Graves’ disease (GD) is a systemic autoimmune disease that targets the thyroid, orbit and the skin. Despite advances in the treatment of endocrinologic dysfunction associated with GD, few therapies are available for the thyroid eye disease (TED). Recent progress has identified several molecular mediators such as Insulin like growth factor (IGF)-1R auto-antibody, several cytokines and molecular interactions which may be central to both the inflammatory process and deposition of extracellular matrix. Based upon these findings, several therapeutic strategies are likely to emerge in the near future which would specifically interrupt the proinflammatory and profibrotic processes in TED.

The establishment of International Thyroid Eye Disease Study group (ITEDS) marks the commencement of a worldwide effort by thyroid specialists to raise the relevant unanswered questions, design and conduct studies to find the answers, and then direct biological preventive options to thyroid eye disease. We all look forward to an era when we can understand the molecular basis for Graves’ disease, treat it medically, and avoid or reverse the late changes that require surgical correction.

However, until we reach there, surgery will remain an important tool in the management of patients who are unfortunate to get these mechanical and fibrotic sequelae. The surgical rehabilitation of TED has continued to evolve, restoring appearance and function to the patients. Technical and conceptual advances have allowed us to continually improve the results of surgery, using less invasive techniques that decrease complications and speed up recovery.

The Four stages of Surgical Rehabilitation

Surgical management of TED involves four major stages of surgical rehabilitation: orbital decompression, extraocular muscle surgery, eyelid repositioning, and soft tissue volume and redraping. Not all patients require all four stages, but one may require more than one stage of surgery. In this article we shall review the current day conceptual and technical advances in surgical rehabilitation of Graves’ orbitopathy.

Evolution and Paradigm Shifts in Surgery for TED

Paradigm shifts have occurred in the field of indications of decompression, the surgical approaches, and the understanding of ‘congestive’ orbitopathy.

Traditionally, orbital decompression was performed only for extreme proptosis, or compressive optic neuropathy. There has been a gradual evolution in the indications for surgery for orbital decompression.

Today, the indications with respect to proptosis have expanded, and those regarding optic neuropathy have perhaps contracted. It is increasingly common and accepted to perform orbital decompression for cosmetically disfiguring proptosis, rather than just for extreme vision threatening proptosis. Though optic neuropathy responds well to surgery, it is now known that the nerve is resilient, and minor degrees of compressive optic neuropathy are probably
not as emergent as we once thought\textsuperscript{7,8}. Optic neuropathy is now often managed medically with steroids, and surgery can be postponed to the post-inflammatory stage of the disease.

Diplopia is the most disabling side effect of TED, and most difficult to treat. Decreasing the rate of new onset of strabismus is of prime importance\textsuperscript{9-12}.

Earlier, decompression surgery was performed through large incisions and more invasive procedures, with resultant complications such as sinusitis, inferomedial globe displacement, and scarring. Today, advancements in orbital decompression allow new areas of bone removal, realization of orbital fat as the ‘first wall’ for decompression, and the use of smaller incisions.

Another paradigm conceptual change relates to the recognition of the entity of congestive orbitopathy\textsuperscript{4}. Congestive orbitopathy is a result of venous congestion created by the expansion of the orbital soft tissues. This can produce symptoms of pressure, pain, and redness that mimics active inflammation. It is important to identify this entity of congestive orbitopathy, because the symptoms will respond well to orbital decompression.

**The First Stage**

The principle of orbital decompression surgery is to expand the orbital space by expansion of the bony orbit and removal of orbital fat. This decreases the venous congestion, and mechanical pressure on the optic nerve, and also reduces proptosis. Essentially, there are three orbital walls available for decompression: medial, inferior, and lateral wall. Historically, the inferior and medial wall, connecting to the maxillary and ethmoid sinuses, was removed by the otolaryngologists, and the deep lateral wall, connecting to the middle and anterior cranial fossa, was removed by the neurosurgeons. Today, all three walls can be reached via orbital approach by an ophthalmic plastic surgeon trained in orbital surgery. The transantral approach created unbalanced inferomedial decompression with high incidence of consecutive strabismus, numbness, and sinusitis, and hence is performed less often\textsuperscript{13,14}. The medial wall and floor can be accessed through hidden conjunctival incisions, including the transcaruncular incision (Figure 1)\textsuperscript{15-18}.

The deep lateral wall (sphenoid bone) can be accessed through an orbital approach with substantially less morbidity compared to an open craniotomy\textsuperscript{19-23}. Removing bone from the deep lateral wall causes less consecutive strabismus and eliminates the risk of sinusitis.

Removing orbital fat is a major technical change in orbital decompression. Initially, there was a concern that cutting into the intraconal fat could worsen strabismus. It turns out that removing intraconal fat may actually improve double vision, and the technique is effective in reducing congestive orbitopathy, proptosis, and even compressive optic neuropathy\textsuperscript{24}. For many surgeons, removal of intraconal fat is the “first wall” of orbital decompression, and can give approximately 2mm of reduction in proptosis. Each bony wall is added as per the requirement, following a general rule of 1wall= 2mm of proptosis reduction. When 2mm or less of decompression is required, a mere fat decompression via inferior trans-conjunctival route may suffice. For a 2-4mm correction, one bony wall needs to be added (either medial, or lateral). For a 4-6mm correction, a balanced two-wall decompression would be required. Most surgeons prefer the medial and lateral wall in this scenario. For extreme proptosis where the required reduction is >6mm, a three wall decompression is essential (Figure 2&3).

**The Second Stage**

Strabismus surgery has improved over time, with better understanding of the anatomy and physiology of the orbital connective tissue system and pulleys\textsuperscript{25}. Unfortunately, the basic paradigm of repositioning the insertions of the extraocular muscles has remained unchanged for a century, and in severe TED, even a successful strabismus surgery cannot re-create normal fields of binocular vision. Ophthalmologists however are now more aware of associated lower eyelid retraction, and plan to avoid it\textsuperscript{26}.

**The Third Stage**
Eyelid repositioning surgery is the third stage (Figure 4), and has undergone incremental advances, with smaller incisions, trans-conjunctival approach, and fat grafting.\textsuperscript{27-29} Nonsurgical treatment with hyaluronic acid gel may be useful for temporary improvement in some cases.\textsuperscript{30} Overall, the results of eyelid repositioning surgery have always been good, although there is still un-predictability and sometimes more than one stage of surgery is required.\textsuperscript{31}

### The Fourth Stage

The fourth stage of surgical rehabilitation involves soft tissue redraping and procedures to address the esthetic sequelae of Graves’ orbitopathy, which include deep glabellar folds, loss of skin elasticity, and midface contour irregularities. Not only for Graves’ but also for all patients, we are now more aware of the aesthetics of periorbital surgery. For many Graves’ patients, aesthetic surgery involves adding volume into the periorbital hollows, skin treatments to address the chronic loss of skin elasticity and subcutaneous volume, and Botox to relax the glabellar lines.\textsuperscript{32}

### Summary

In summary, the techniques for the surgical rehabilitation of patients with Graves’ orbitopathy continue to improve. We have been able to decrease the incidence of some of the worst complications—particularly, new onset double vision. We can accomplish surgical rehabilitation through smaller incisions and less invasive procedures that hasten postoperative recovery. Less invasive techniques have expanded the indications for decompression, allowing us to operate lesser degrees of proptosis for cosmetic reasons.

Despite these advances, we cannot avoid the fibrotic and structural changes that can be camouflaged and compensated, but not truly cured, by surgery. While we continue to evolve the surgical rehabilitation, we eagerly await path-breaking advances in immunotherapy, which could prevent the fibrotic changes in this disease.

### References

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