement. As a result, very few patients are satisfied with the initial surgical procedure.

Needless to say, these patients frequently require more than orbital decompression. Strabismus surgery for the correction of diplopia and lid lengthening for eye lid retraction are common adjunctive procedures. Ideally, orbital decompression is performed first, followed by strabismus surgery and then lid lengthening.

## **Orbital Decompression**

For each of the 4 sides of the orbital aperture a technique has been described for orbital decompression. The name of the surgeon associated with each technique will be placed in parentheses.

### **SUPERIOR ORBITAL DECOMPRESSION (Naffziger)**

This involves complete unroofing of the orbit via a frontal craniotomy. The advantage of this approach is that a very large amount of orbital bone can be removed. Major disadvantages include the need for a craniotomy and the transmission of pulsations from the brain to the globe postoperatively. The problem with pulsations can be overcome by using a titanium shield to support the frontal lobe.

This approach must be performed in conjunction with neurosurgery. The optic nerve must be visualized. The orbital roof is removed from just anterior to the optic foramen anteriorly to the anterosuperior orbital rim. Periosteum must be left intact as bone is removed to prevent injury to the levator muscle. Once the entire superior periosteum has been uncovered, an H-shaped incision may be made in the periosteum to allow herniation of orbital fat into the cranial vault. Titanium mesh can then be secured with self-tapping screws to cover the orbital roof. The cranial flap is then replaced. A temporary tarsorrhaphy should be considered if edema associated with the procedure has caused an immediate worsening of proptosis. Postoperative steroids can be given for 3 days, at which time the tarsorrhaphy can be removed.

This approach is uncommon, but is most frequently used in the setting of orbital trauma.

### **MEDIAL DECOMPRESSION (Sewell)**

This may be approached via a coronal incision, which should be considered for cosmesis, or, more commonly, a standard external ethmoidectomy incision.

After incision, the medial canthal tendon is tagged and divided. The anterior and posterior ethmoid arteries are identified and the anterior artery is ligated with a clip. Beginning at the lacrimal fossa, a complete ethmoidectomy is performed. One must take care not to injure the optic nerve.

When using a coronal incision, the medial canthal tendon is left intact. Ethmoidectomy is performed from above. There is a greater risk to the lacrimal sac and insertion of the trochlea because of the need for wider periosteal undermining for exposure.

Once ethmoidectomy has been completed, the medial periosteum is incised (various incisions have been described) and the orbital fat is allowed to herniate or gently teased into the ethmoidectomy cavity. Great care must be taken to avoid injury to the medial rectus muscle.

### **INFERIOR DECOMPRESSION (Hisch and Urbanek)**

This involves creation of an orbital floor blowout fracture while sparing the infraorbital nerve. The approach involves either a transconjunctival or a subciliary incision plus a Caldwell-

Luc maxillary antrostomy. This allows for visualization of the floor while removing bone via the antrostomy. The bone becomes thicker and denser as the surgeon reaches the posterior extent of the orbit. A total of 3 cm of bone removal from anterior to posterior is usually adequate and safe. Medially, the floor can be removed up to the lacrimal fossa, and laterally to the zygoma.

After incision of the periorbita and decompression of orbital fat, forced duction testing should be performed to ensure that the extraocular muscles are not hindered.

### **LATERAL DECOMPRESSION (Kronlein)**

This was the first technique for orbital decompression described in the literature (Dollinger, 1911). The approach options for this technique include a coronal incision, a direct rim incision (or lateral extension of a subciliary incision), an extended lateral canthotomy, or an upper lid crease incision with extension along a laugh line over the rim. When performed in combination with medial decompression or endoscopic decompression, it is best performed AFTER these techniques.

The orbital contents can be gently retracted medially and protected allowing excellent exposure.

Following incision, the periosteum over the lateral orbital rim is exposed from the reflection of the zygomatic arch to the zygomaticofrontal suture. An incision in the periosteum is made along the length of the lateral rim. The periosteum is then elevated on both the infratemporal fossa side and the orbital side of the lateral rim for 3-3.5 cm posteriorly. The roof and floor of the orbit are also exposed. The lateral canthus is left intact. Leaving the lateral rim intact, as much orbital bone as possible is removed using a cutting burr to excavate the lateral orbital wall while the malleable protects orbital contents. Bone is removed to the level of the lateral periosteum, fascia of the temporalis muscle, and to the dura superiorly until the thick bone of the skull base is encountered posteriorly (a 2.5-3.5 cm diameter circle of bone should be removed). The periorbita is then incised and the orbital fat teased out. Alternatively, the lateral rim can be cut and mobilized on a hinge of periosteum before bone removal, then fixated with a microplate or wire at the conclusion of the procedure.

Of note, CSF leak was the most common complication in one series examining this technique (Graham). This occurred while burring down bone of the greater sphenoid wing with inadvertent penetration of the inner bony cortex and dura. Reportedly, these leaks were easily repaired intraoperatively without recurrence.

### **COMBINED MEDIAL AND INFERIOR DECOMPRESSION (Walsh-Ogura)**

Like the inferior approach mentioned above, this involves a Caldwell-Luc/transantral approach. This was the surgical technique of choice for orbital decompression until the 1990's, at which time endoscopic techniques became more popular.

### **ENDOSCOPIC DECOMPRESSION**

Non-minimally invasive techniques are falling out of favor as the endoscopic approach becomes more prevalent. An endoscopic approach avoids an external incision, benefits from

limited morbidity, allows for excellent access to the optic nerve at the orbital apex when needed, and can be performed under local anesthetic.

The eyes must be included in the surgical field, and are best protected with corneal shields. The procedure begins with a standard uncinectomy. A very large middle meatal antrostomy is created and the 30 degree endoscope should be used to identify the position of the infraorbital nerve in the roof of the maxillary sinus. A total ethmoidectomy is performed, and the sphenoid ostium is identified and enlarged.

The lamina papyracea is then skeletonized, and the position of the anterior and posterior ethmoid arteries is noted. Classically, the middle turbinate is resected to improve exposure for post-operative cleaning (though some authors retain the middle turbinate because it prevents the prolapse of orbital fat from obstructing the sphenoid ostium). Similarly, a small piece of lamina should be retained in the frontal recess area to prevent prolapsing fat from obstructing the frontal sinus. A spoon curette or Freer elevator is then used to crack the lamina papyracea in its thin midportion and a Cottle is used to bluntly elevate bone away from the periorbital taking care to leave the periorbital intact so fat does not herniate into the field of view. Bone should be removed up to the roof of the ethmoid superiorly, the face of the sphenoid posteriorly, the maxillary line (nasolacrimal duct) anteriorly, and the maxillary antrostomy inferiorly.

Finally, bone from the orbital floor is removed medial to V2 with downward pressure using a spoon curette on the remaining bony rim of the maxillary antrostomy. The bone typically fractures along the cleavage plane of the infraorbital canal.

The periorbital is then incised with a sickle knife starting posteriorly, keeping the blade superficial to avoid injury to the extraocular muscles. In fact, a method of placing a “guard” on the sickle knife using a steri-strip to leave 2-3 mm of blade tip has been described. Multiple cuts in the periorbital or complete removal of periorbital should be performed to allow for herniation of orbital fat.

Gentle orbital pressure during this technique encourages the extrusion of orbital fat.

The advantages of this technique are a lack of external incisions and a decreased incidence of oral-antral fistula as compared to the Walsh Ogura technique. However, laterally, decompression of the orbital floor is limited by the infraorbital nerve.

On average, 3.5 mm of exophthalmos can be corrected with the endoscope alone; an average of 5.4 mm can be corrected if this is combined with an open lateral decompression.

Postoperatively, visual acuity and extraocular movement must be checked. Nasal packing must be avoided to prevent compression of the optic nerve. The patient can be discharged to home in less than 24 hours on oral antibiotics and nasal saline irrigation. Post-operative endoscopic cleaning is performed per routine for endoscopic sinus surgery. Nose blowing should be avoided for 2 weeks postoperatively.

Bilateral orbital decompressions, when required, can be done at an interval of 1 week.

## **ORBITAL FAT REMOVAL**

This represents an alternative to traditional orbital decompressive procedures. With this procedure, the preoperative CT scan is helpful in demonstrating the location of orbital fat pockets. These fat pockets can then be approached via an upper lid crease and subciliary or transconjunctival incisions. The orbital septum in both upper and lower eyelids must be opened longitudinally and the fat compartments debulked. Excellent hemostasis must be obtained with the bipolar, and injury to the lacrimal gland in the superolateral quadrant is best avoided. Trauma to the inferior oblique muscle must also be avoided.

As much as 6 mm of proptosis can be corrected with this technique, which correlates with the removal of 5 to 6 ml of fat.

This may be a more useful technique when orbital fat involvement is the major underlying problem as opposed to extraocular muscle involvement or optic neuropathy.

### **Choosing the Appropriate Technique**

For mild (2-3 mm) exophthalmos, any one of the decompression approaches may be used. For moderate exophthalmos (3-5 mm), inferior decompression alone may be sufficient. Alternatively, a combination of medial and lateral decompression may be used. For severe exophthalmos (5-7 mm), 3 wall decompression can be performed.

Again, these external approaches have been largely supplanted by the endoscopic technique with or without lateral decompression.

After healing and stabilization, one may need additional surgery for eyelid retraction. Resection of Muller's muscle may be adequate for slight upper eyelid retraction. For greater retraction, transection of the eyelid retractors with the insertion of cartilage or Gore-Tex grafts to lengthen the eyelids may help.

### **Results and Complications**

The function and cosmesis of approximately 75% of patients stabilize or improve after surgical decompression.

A corneal abrasion is a real possibility during orbital decompression. Most believe the cornea is best protected using a corneal shield. However, some advocate that it is better to leave the cornea exposed with frequent irrigation because a dilating pupil is an important early sign of excessive traction on the globe or optic nerve. (It is important to take frequent breaks while retracting on the globe.)

Retrobulbar hematomas are best avoided by achieving excellent hemostasis with bipolar cautery and placement of a Penrose drain. If it occurs, it is considered an emergency. The skin incision should be opened, the hematoma evacuated, the orbit irrigated, bipolar cautery used for hemostasis, and a drain placed.

Temporary neuropraxia of the infraorbital nerve is common, and may be difficult to avoid

in inferior decompression.

Retinal hemorrhage is a rare complication, and almost always seems to occur in diabetic patients. This complication necessitates ophthalmologic consultation.

Orbital cellulitis is also rare. It may be a good idea to treat those patients with purulent rhinorrhea or other evidence of sinusitis with prophylactic antibiotics preoperatively.

Retinal vascular occlusion (heralded by pain in the eye and/or decreased vision), corneal ulcer, and retrobulbar hematoma represent the 3 major eye emergencies that may occur as a complication of decompressive surgery. At least the first 2 necessitate prompt ophthalmologic consultation. Furthermore, the patient should be instructed at discharge to seek immediate care for increased pain in the eye or decreased vision.

## **Diplopia**

As many as 50% of patients experience some degree of diplopia postoperatively. In fact, some authors contend that virtually all patients undergoing orbital decompression will experience some degree of diplopia at some time during their postoperative course. Preoperative diplopia is often worsened by decompression. Many patients will experience spontaneous resolution of their diplopia once inflammation subsides. Other patients may have diplopia present only on peripheral gaze and do not require any further treatment. But, if significant diplopia is still present 6 to 8 months after decompression, then correction must be performed by ophthalmology. Several modifications have been proposed to avoid diplopia.

One is complete removal of the inferior periorbita when performing inferior decompression. This is thought to prevent fibrosis of the periorbita to the inferior rectus.

Another is orbital lipectomy rather than orbital decompression. Small series have shown that lipectomy alone is unlikely to worsen diplopia, and likely to make it better.

Preservation of a bony orbital strut in the lamina papyracea, though technically difficult, has for several years been thought to play an important role in diplopia prevention.

Decompression confined to the lateral wall rarely causes diplopia.

A “balanced” decompression involving both the medial and lateral orbit is also far less likely to result in diplopia. Along those lines, avoidance of any involvement of the orbital floor is far less likely to result in diplopia.

More recently, Metson has described the orbital sling technique during endoscopic orbital decompression. In this technique, 2 horizontal incisions are made in the medial periorbita that approximate the superior and inferior margins of the medial rectus muscle. These incisions sit approximately 10 mm apart beginning just anterior to the face of the sphenoid and extending all the way to the maxillary line. The remaining periorbita above and below the above mentioned incisions can then be removed to allow for prolapse of orbital fat. Thus, a medial sling of periorbita is left in place to protect the medial rectus muscle. Forced duction with lateral rotation of the globe can be used intraoperatively to confirm the location of the medial rectus before the

periorbital incisions are made. In Metson's series, no patients who underwent the orbital sling technique experienced worsened diplopia. Those patients who had a lateral decompression in addition to the orbital sling were even more likely to experience improvement in diplopia postoperatively.

Another more recently described option is orbital rim advancement, which involves the use of onlay grafts to the bony orbit, rather than decompression of orbital contents, to change the globe-rim relationship. Goldberg reported a series in which onlay grafts (porous polyethylene) were used either in isolation or in combination with orbital decompression. The onlay is typically placed via an inferior transconjunctival approach with suspension of the suborbital orbicularis oculi fat (SOOF) from the implant (a SOOF lift). Using this onlay technique, proptosis decreased an average of 4.65 mm. This technique is most useful in fibrotic, "woody" orbits or when the bony orbits are shallow (e.g., congenitally hypoplastic maxilla).

## **Conclusion**

The most common cause of bilateral exophthalmos is Graves orbitopathy. The presence or severity of Graves orbitopathy does not correlate well with the thyroid status of the patient. Though Graves orbitopathy is a product of autoimmune disease, definitive treatment remains primarily surgical. Treatment of Graves disease and Graves orbitopathy should be multidisciplinary and involve an endocrinologist, an ophthalmologist, and an otolaryngologist.

Preoperative imaging is vital and should include both the orbits and the sinuses.

The current surgical treatment of choice is endoscopic orbital decompression or lateral decompression or both. Every effort should be made to protect the inferior and medial rectus muscles and to minimize the extent of postoperative diplopia, which remains common following orbital decompression.

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