THE GRADED LEVATOR HINGE PROCEDURE FOR THE CORRECTION OF UPPER EYELID RETRACTION (AN AMERICAN OPHTHALMOLOGICAL SOCIETY THESIS)

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ABSTRACT

Purpose: Many surgical techniques have been developed to address eyelid retraction with varying results. Identifying and evaluating the anatomical and pathophysiological factors involved will assist in its surgical treatment. This prospective study evaluated the graded levator hinge procedure, in combination with a Müllerectomy and/or lateral canthoplasty when indicated, in an attempt to precisely and selectively target the pathophysiology responsible for the various causes of eyelid retraction in only one surgical session.

Methods: This is a clinical, prospective study of patients with moderate to severe eyelid retraction due to various causes who underwent the graded levator hinge procedure, in combination with a Müllerectomy and/or lateral canthoplasty when indicated. The exact amount of hinging of the levator aponeurosis, and combination with a Müllerectomy and/or lateral canthoplasty, was determined by the clinical operative findings with active cooperation from the conscious patient.

Results: Thirty-two consecutive patients (48 eyelids) with varying degrees of upper eyelid retraction underwent the graded levator hinge procedure in combination with a Müllerectomy and or lateral canthoplasty when indicated. The mean (± standard deviation) preoperative palpebral vertical fissure height was 12.4 mm (±0.45 mm), and the mean postoperative palpebral fissure height was 9.0 mm (±0.20 mm). The mean preoperative asymmetry in the palpebral fissure height was 2.41 (±0.29 mm), and the mean postoperative asymmetry was 0.59 mm (± 0.09), and this difference was statistically significant (P < .001). The mean reduction in the palpebral fissure height was 4.6 mm (±0.29 mm) (range, 1-10 mm). The graded levator hinge procedure in combination with a Müllerectomy and or lateral canthoplasty when indicated, led to a statistically significant (P < .001) reduction in mean palpebral fissure height for all patients, the bilateral subset of patients, the unilateral subset of patients, and the thyroid-related orbitopathy subgroup. The graded levator hinge procedure in combination with a Müllerectomy and/or lateral canthoplasty when indicated led to a statistically significant reduction in palpebral fissure height, asymmetry between the eyes in the total set of patients, the unilateral set of patients, and the thyroid-related orbitopathy subset, but not in the bilaterally operated subset of patients, which were already relatively symmetric preoperatively. Postoperatively 90.6 % of all eyelids were within 1 mm of the desired postoperative level (25% were equal, 68.8% were within 0.5 mm, and 6.2% greater than 1 mm from the desired level).

Conclusions: The graded levator hinge procedure, alone or in combination with a Müllerectomy and/or lateral canthoplasty, is a safe and highly effective surgical approach for the treatment of various causes of upper eyelid retraction. Through consideration of the various anatomical and pathophysiological causes of eyelid retraction, excellent functional and cosmetic results are achieved with a graded procedure tapered to the needs of each individual.


INTRODUCTION

Upper eyelid retraction is a functional and cosmetic disease process that poses a threat to vision and can be psychologically debilitating to patients. Eyelid retraction increases the vertical height of the palpebral fissure and therefore increases the area of exposure of the cornea. This results in increasing ocular discomfort, foreign body sensation, photophobia, epiphora, other symptoms of exposure keratopathy, and alteration in appearance and disfigurement.

Upper eyelid retraction presents a difficult surgical challenge, especially in patients with thyroid-related orbitopathy. Numerous surgical procedures have been devised in attempts to improve the predictability of postoperative results. The evaluation and management of eyelid retraction presents many challenges for the patient and the physician. Procedures for the surgical correction of eyelid retraction should attempt to precisely and selectively target the pathophysiology responsible for the cause of eyelid retraction in each individual patient. This identification and evaluation of the anatomical and pathophysiological factors involved in the development of upper eyelid retraction will assist in the preparation and the performance of the surgical treatment of eyelid retraction. We continue to search for the best techniques available for the management of this disease process.

The driving hypothesis for this study is that the graded levator hinge procedure combined, when indicated, with a Müllerectomy and/or lateral canthoplasty, is determined by the clinical operative findings with active cooperation from the conscious patient, leads to good surgical management of upper lid retraction secondary to diverse physiological and anatomical causes at one surgical setting, decreasing the need to return to the operating room for additional procedures to be performed.

Surgical intervention is usually not undertaken until the inflammatory phase of the inciting cause or disease process has abated, unless vision-threatening problems develop. When surgery is performed in the acute phase of the disease process, it often results in unpredictable eyelid levels, short-lasting results, and occasionally a more complex postoperative course.

Eyelid retraction is the most common ophthalmic feature of thyroid-related orbitopathy, occurring unilaterally or bilaterally in more than 90% of patients at some point in their clinical course.1-3 Retraction of the upper eyelid may cause decreased excursion of the eyelid and lagophthalmos, which may result in exposure keratopathy. The effect of these conditions resulting from eyelid involvement...
range from minor ocular irritation and discomfort to vision-threatening corneal decompensation, potentially resulting in severe vision loss. Exposure keratopathy may lead to foreign body sensation, discomfort, epiphora, keratitis, formation of erosive corneal ulcers, burning, reactive epiphora, photophobia, blurred vision, conjunctival irritation, and decreased visual acuity due to the chronic exposure of the cornea and conjunctiva, laxation of the globe, and cosmetic concerns with the related emotional stress.

In thyroid-related orbitopathy, upper eyelid retraction present in primary gaze is called Dalrymple sign, and an abnormally high upper eyelid in downgaze is called the von Graefe sign or lid lag. Eyelid retraction may be present in patients with or without exophthalmos and results from various mechanisms that act alone or in concert.

In thyroid-related orbitopathy the upper eyelid is more commonly retracted than the lower eyelid, though both may be affected, and the lateral aspect of the upper eyelid is frequently more retracted than the medial aspect. The increased vertical interpalpebral fissure height, with exposure of superior and/or inferior sclera, creates an appearance of staring by the patients. Such a cosmetic appearance is very displeasing to patients and contributes strongly to their search for treatment and intervention. Patients with thyroid-related orbitopathy are very aware of how their facial and ocular facies differ from their former appearance. They generally perceive their new appearance as unsightly, especially if it is asymmetrical. In extreme cases upper eyelid retraction is associated with subluxation of the globe, which is even more disturbing. Eyelid retraction may also give the appearance of an exaggerated amount of exophthalmos present. Thyroid-related orbitopathy is both a disturbing and symptom-promoting disease process that can profoundly impair the quality of life of the affected individual.

Correction of upper eyelid retraction is often necessary to protect the cornea, prevent conjunctival exposure problems, and enhance appearances. Conventional treatment is conservative or surgical. Patients with significant eyelid retraction require lubricating eye drops and ointments for relief of their symptoms of tearing, grittiness, dry eye symptoms, photophobia, and pain.

The surgical treatment of eyelid retraction presents challenging management problems to the surgeon. Although patients frequently attained postoperative reduction in their eyelid retraction with many prior techniques, occasional contour defects and the occasional residual lid retraction, more prominent temporally, led to the search for new or modified techniques for the correction of upper eyelid retraction. The large number of surgical procedures described for the correction of upper eyelid retraction attests to the difficulty of reliably correcting this disease process. In thyroid-related orbitopathy, results are often unpredictable with inconsistent eyelid position and contour abnormalities. Recurrent retraction, overcorrection, and undercorrection are recognized complications of eyelid retraction surgery secondary to thyroid-related orbitopathy. Several operations may be necessary to achieve complete success.

Procedures should address the anatomical and pathophysiological causes of eyelid retraction, especially the diffuse nature of eyelid retraction secondary to thyroid-related orbitopathy, which may involve all layers of the eyelid in varying degrees. Thyroid-related orbitopathy can diffusely affect all layers of the eyelid, including the skin, levator aponeurosis, Müller’s muscle, and the conjunctiva, to result in retraction of the upper eyelid. The cause of upper eyelid retraction is probably multifactorial. A unified theory of the mechanisms involved in the upper eyelid retraction, eyelid position, and movement in patients with thyroid-related orbitopathy will vary from patient to patient, with varying degrees of manifestation in each patient, being unilateral, bilateral, and/or asymmetrical. This is an important consideration in the evaluation and management of each and every patient. An initial inflammation may cause changes in the levator muscle and aponeurosis, Müller’s muscle, and conjunctiva, which may progress to fibrosis and a more restrictive involvement of the retractors, resulting in a tight or fixed retracted eyelid.

Surgery should always be individualized to the patient’s specific anatomical and functional needs, and in thyroid-related orbitopathy there will be varying manifestations of the disease process. The least invasive approach should be selected to reduce complications. Variables that affect the surgical decision-making process include the amount of eyelid retraction, involvement of Müller’s muscle, and the horizontal interpalpebral fissure. Treatment planning should take into account the individualized nature of each patient. Not all patients with thyroid-related orbitopathy eyelid retraction are alike, and a “one size fits all” surgical approach should be discouraged.

In patients with unilateral or highly asymmetric proptosis, orbital decompression with fat removal and/or bone removal should be considered for an optimal functional and aesthetic result. Some patients with thyroid-related orbitopathy are best managed with only eyelid retraction surgery, others will require orbital decompression alone, and others will require a combination of orbital decompression, strabismus surgery, and/or eyelid surgery. The choice of the appropriate procedure or procedures depends on the evaluation of multiple variables and is individualized for each patient. This evaluation will consider the presence of optic neuropathy, degree of proptosis, unilateral or asymmetric proptosis, and pressure pain or sensation.

The prevalence of thyroid-related orbitopathy is fairly significant. It is present in 0.1% of the population and affects women more than men. Thyroid-related orbitopathy causes changes in almost all patients. Approximately 50% have significant eye involvement. Approximately 30% are diagnosed with ocular problems before they are diagnosed with thyroid disease. Approximately 30% are diagnosed with eye and thyroid disease at the same time, and 30% develop ocular symptoms after diagnosis of thyroid disease. Many of these patients have spontaneous improvement of their symptoms after treatment of their thyroid disease.

**PERTINENT EYELID ANATOMY**

The levator aponeurosis originates from the levator palpebrae superioris muscle slightly distal to Whitnall’s ligament. There are medial and lateral horns to the levator aponeurosis, with the lateral horn being both stronger and wider. The insertion site of the levator aponeurosis is to the inferior 7 to 8 mm of the anterior tarsus. Some of the anterior fibers of the levator aponeurosis penetrate the orbicularis oculi muscle and attach to the subcuticular tissue and others to the orbital septum, creating the upper eyelid crease and fold.
Müller’s muscle originates from the levator aponeurosis approximately 15 mm above the superior tarsal border and inserts onto the superior tarsal border. It is firmly attached to the conjunctiva on its posterior surface and is loosely attached to the levator aponeurosis on its anterior surface. The width of Müller’s muscle spans the horizontal dimension of the eyelid.\textsuperscript{13,14}

**DIFFERENTIAL DIAGNOSIS AND CLASSIFICATION OF EYELID RETRACTION**

Retraction of the upper eyelid most frequently occurs as one of the ocular manifestations of thyroid disease but may also occur as a congenital malformation, after trauma to the orbital and periorbital structures, or iatrogenically after eyelid or orbital surgery. Thyroid-related orbitopathy is the most common cause of eyelid retraction. The underlying anatomical defect or changes creating the eyelid retraction vary with each of the causative factors involved. In thyroid-related orbitopathy, a variety of pathophysiologic mechanisms in varying combinations may lead to the retraction. These include inflammatory fibrosis of Müller’s muscle, abnormal sympathetic tone in Müller’s muscle, proptosis, contracture of the inferior rectus muscle with superior rectus hyperactivity, and overmedication with thyroid replacement.\textsuperscript{1,4,7,8,12,15,16}

Eyelid retraction may also result from surgical overcorrection of blepharoptosis or blepharoplasty or both and is due to a shortening of the anterior eyelid lamellae from excessive skin removal or a levator resection that is too extensive. Traumatic cases usually result from cicatrix formation. Cicatricial retraction may develop secondary to trauma or as a sequela to severe inflammation, such as with herpes zoster opthalmicus. Eyelid retraction may be secondary to topical or systemic medications or central nervous system causes.

Eyelid retraction is usually acquired but may be congenital. Congenital cases typically result from neurological causes. Lid retraction may be due to a combination of both anterior and posterior lamellar shortening that results from developmental abnormalities. Congenital eyelid retraction may occur as a rare, isolated entity and may involve the upper, lower, or both eyelids. Primary congenital eyelid retraction is a diagnosis of exclusion. Congenital hyperthyroidism, aberrant innervation of the third cranial nerve, Marcus Gunn (jaw-winking) syndrome, seventh cranial nerve palsy, and orbital tumor must be ruled out.\textsuperscript{12,17,23}

The most frequent cause of acquired upper eyelid retraction is thyroid-related orbitopathy.\textsuperscript{23} Other causes include the following: trauma,\textsuperscript{20} proptosis, enophthalmos with hypoglobus,\textsuperscript{24} midbrain diseases or lesions (Collier sign),\textsuperscript{23} seventh cranial nerve palsy,\textsuperscript{23} posterior commissure brain lesion, congenital defects, high axial myopia, medications (sympathomimetic drugs, corticosteroids), metabolic syndromes (cirrhosis, Cushing syndrome, hypokalemic periodic paralysis, uremia), after ptosis repair and/or blepharoplasty or eyelid reconstruction, trauma (eyelid laceration, orbital floor fractures, inferior rectus disinsertion), trauma repair, long-standing anophthalmos,\textsuperscript{18,23} neurogenic processes (aberrant regeneration of the oculomotor nerve, Marcus Gunn [jaw-winking syndrome], sympathetic overactivity [Claude Bernard syndrome], central nervous system lesions [Parinaud syndrome], facial nerve palsy, pseudoretraction from contralateral ptosis [Hering’s law]),\textsuperscript{8,12,17,23,25} and glaucoma filtering surgery or valve placement with and without the topical application of mitomycin C.\textsuperscript{26}

Iatrogenic causes of eyelid retraction include overcorrection during ptosis surgery, aggressive blepharoplasty surgery, orbital floor fracture repair, retinal detachment surgery with encircling buckles, eyelid tumor resection and reconstruction, excessive vertical superior rectus surgery due to the anatomical connections between the superior rectus and the levator muscle, and postenucleation syndrome.

The multitude of causes of eyelid retraction has been excellently classified and described by Bartley in 1996.\textsuperscript{23} Eyelid retraction is most frequently associated with Graves ophthalmopathy, but there are numerous other causal entities. Bartley reported an evaluation of 44 patients with eyelid retraction and developed a differential diagnosis and classification system comprising three categories: neurogenic, myogenic, and mechanicistic.\textsuperscript{23}

Inflammatory disease, such as that seen with thyroid-related orbitopathy, orbital inflammatory disease, cicatricial conjunctival disease, chronic dermatitis, as well as burns and chemical burns, may cause upper eyelid retraction. Müller’s muscle fibrosis, as seen from irritated and inflamed palpebral conjunctiva, can result in Müller’s muscle inflammation with subsequent fibrosis and eyelid retraction, similar to the mechanism of eyelid retraction in contact lens wearers and patients with embedded hard contact lens.\textsuperscript{25}

Some evidence suggests that thyrotoxicity or overmedication with thyroid supplements can cause upper eyelid retraction. Correction of the thyroid metabolic imbalance alone is occasionally followed by the spontaneous correction of the eyelid malposition. Some state that the acute upper eyelid retraction is secondary to sympathetic stimulation due to circulating catecholamine, but this has not been validated. Numerous studies have demonstrated that the best correlative finding was involvement of the superior striated muscle complex. Increased levels of thyroid hormone and/or inflammation can produce eyelid retraction through increased contraction of the levator muscle.\textsuperscript{8,12,23,27} In the postinflammatory period of thyroid-related orbitopathy, chronic fibrosis or enlargement of the muscle has been postulated to be a cause of eyelid retraction.\textsuperscript{12}

Proptosis may also be a factor causing a pseudo-eyelid retraction.\textsuperscript{28} Exophthalmos with the globe acting as a wedge can accentuate the retraction of the upper and lower eyelid. The tight horizontal tarsal ligamentous band and the eyelid retractors cannot lengthen to accommodate the anteriorly displaced, proptotic globe, which results in further retraction of the upper eyelid.\textsuperscript{27,28} Hypoglobus after orbital decompression is probably secondary to the combined effects of laxity of the suspensory ligament of the globe and loss of support of the globe by the bone and periornitha of the inferior and inferomedial wall.\textsuperscript{24}

Upper eyelid retraction may be associated with levator muscle enlargement.\textsuperscript{29} Inoue and colleagues\textsuperscript{30,31} demonstrated hypertrophy of the levator muscle in 100% of patients with eyelid retraction secondary to thyroid-related orbitopathy with magnetic resonance imaging scans of the orbit. Others found that only 93% of thyroid-related orbitopathy patients with eyelid retraction have hypertrophy of the levator muscle.\textsuperscript{32} Still others state that the enlargement of the superior rectus/levator complex as seen on computed tomography and magnetic resonance imaging does not correlate with the degree of eyelid retraction seen in thyroid-related orbitopathy.\textsuperscript{33}

Patients presenting with only eyelid retraction should also be evaluated for the other major causes as stated above and to rule out...
PATHOGENESIS OF THYROID-RELATED ORBITOPATHY

Thyroid-related orbitopathy activates an autoimmune reaction in the ocular adnexal and orbital structures that results in a variety of ocular signs and symptoms. The specific immune process responsible for thyroid-related orbitopathy remains elusive, and its cause continues to be elucidated. The pathogenesis of thyroid-related orbitopathy involves a combination of cell-mediated and humoral events that promote inflammatory cell migration with coincident production of glycosaminoglycans, which result in orbital edema, thickening of the extraocular muscles, increase in orbital fat volume, and subsequent eyelid retraction.34

Thyroid-related orbitopathy is an autoimmune disorder caused by autoreactive CD4 T lymphocytes that recognize an antigen similar to thyroid and orbital tissue. These infiltrate orbital tissue, extraocular muscles, and levator muscles. The immune-mediated inflammation that is created causes an increased production of glycosaminoglycans in the orbital tissue, edematous enlargement of the extraocular muscles, and an increased volume of the orbital tissue. After the acute phase of thyroid-related orbitopathy, cicatricial formation may result, which can cause irreversible changes in the orbital connective tissue, extraocular muscles, and the levator muscle.35,36

Increased understanding of the biological reactions in the pathogenesis of thyroid-related orbitopathy is allowing researchers to expand current therapies. The immune reaction from thyroid-related orbitopathy results in the accumulation of activated T-cell lymphocytes within the orbital tissues. A variety of cytotoxic TH-1 type cytokine profiles, such as IL-2, interferon-γ, and tumor necrosis factor-α are also released. These cytokine profiles mediate the immune reaction in the orbit. The inflammatory mediators cause lymphatic relaxation and valve incompetence with stasis, vascular dilatation with increased blood flow, and permeability increases in the vasculature that contribute to tissue edema. The cytokines released promote receptor signaling by fibroblasts and cause them to secrete glycosaminoglycans. These accumulate in the tissues and, because they are hydrophilic, result in increased orbital edema. The cytokines also act on the fibroblasts directly, causing collagen synthesis and increased orbital fibrosis.34-39

Chemokines, a subset of the cytokines, act as chemoattractants. Their effect on the receptor sites in the vasculature causes a reorganizing of the direction and polarity of the receptor sites, which attracts activated T cells (mostly monocytes) into the area of inflammation.36 A human monoclonal autoantibody (MAb) to thyroid-stimulating hormone (TSH) receptor has been isolated. The MAb is about 3000 times more active than donor serum IgG in its ability to inhibit TSH binding and stimulate cyclic AMP. This finding could lead to the development of diagnostic and therapeutic agents for patients with thyroid-related orbitopathy and a better understanding of the disorder.39

HISTOPATHOLOGICAL CHANGES IN THYROID-RELATED ORBITOPATHY

The inflammatory processes induced by thyroid-related orbitopathy diffusely affect the orbital, eyelid, facial, and systemic tissues.34,37,38,40 This results in adipocyte proliferation, extracellular matrix deposition, and cicatricial fibrosis within these tissues. Although upper eyelid retraction, the most common clinical feature of thyroid-related orbitopathy,23 is classified clinically as myogenic,23,40 the pathogenesis of thyroid-related orbitopathy suggests that the entire retracted eyelid is diffusely affected by the disease process.

Histopathological changes found in the eyelids of thyroid-related orbitopathy patients are an inflammatory infiltration and fibrous contraction of the eyelid retractors. Müller’s muscle, a sympathetically innervated eyelid retractor of the upper eyelid, is frequently affected by the inflammation and fibrosis of thyroid-related orbitopathy. There can also be a fibrosis of the conjunctival substantia propria as well as Müller’s muscle. Light microscopy, immunohistochemistry, and electron microscopy have demonstrated inflammatory changes with an increase in mast cell infiltration or significant fibrous reaction in the absence of lymphocyte infiltration.34

Müller’s muscle can be involved in the inflammation and fibrosis of thyroid-related orbitopathy. Müller’s muscle is grossly enlarged. There is fibrosis, fatty infiltration, and increased mast cell presence that accompanies focal atrophy of Müller’s muscle. The fibrosis of Müller’s muscle fibers in thyroid-related orbitopathy can range from small focal areas to extensive areas of dense fibrosis. The atrophic Müller’s muscle may be minimally to extensively replaced by adipose tissue. Fatty infiltration of Müller’s muscle does not correlate with increasing age. Müller’s cells are in an actively contracting state on electron microscopy. Müller’s muscle contains elastic afferent receptors that increase levator muscle tone upon stretching. Suppression of Müller’s muscle stretching should decrease levator tone.

The levator muscle in thyroid-related orbitopathy is involved by a fibrosis with coincident collagen proliferation and associated with striated muscle atrophy, fat infiltration, and mast cell infiltration. The levator muscle is often atrophic and partially replaced by fibrous and adipose tissues. Leukocyte common antigen is positive, which indicates the presence of local inflammation in the levator muscle. Again, the degree of clinical retraction in millimeters does not always correlate with the degree of fibrosis, inflammation, or fat infiltration.36
PATHOPHYSIOLOGIC MECHANISMS OF RETRACTION OF THE UPPER EYELID

Retraction of the upper eyelid in thyroid-related orbitopathy does not have a singular pathophysiologic explanation. Thyroid-related orbitopathy can produce a complex abnormality affecting the eyelid, ocular motility, and orbital contents due to lymphocytic infiltration and congestion of the eyelid retractors, extraocular muscles, orbital fat, and other orbital tissues.

During the early stages of thyroid-related orbitopathy, lid retraction may be secondary to a sympathomimetic response, with increased α-adrenergic tone driving Müller’s muscle contractility.4 During the later stages of the disease, there are a number of purposed explanations for eyelid retraction, including proptosis, fibrosis in the superior rectus-levator complex, contraction of the same muscle complex in counteraction to fibrosis in the inferior rectus muscle, overmedication, and increased anxiety level.

Pathophysiologic mechanisms proposed for the cause of upper eyelid retraction in thyroid-related orbitopathy are (1) inflammation due to thyroid-related orbitopathy, which causes adhesions between the levator aponeurosis and/or levator muscle and the surrounding tissues, with resultant fibrosis and contracture of the musculoaponeurotic complexes, secondary sympathetic stimulation, or increased sympathetic tone,3,5,6,13 also causing lid lag on downgaze (von Graefe sign), and (2) contour abnormalities such as lateral or temporal flare due to the adhesions between the lateral horn of the levator aponeurosis and the contiguous orbital tissues.4,34 The degree of clinical retraction in millimeters does not always correlate with the degree of fibrosis, inflammation, or fat infiltration.12

Another mechanism is fixation duress, which results from an overaction of the levator muscle in response to a tight inferior rectus muscle. The innervational forces or increased muscle tone of the eyelid retractors are a contributing cause of upper eyelid retraction. The inflammation and resultant fibrosis of the inferior rectus muscle may cause a hypodeviation of the eye and a compensatory overaction of the superior rectus-levator complex. With inferior rectus restriction, any effort to maintain vertical eye alignment results in overaction of the superior rectus muscle, and because the levator muscle is linked to the superior rectus muscle action, increased innervation of the levator muscle will also occur secondarily. The degree of retraction may be a variable manifestation of sympathetic stimulation.35,36,38 If upper eyelid retraction increases on attempted upgaze and resolves on downgaze, tight inferior rectus muscles are probably contributing to the upper eyelid retraction and should be surgically recessed first, before surgical correction of the eyelid retraction is entertained.

Eyelid retraction may be the result of abnormal adhesions formed by the inflammation between the levator aponeurosis and/or levator muscle and surrounding tissues. Grove41 noted abnormal adhesions between the levator muscle and surrounding orbital tissues, as well as fatty infiltration of the levator and Müller’s muscle, as contributing to the etiology of eyelid retraction. Also found are levator muscle contraction and fibrosis; abnormal adhesions between the levator muscle and orbital connective tissue, septum, lacrimal gland and fat13; and levator muscle hypertrophy.5,6,29,36,39,42 Inflammation and fibrosis also cause contracture of the levator aponeurosis and Müller’s muscle, causing lid retraction. This contracture can also involve the recti muscle, causing contracture of the inferior rectus muscle and, as noted above, increased tone and overaction of the synergistic superior rectus and levator muscles,6 especially upon fixation with the hypertropic eye, and promote increased retraction and temporal flare. Histopathological evaluation and magnetic resonance imaging studies have shown upper eyelid retraction to be associated with levator muscle enlargement.39,40 There has been no correlation shown between the amount of eyelid retraction and the amount of enlargement of the levator/superior rectus complex.4,39 Enlargement of these muscle groups may lead to restriction of motion and lid lag.

Another theory is hyperactivity or increased sympathetic tone or drive to the Müller’s and the levator muscles,6 which contributes to or is causal in upper eyelid retraction in thyroid-related orbitopathy. This increased sympathetic tone causes overaction of Müller’s muscle. This may or may not improve upon treatment of clinical hyperthyroidism and normalization of thyroid hormone levels.38 Patients with acute thyroid-related orbitopathy may have unilateral or bilateral eyelid retraction caused by an increased sympathetic tone in Müller’s muscle. As the acute involvement resolves, eyelid retraction also resolves in many patients. In other patients, the eyelid retraction becomes chronic. The cause of this chronic eyelid retraction remains elusive but may be secondary to involvement of the levator muscle and/or Müller’s muscle.41,43 Müller’s muscle overaction plays a role in the retraction of the upper eyelid in thyroid-related orbitopathy, since the sympatholytic drugs guanethidine,44 bethanidine,45 and thymoxamine46 can decrease retraction. These topical medications generally are not suited for long-term use because of their locally irritating side effects.16 Proptosis contributes to the eyelid retraction and exposure. As orbital volume increases, the globes push forward against the constraint of the lids. The eyelids retract back over the globes, which serve as a wedge and increase the palpebral fissure.

Weakness of the antagonist protractor muscle, the orbicularis oculi, may also contribute to retraction of the upper eyelid. Frueh and colleagues10 found the posterior force generated by the eyelid protractors to be significantly lower in patients with thyroid-related orbitopathy than in normal control subjects. This results from orbicularis atrophy that is secondary to chronic eyelid inflammation.

In summary, the exact mechanism of thyroid-related orbitopathy eyelid retraction remains unclear but is likely a multifactorial process, with varying manifestations in each patient, and secondary to combinations of the above mechanisms. Further research is needed to determine its underlying causes and how this phenomenon is affected by surgery.

TEMPORAL FLARE

Eyelid retraction induced by thyroid-related orbitopathy can cause several abnormalities of the eyelid.32 Increased retraction of the lateral aspect of the eyelid is an important finding that should be specifically addressed during surgery. Enhanced lateral retraction may be secondary to a contour abnormality highly specific for thyroid-related orbitopathy47,48 or may have an anatomical origin, which may be associated with the various causes of eyelid retraction.

The etiology of temporal flare or accentuated lateral retraction is probably multifactorial. Temporal flare in thyroid-related orbitopathy retraction of the upper eyelid has several anatomical explanations, and it may also result from contribution of
innervational forces. The results of inflammation, resultant adhesions, and fibrosis clearly affect the lateral horn of the levator aponeurosis.\textsuperscript{31,42,49} The lateral horn of the levator aponeurosis is much stronger than the medial horn, and its insertion through the lateral orbital retinaculum at the lateral orbital tubercle is much more defined than its medical insertion. The lateral fibers of the muscular portion of the levator muscle, proximal to Whitnall’s ligament, blend with the superior transverse ligament as it courses to the lateral orbital attachment, exerting a strong pull on the lateral aspect of the eyelid through the aponeurosis, the suspensory ligament of the fornix, and the conjunctiva.\textsuperscript{13,28}

Müller’s muscle, an involuntary muscle, may develop overreaction or be enlarged secondary to a direct inflammatory infiltrate in thyroid-related orbitopathy. An involved Müller’s muscle, with its substantial lateral extensions, contributes to and may cause more temporal flare than in those patients with thyroid-related orbitopathy but without this muscle involvement.\textsuperscript{42,47} Grove\textsuperscript{50} reported in 1980 that a fibrosis in the lacrimal gland and adjacent lateral levator aponeurosis leads to greater lateral eyelid retractor shortening along the lateral axis.

Van den Bosch and colleagues\textsuperscript{51} demonstrated that eyelid position was directly affected by the position of the globe. Lemke\textsuperscript{28,40,52} provided an anatomical explanation, in that the forces that govern position of the upper eyelid are understandably affected by variations in orbital size and shape, globe size and position, and the length-tension characteristics of the eyelid structures. In primary position, the eye must adduct away from the axial projection of the orbit and, in doing so, expose more lateral sclera. This retraction is accentuated by axial propotasis and causes an enhanced lateral upper eyelid retraction due to shortened or fibrotic retractors. The greatest effect is on the portion of the eyelid farthest beyond the plane of the anterior entrance to the orbit. In primary position the eye looks medially away from the orbital axis and projects more lateral sclera, increasing the lateral retraction.

**HISTORY OF THE SURGICAL TREATMENT OF EYELID RETRACTION**

The primary indication for the surgical correction of upper eyelid retraction is to produce a functional eyelid that protects the globe and vision, which may also secondarily improve the cosmetic appearance. Correction should be directed toward the underlying cause. The location of scarring or pathologic changes within the eyelid should be determined; it may be in the anterior or posterior lamella or both.

The numerous and varied surgical techniques employed for the correction of upper eyelid retraction are indicative of the difficulty in both treating this disease process and identifying the best interventional procedure. The ideal procedure should yield the desired postoperative eyelid level while maintaining or creating a normal contour, eyelid crease, and fold while maintaining lid function, and should have a predictable and reliable technical approach, preferably under local anesthesia.

A variety of procedures have been proposed as surgical treatment for the correction of eyelid retraction. Most of these procedures involve alterations in the levator aponeurosis, levator muscle, and/or Müller’s muscle (recession, lengthening, excision, or transposition of the eyelid retractors), which weakens or lengthens the upper eyelid retractors, alone or in varying combinations.\textsuperscript{53-56} Many techniques reported a higher incidence of postoperative residual temporal flare or flattening of the central eyelid contour, leading to a lack of predictability with inconsistent postoperative eyelid positions, overcorrections, and undercorrections. The need for reoperations indicated that the primary operation did not restore the eyelid to a normal position, and the number of such procedures is an index of the effectiveness of a surgical technique. Clearly, the predictability of the final eyelid height and contour of the eyelid after the surgical correction of eyelid retraction is challenging.

Many excellent techniques have been developed for the correction of upper eyelid retraction via two basic approaches: through the conjunctiva or through the skin. Various techniques have been developed within each of these two approaches. Retraction of the upper eyelid (in thyroid-related orbitopathy) has been recognized since the 19th century, and today there is still no agreement on its cause or a definite treatment plan. Early attempts to correct upper eyelid retraction were various types of tarsorrhaphy. Upper eyelid retraction can be corrected by excising or recession Müller’s muscle from an anterior or posterior approach\textsuperscript{12,43,49,57-61}; recessing the levator aponeurosis, with or without hang-back sutures\textsuperscript{2,20,58}, performing a measured myotomy of the levator muscle\textsuperscript{41,50,62}; inserting a spacer (autologous and banked fascia lata, donor sclera, ear cartilage, tarsus, processed collagen, Gortex, or alloplastic material) between the distal end of the levator and the tarsus\textsuperscript{12,49,58,65}; placement of Müller’s muscle, conjunctiva, and tarsus harvested from the fellow eyelid during the correction of ptosis or the pedicle tarsal rotation flap.\textsuperscript{64} Some of these spacer materials cause lid thickening, cyst formation, and variable and often unpredictable absorption and have the potential to transmit prion or other infectious diseases. Basically, these techniques are all variations on the theme of weakening or lengthening of the upper eyelid retractors.

In 1934 Goldstein\textsuperscript{65} reported a technique of recession a 1-mm strip of tarsus along with the levator aponeurosis and Müller’s muscle, freeing up all the muscle and aponeurotic attachments, from either an anterior or a posterior approach. The von Blaskovics and Kettesy technique involved severing the levator aponeurosis and probably Müller’s muscle from the superior tarsal border and retracting it with 3 sutures. For patients with more than 2 to 3 mm of retraction, the levator was dissected free from the skin and orbicularis, which allowed it to retract freely.

In 1956 Moran\textsuperscript{66} reported his procedure for lid retraction, in which an incision was made through the levator aponeurosis and Müller’s muscle horizontally, varying the length of the incision to achieve a functional result measured by having the patient open and close the eyelids.

In 1965 Henderson\textsuperscript{67} published a review of the literature regarding the surgical treatment of upper eyelid retraction. He reported that the early surgical treatment of upper eyelid retraction was mainly various types of tarsorrhaphy. Moran\textsuperscript{66} was one of the first to describe a combined myotomy of the levator aponeurosis and Müller’s muscle under local anesthesia. Henderson described a graded Müller’s muscle and levator aponeurosis excision by a posterior approach, and many surgical variations of this technique have been described since. His modification of other procedures\textsuperscript{60,66} for the treatment of eyelid retraction secondary to thyroid-related orbitopathy.
orbitopathy was the use of a partial-thickness posterior blepharoplasty approach, with a Müller’s muscle myotomy for mild or moderate retraction of 2 to 3 mm, and additional graded division of the levator aponeurosis for more severe retraction. The procedures were fast, with a low incidence of overcorrections, but undercorrections and temporal flare were quite common, limiting effectiveness to patients with mild retraction and limited temporal flare.

In 1972 Putterman and colleagues reported an internal, graded excision of Müller’s muscle, with or without recession of the levator aponeurosis depending on the amount of correction required, and with these adjustments made intraoperatively by monitoring the response with the patients sitting up. Their variation was an attempt to improve on the unsatisfactory results that they had obtained with other techniques. They further modified their technique to only the lateral two-thirds of Müller’s muscle in the myectomy to prevent nasal overcorrection and ptosis.

Baylis and colleagues in 1976 reported for various causes of retraction a transconjunctival Müllerectomy for small amounts of retraction and a transcutaneouslevator aponeurosis recession for larger amounts of retraction. They reported their results for 10 cases of eyelid retraction, 12 eyelids with 7 excellent results (eyelids equal levels), 3 undercorrections, and 2 overcorrections.

In 1980 Grove reported a procedure that addressed the inflammatory changes contributing to lid retraction through adhesions of the subcutaneous tissues to the levator aponeurosis. He developed a marginal myotomy as a means to weaken the levator muscle and free the adhesions. Pathology demonstrated collagen proliferation, striated muscle fiber atrophy, and fatty infiltration of the associated tissues.

In 1981 Harvey and Anderson were among the early surgeons to describe aponeurotic surgery for the treatment of upper eyelid retraction. Later, others described surgical techniques of weakening and/or lengthening both the levator aponeurosis and Müller’s muscle, myotomies, the placement of various spacers, tarsal rotational flaps, adjustable sutures, and aponeurosis lengthening procedures. In 1965 Callahan reported the use of pretarsal orbicularis or collagen film as a spacer for recession of the levator aponeurosis.

Harvey and Anderson reported in 1981 their modification with an anterior approach for upper lid retraction through recession of the levator aponeurosis and Müller’s muscle extirpation, and severance of the lateral horn of the levator aponeurosis to correct for temporal flare. They also performed adjustment of the eyelid height and contour intraoperatively. In 1982 Dixon reported his results of a Müllerectomy for the treatment of thyroid-related orbitopathy eyelid retraction.

In 1983 Kohn reported his technique of recessing the levator aponeurosis beyond the tarsal border, maintaining an attachment to the tarsus by two pedicle tarsal rotation flaps. Kohn reported the treatment of 4 retracted upper eyelids, 2 eyelids retracted secondary to overcorrected blepharoptosis surgery and 2 eyelids secondary to thyroid-related orbitopathy. Retraction and scleral show were eliminated in the primary position in all cases, with a 5- to 15 month follow-up period. Retraction improvement ranged from 3.5 to 4.5 mm for the 4 upper eyelids.

Hurwitz and Rodgers reported their techniques in 1983 of the use of a Müllerectomy for mild retraction, a Müllerectomy combined with levator aponeurosis weakening for moderate retraction, and either Müllerectomy and levator aponeurectomy or scleral graft implantation for severe retraction.

In 1986 Putterman and Fett reported a graded, controlled excision of Müller’s muscle with or without recession of the levator aponeurosis for the treatment of eyelid retraction secondary to thyroid-related orbitopathy in 197 eyelids. Ninety-five percent of the eyelids achieved a lid level within 1.5 mm of the opposite side. Three percent were within 2 mm from the opposite side, and 2% were within 3 mm. Seven eyelids required additional surgery for residual retraction or ptosis. In 1986 Putterman and Fett also reported a series of patients receiving their graded Müllerectomy operation, in which 112 of 156 (71.8%) achieved postoperative results within 1 mm of the desired level and 95% were within 1.5 mm of the level of the opposite eyelid.

In 1989 Downes and Jordan reported the use of Mersilene mesh as a spacer for the treatment of upper eyelid retraction secondary to thyroid-related orbitopathy in 4 upper eyelids. They report that the 4 patients were within 1 mm of the superior limbus, and only one had significant lateral peaking, which required a second operation.

In 1991 Levine and Chu reported an anterior approach, which incorporated a levator aponeurotic/Müller’s muscle recession with preservation of the normal orbital septum and levator aponeurosis anatomy. The levator aponeurosis, Müller’s muscle, and the orbital septum were resected together as a unit. No Müller’s muscle was excised. In a review of 15 consecutive patients they reported a success rate in 87% of cases, which were within 1 mm or less of the fellow eyelid and with a marginal reflex distance as close to 4 mm as possible. Nine of the 15 patients had excellent symmetrical lid position, 4 had minimal asymmetry (ranging from 0.5 mm to 1 mm), and only one case was overcorrected with 3.5 mm of asymmetry.

In 1991 Older reported a technique of recessing the levator aponeurosis and Müller’s muscle through a lid crease incision. No spacers or traction sutures were used, and the recessed muscles were not sutured to any of the surrounding tissues. There were no overcorrections or undercorrections in the 22 eyelids of 15 patients.

After recessing the levator aponeurosis and Müller’s muscle complex, some surgeons leave this unsutured, or it can be sutured to adjacent structures. Harvey and colleagues loosely attached the recessed levator and Müller’s muscle complex to the superior tarsal border with two or three 6-0 polyglactin sutures tied in a “hand-loose” technique. Some attached the recessed levator to the conjunctiva with absorbable sutures. Levine and Chu place three double-armed 5-0 chromic sutures through the recessed levator aponeurosis and Müller’s muscle and brought these sutures through the pretarsal orbicularis and skin.

In 1995 Ceisler and colleagues reported a surgical technique that consisted of a Müllerectomy and recession of the levator aponeurosis combined with a medial transposition of the lateral horn of the levator aponeurosis, which they attached to Müller’s muscle in a graded fashion. They proposed that the incision through Müller’s muscle near its origin partially denervates the muscle and augments the upper eyelid recession. Müller’s muscle was used as an autogenous spacer to set the eyelid height. Transposition of
the levator aponeurosis allowed for the adjustment of the eyelid contour. They achieved success in 58 of 72 patients (81%) and excellent results with the eyelid margin above the pupil and 1 mm or more below the upper limbus, and with less than 1.5 mm asymmetry. The procedure was performed on 37 patients (72 eyelids), with 30 patients (58 eyelids) having excellent results, 6 patients (13 eyelids) having good results, and 1 patient (1 eyelid) having a poor result. None of the patients required reoperation for asymmetry, unacceptable contour, or malposition. Only one eyelid had a significant overcorrection, and only one eyelid had significant undercorrection, both of which required further surgery. Their most frequent unwanted postoperative results were a high eyelid crease seen in 24 eyelids and residual temporal flare in 6 eyelids.

Tucker and Collin reported their retrospective experience in 1995 comparing adjustable and nonadjustable suture techniques for the treatment of eyelid retraction, including cases of non-thyroid-related orbitopathy eyelid retraction. They obtained good results in 10 (77%) of 13 eyelids using adjustable sutures, compared with 56 (38%) of 148 using nonadjustable suture technique. They describe good results as the postoperative eyelid level within 1 mm to 2 mm below the upper limbus, within 1 mm of the other side for unilateral procedures, and a good eyelid contour. They noted that with nonadjustable sutures, good results were achieved more often for nonthyroid patients compared with eyelid retraction secondary to thyroid-related orbitopathy (26 of 55 vs 31 of 93 eyelids, respectively).

In 1995, Small reported his experiences in 100 patients (181 eyelids) over a 15-year period comparing the results of 3 techniques for the treatment of upper eyelid retraction secondary to various causes. The procedures were pre-Whitnall levator recession with an adjustable suture, recession of the levator aponeurosis (half with adjustable sutures and the other half without adjustable sutures), and the Henderson operation (recession of the conjunctiva and Müller’s muscle, and if further recession was needed, dissection of the levator aponeurosis from its tarsal attachments). The overall reoperation rate was 23%. Of the 100 patients, he reported excellent results in 60, good in 28, and fair in 7. Five patients were not rated. Unfortunately, the criteria or requirements for excellent, good, and fair were not described. A tarsorrhaphy was required in 12 patients for temporal undercorrections.

In 1999, Lemke and Khwarg reported the technique of lateral canthal advancement as an adjunct to retractor recession in the correction of eyelid retraction secondary to thyroid-related orbitopathy, when horizontal tightness of the eyelid was present. They proposed that the tight horizontal tarsal ligamentous band cannot lengthen to accommodate an increasingly exophthalmic globe in thyroid-related orbitopathy, leading to an increased exposure of the lateral sclera and accentuating the temporal flare. Addition of a lateral canthal advancement to the retractor recession was effective in enhancing the impact of retractor recession and in reducing temporal flare.

Khan and colleagues in 2002 reported a similar technique to the graded levator hinge procedure, where they disinserted the distal levator aponeurosis, and the lateral three-fifths of the distal aponeurosis was developed into a flap and rotated inferiorly 90 degrees, before attaching it to the tarsal plate and excising Müller’s muscle. They reported that only 67% of eyelids (8 of 12) had a successful eyelid height, and the final symmetry between eyelids was good in 90% (9 of 10 eyelids).

There are differences between the Khan technique and the surgical procedures described in this thesis. Our procedures were initially performed in 1995, 7 years prior to Khan’s publication. With our technique, a graded hinge or flap of varying length of the levator aponeurosis was developed, depending on the amount of vertical lengthening desired determined with the patient’s cooperation, not just the lateral three-fifths for all patients; a Müllerectomy was performed only if clinical involvement was noted during the surgical procedure, and a lateral canthoplasty was performed if indicated.

Fenton and Kemp in 2002 reported their results with the use of Mersilene mesh and polyglactin mesh for the treatment of eyelid retraction secondary to various causes in 48 patients (79 eyelids). If more than 3 mm of lid retraction was present, they placed a spacer material between the tarsus and the inferior edge of the levator aponeurosis, with the vertical length of the spacer twice the amount of preoperative scleral show laterally and one-and-a-half times the show centrally. Initially the spacer material was Mersilene, and later it was changed to polyglactin mesh. They noted an extrusion of the Mersilene mesh in 20% of cases, which eroded through the conjunctiva. A good result, described as a palpebral aperture of 10 mm, symmetry between the 2 upper lids, and an acceptable lid contour, was achieved in 80% of satisfied patients with one procedure. In 10% of cases there was undercorrection, and in 8% of cases there was overcorrection.

In 2002 Chung-Sheng Lai and associates reported their technique of an orbital septal flap that was interposed between the recessed levator complex and the tarsus to correct upper eyelid retraction. They reported one patient without preoperative or postoperative measurements, only stating that the final result 1 year later was quite satisfactory. Obviously, it is difficult to objectively evaluate the outcomes of such a surgical approach with only a single patient. No other studies have followed up on this report.

In 2004 McNab and colleagues reported a technique of lengthening the levator muscle at the level of the superior transverse orbital (Whitnall’s) ligament and then, after division of the muscle belly, a technique of a graded hang-back sutures. This technique was performed on 38 eyelids of 21 patients. The mean preoperative eyelid retraction was 4.7 mm (range, 3-8 mm). Thirty-two eyelids (84%) were within 1 mm of the desired postoperative position. One patient (2 eyelids) required reoperation for significant undercorrection, and another 4 patients (5 eyelids) required ptosis repairs for overcorrection. One eyelid required medial contour repair, but none required lateral contour correction.

In 2004 Elner and colleagues reported their results on 50 retracted eyelids of 32 patients with a transcunicatus, graded blepharotomies technique as developed by Leo Koornneef. Their technique describes a full-thickness blepharotomy that includes the skin, orbicularis muscle, levator aponeurosis, Müller muscle, and the conjunctiva, irrespective of the amount of eyelid retraction. The incision is initiated at the junction of the lateral and central thirds of the eyelid and cut medially and laterally in a graded manner until an eyelid height of 2 to 4 mm was obtained in the sitting position. If there was temporal flare, the lateral horn of the levator aponeurosis was also incised. More than 90% of preoperative symptoms resolved or improved, and upper eyelid position,
Eyelid retraction in 256 patients. The eyelid retraction responded in 85% of thyroid-related orbitopathy patients, but in only 67% of the cases secondary to iatrogenic or traumatic causes. None of the patients developed an overt reaction to the solution. Only 15.5% developed conjunctival injection, 1.5% lid erythema, 17.2% tolerable smarting, 2.9% tearing, and 2.1% complained of ocular pain.

**MANAGEMENT OF THYROID-RELATED ORBITOPATHY PATIENTS**

The management of thyroid-related orbitopathy is a long-term process with each patient, given a condition that has numerous ramifications over a period of months to years. Some of these patients may develop such severe thyroid-related orbitopathy that extreme measures are required to save vision, such as high-dose systemic steroids, orbital decompression, orbital injections of agents—guanethidine, produced the best results, but their long-term use was limited by the local ocular toxicity and the transient and variable efficacy. Guanethidine, a topical sympatholytic that causes depletion of neuronal noradrenaline, has been used in the management of eyelid retraction secondary to thyroid-related orbitopathy, but its use has been limited owing to the variable efficacy and the frequent development of irritation, hyperemia, photophobia, pain, edema, burning, and punctate keratitis.

Haddad in 1995 reported the effect of topical guanethidine sulfate solution (5% to 10% weight/volume) for the treatment of eyelid retraction in 256 patients. The eyelid retraction responded in 85% of thyroid-related orbitopathy patients, but in only 67% of the cases secondary to iatrogenic or traumatic causes. None of the patients developed an overt reaction to the solution. Only 15.5% developed conjunctival injection, 1.5% lid erythema, 17.2% tolerable smarting, 2.9% tearing, and 2.1% complained of ocular pain.

** Levator Hinge Procedure And Upper Eyelid Retraction **

The evaluation and treatment of thyroid-related orbitopathy may require one or multiple stages of surgery, depending on the severity and manifestation of the disease process. Each stage will affect the decision making for subsequent stages, and therefore the surgery should be staged in a specific sequence, with orbital decompression, then strabismus surgery if indicated, and finally eyelid repositioning and removal of excess fat and skin. Any of the stages may be skipped when deemed unnecessary or not indicated, but maintaining the correct order reduces the number of procedures to a minimum. Orbital decompression can result in a change in the extraocular muscle position and function relative to the globe, displacement of the muscle cone, and alteration of the muscle pulley system, which may result in postoperative phorias or diplopia. Since postoperative primary gaze diplopia can occur in 0% to 70% of cases after orbital decompression surgery, strabismus surgery and then eyelid surgery should be postponed until after complete recovery from the previously staged surgeries. The contour of the upper eyelids can develop a relatively straight appearance after recession of the upper eyelid. This may be secondary to hypoglobus, which may develop after an orbital decompression, and a relative higher position of the lateral canthal angle. Recession or resection of the vertical extraocular muscles for the correction of hypertrophia, especially large deviations, may increase the retraction of the eyelids secondary to alterations of the anatomical connectivity between the retractor complex and the vertical extraocular muscles. This is avoidable by careful and meticulous dissection of the extraocular muscles. Orbital decompression can also change the position of the eyelids.

Some patients with thyroid-related orbitopathy are best managed with only eyelid retraction surgery, whereas others will require orbital decompression alone, and others will require a combination of orbital, strabismus, and eyelid surgery. The choice of the appropriate procedure or procedures depends on the evaluation of multiple variables and is individualized for each patient.

The patient’s evaluation should consider the presence of optic neuropathy, degree of proptosis, unilateral or asymmetric proptosis, and the presence of pressure pain or sensation. In patients with unilateral or highly asymmetric proptosis, orbital decompression with fat removal and/or bone removal should be considered for an optimal functional and cosmetically aesthetic result. In thyroid-related orbitopathy, proptosis and eyelid retraction commonly coexist, and the proptosis may mimic findings of eyelid retraction. These conditions must be differentiated preoperatively by careful eyelid measurements and exophthalmometry evaluations.
Many advocate treating eyelid retraction as a separate-stage procedure after orbital decompression and eye muscle surgery because of the possible difficulties in the estimation of true retraction in cases of a prominent globe or displaced eye in the horizontal or vertical plane. Once the ocular muscles have stabilized, and the eyes have achieved their best alignment, at least in the primary and downgaze areas, surgical correction of any asymmetry of the eyelids or eyelid retraction may be entertained, but accurate evaluation of eyelid retraction can be made only if the eye is in an orthotropic position. Neurogenic overstimulation of the levator muscle secondary to fibrosis of the inferior rectus muscle may falsely increase the retraction of the upper eyelid. A large recession of the inferior rectus muscle may increase retraction of the lower eyelid and decrease retraction of the upper eyelid.

The active orbital inflammatory process in thyroid-related orbitopathy can last from months to over 5 years. Eyelid retraction will respond in 50% of patients who are rendered euthyroid, but the rest may develop a permanent retraction of the eyelids.\textsuperscript{109} Definitive surgery should be delayed until the disease process has stabilized.

Chang and colleagues\textsuperscript{110} demonstrated that reducing axial proptosis with orbital decompression surgery produced a reduction in the palpebral fissure surface area, with an average reduction of 1.71 mm in the vertical height of the palpebral fissure and an average reduction of 56.2 mm in the palpebral fissure surface area, with coincident improvement of the temporal flare. Therefore, they recommend that decompression surgery should be considered before any other lid surgery in the rehabilitation of patients with thyroid-related orbitopathy.

**METHODS**

A prospective clinical trial was undertaken using a graded levator hinge procedure in all patients, combined with a Müllerectomy, when indicated, and/or lateral canthoplasty when indicated, in cases of upper eyelid retraction secondary to the various causes. Patients with eyelid retraction secondary to skin contracture or anterior lamellar disease, which required treatment with a skin graft, were omitted from this series. The procedures were performed on 48 eyelids of 32 consecutive patients with eyelid retraction. These are consecutive patients undergoing the graded levator hinge procedure in a private practice setting. There was no prior effort to conduct a power analysis to estimate the numbers of patients needed to achieve solid statistical inferences. An institutional review board (IRB) was contacted, and since the graded levator hinge procedure did not require the use of foreign material, grafts, donor tissue, and so on, and these procedures are modifications of currently accepted techniques of lid reconstruction, IRB approval was not required.

**PATIENT EVALUATION AND MEASURES**

It is important to perform eyelid retraction surgery in thyroid-related orbitopathy patients when the systemic as well as ocular status is in a quiescent state. Otherwise, the underlying disease process may continue and compromise the long-term surgical results. The systemic thyroid status, ocular examination, and especially eyelid examination and measurements should be stable for 6 to 12 months, unless severe corneal exposure problems necessitate earlier intervention.

Preoperatively all patients with ocular and systemic conditions should be stable for at least 6 months. In all patients with thyroid-related orbitopathy, the condition of the thyroid axis was stable systemically, with clinically euthyroid status and normal levels of triiodothyronine, thyroxine, and thyrotropin. There was no change in medical therapy for at least 6 months prior to surgical intervention. In all patients the ophthalmologic condition was also stable, with reproducible upper eyelid retraction measurements and ophthalmic examinations. Indications for surgery included upper eyelid retraction with symptomatic exposure keratopathy, epiphora, burning, foreign body sensation, and lagophthalmos. Surgical intervention should be delayed for at least 6 months to ensure that the amount of retraction is stable. The exceptions are patients with severe eyelid retraction combined with marked corneal involvement or corneal ulceration, who must have the procedure as an emergency to prevent further corneal compromise or perforation.

All patients were fully evaluated preoperatively with a complete ophthalmic examination. Slit-lamp biomicroscopy was used to evaluate the presence and severity of exposure keratopathy. Where there is moderate to significant inferior rectus muscle restriction that contributes to upper eyelid retraction, the inferior rectus muscles should be initially addressed and recessed when indicated and the residual upper eyelid retraction treated subsequently as indicated. Inferior rectus muscle restriction is noted when the eyelid retraction increases on attempted upgaze and decreases or disappears in downgaze, fixation duress. Three of the 32 patients required prior strabismus surgery (patients 9, 14, and 23 in Table 1), and surgical treatment of their eyelid retraction was not considered for at least 6 to 9 months after their strabismus surgery.

Palpebral fissure and levator function of all patients was measured with a millimeter ruler. Great care is taken to maintain the ruler perpendicular to the line of gaze, to ensure that the patient maintains exact primary gaze, and with the examiner sitting at eye level relative to the patient. Patients were instructed to relax their eyebrows and eyelids during clinical examination and measurement procedures. The amount of eyelid retraction is assessed quantitatively in each eye individually as fixation is maintained. Vertical phoria and tropia are coincidentally assessed. This allows one to differentiate between upper eyelid retraction secondary to levator muscle fibrosis and adhesions from fixation duress. Measurement of central palpebral fissure height in primary gaze is taken as the distance from the central lower eyelid margin to central upper eyelid margin in millimeters; that is, palpebral fissure height is the maximum distance between the eyelid margins. All patients underwent at least 3 preoperative and postoperative measurements by the same observer. Measurements were rounded to the nearest 0.5 mm, and the mean value was tabulated. This established and clinically acceptable measurement technique leads to acceptable interobserver and intraobserver measurement variabilities.\textsuperscript{111} The preoperative and postoperative measurements, as well as surgeries, were performed by only one observer.

Care was taken with all preoperative and postoperative measurements, since subtle and possible undetected motility restrictions
may affect the upper eyelid in primary gaze and may cause a variable upper eyelid resting position in patients with thyroid-related orbitopathy. The measurement of the palpebral fissure height avoids inaccurate evaluation of palpebral aperture height secondary to deviation of ocular alignment. Only the central vertical height is measured—the distance from the lower eyelid margin to the upper eyelid margin—and the medial and lateral aspects of the palpebral fissure were not quantified. Palpebral fissure measurements can be used reasonably to approximate upper eyelid position in primary gaze, provided that there is no change in the lower eyelid position from preoperative to postoperative measurements. None of the patients had any surgical procedure that would affect the height of the lower eyelid position centrally. Overcompensation for a contralateral ptosis, as described by Hering’s law, must be distinguished from true eyelid retraction by manually elevating the ptotic eyelid. The nature of the restriction may be purely mechanical, which can be established directly by a forced traction test of the upper eyelid. Fibroses may be detected by a positive force duction test.

### TABLE 1. EYELID RETRACTION: PATIENT DEMOGRAPHICS AND PROCEDURES THAT WERE PERFORMED WITH THE GRADED LEVATOR HINGE PROCEDURE

<table>
<thead>
<tr>
<th>PATIENT</th>
<th>AGE</th>
<th>GENDER</th>
<th>SIDE</th>
<th>ETIOLOGY</th>
<th>LEVATOR HINGE WAS COMBINED WITH</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>47</td>
<td>F</td>
<td>Left</td>
<td>TRO</td>
<td>Müllerectomy</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>M</td>
<td>Bilateral</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
<tr>
<td>3</td>
<td>49</td>
<td>M</td>
<td>Right</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
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</tr>
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<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>F</td>
<td>Right</td>
<td>TRO</td>
<td>Canthoplasty</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>F</td>
<td>Left</td>
<td>Duane’s syndrome</td>
<td>None</td>
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<tr>
<td>8</td>
<td>89</td>
<td>F</td>
<td>Right</td>
<td>S/P Ptosis</td>
<td>Müllerectomy, canthoplasty &amp; marginal rotation for entropion</td>
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<tr>
<td>9</td>
<td>43</td>
<td>F</td>
<td>Bilateral</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
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<td>10</td>
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<td>F</td>
<td>Right</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
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<td>52</td>
<td>F</td>
<td>Bilateral</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
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<td>70</td>
<td>F</td>
<td>Left</td>
<td>TRO</td>
<td>Canthoplasty</td>
</tr>
<tr>
<td>13</td>
<td>33</td>
<td>M</td>
<td>Left</td>
<td>7th CN paralysis</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
<tr>
<td>14</td>
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<td>F</td>
<td>Bilateral</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
<tr>
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<td>Right</td>
<td>TRO</td>
<td>Canthoplasty</td>
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<td>F</td>
<td>Left</td>
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<td>Canthoplasty</td>
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<tr>
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<td>19</td>
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<td>Bilateral</td>
<td>TRO</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
<tr>
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<td>46</td>
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<td>Bilateral</td>
<td>TRO</td>
<td>None</td>
</tr>
<tr>
<td>19</td>
<td>55</td>
<td>F</td>
<td>Left</td>
<td>S/P ptosis</td>
<td>Müllerectomy &amp; canthoplasty</td>
</tr>
<tr>
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<td>31</td>
<td>F</td>
<td>Bilateral</td>
<td>TRO</td>
<td>Left Müllerectomy &amp; bilateral canthoplasty</td>
</tr>
<tr>
<td>21</td>
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CN, cranial nerve; S/P, status post; TRO, thyroid-related orbitopathy.

Restoring the height of the eyelid, arch, and shape of the upper eyelid demands individual considerations. For every patient, identification and evaluation of the anatomical and pathophysiological causes involved in the development of upper eyelid retraction are essential to successful preparation and performance of the surgical management of eyelid retraction. Careful examination is required to identify the patients who will benefit from inferior rectus muscle recession, upper eyelid lengthening, lateral canthoplasty, blepharoplasty, and other procedures. If photographs of the patient prior to the onset of disease are available, these will greatly assist in planning a postoperative functional and cosmetic goal and in the selection of the appropriate surgical procedures needed.

There must be clear communication between the patient and surgeon regarding the desired eyelid height and contour. It must also be made clear that secondary procedures may sometimes be required (eg, adjustment of the eyelid height and/or contour) because of the current lack of strong predictability in the surgical correction of eyelid retraction. It is prudent to counsel patients undergoing unilateral correction that a change in the contralateral eyelid position might be encountered and is not entirely predictable. In patients
with bilateral involvement, the more severely retracted eyelid was operated on first and the fellow eyelid 1 to several weeks later.

Postoperatively, patients were evaluated for the change in palpebral fissure height, keratopathy, eyelid arch, and symmetry with the opposite upper eyelid level and palpebral fissure height.

SURGICAL TECHNIQUE

All patients gave informed consent to the planned surgical procedures. The patients were informed that a graded levator hinge procedure would be performed and that a lateral canthoplasty and/or Müllerectomy would be performed if indicated, depending on the surgical findings. The patients were informed that no consensus had been established regarding the success of these procedures and that further surgery may be required.

Surgery was performed under monitored anesthesia, so that the surgeon could make controlled adjustments in the amount of surgery to be performed, and so that the eyelid height and contour could be set intraoperatively, with the patient’s cooperation. Topical 0.5% tetracaine hydrochloride drops were applied, and a protective corneoscleral contact lens was placed over the globe, to prevent any damage to the globe during the procedure. If a lateral canthoplasty was to be performed at the same time, the upper eyelid and lateral canthus was infiltrated with 1.5 mL of 1% lidocaine hydrochloride containing epinephrine 1:100,000 or 1:200,000 solution. The patient was then prepped and draped in the standard sterile fashion.

If a lateral canthoplasty was to be performed, it was performed first. If the horizontal palpebral fissure was greater than 35 to 37 mm, a lateral canthoplasty was considered. The procedure is as follows: A scalpel is used to remove the mucocutaneous border of the lid margins of the upper and lower eyelids from the desired horizontal length, 35 to 37 mm to the lateral canthal angle. This de-epithelializes that portion of the lid margin. The upper and lower eyelid in this area and laterally is then split into an anterior (skin and orbicularis muscle) and posterior (tarsus and conjunctiva) lamellae. The scalpel incises the lid margin just anterior to the anterior surface of the tarsus. Care is taken to keep the plane of the incision parallel and just in front of the anterior surface of the tarsus and lateral canthal tendon. A horizontal cut at the lateral canthus is then made as in a lateral canthotomy. A cantholysis of the inferior crus of the lateral canthal tendon is made at the lateral orbital wall, similar to a lateral tarsal strip procedure. One end of a double-arm 5-0 polyglactin suture is then placed through the tarsus of the upper eyelid with the other end placed through the tarsus of the lower eyelid. Then both arms are woven through the tarsus of the upper and lower eyelid, the posterior lamellae, and then to the periorbita at Whitnall’s tubercle, at the inner aspect of the lateral rim, at the desired level for the lateral canthal angle, but not tied. A second double-arm 5-0 polyglactin suture is placed just anterior to the first suture in the posterior lamellae. After both sutures are placed, they are tied. Care should be taken to place these sutures on the inner aspect of the lateral rim so that the lid will not pull away from the globe and at the exact vertical height desired. The exact height desired is slightly higher than the medial canthal tendon in order to recreate the normal slight upward slant to the lateral canthus. The anterior lamellae, consisting of the skin and orbicularis muscle, are then sutured together with 5-0 polyglactin suture in an interrupted fashion.

This lateral canthal advancement combined with a canthoplasty procedure is an effective adjunct to retractor recession when horizontal tightness of the eyelid is present, the horizontal palpebral fissure is greater than 35 to 37 mm, or there is lateral canthal dystopia. This lateral canthoplasty is similar to a lateral tarsal strip combined with a lateral tarsorrhaphy. In addition to reducing temporal flare, the lateral canthoplasty provides better coverage for the globe. Care must be taken not to shorten the horizontal palpebral fissure, and to place the lateral sutures at the appropriate level, so as not to elevate or depress the lateral aspect of the lateral canthal angle.

The desired eyelid crease is then marked with a skin-marking pen at the site of the intended incision, to create the position of the desired eyelid crease, and compared with the contralateral side to ensure symmetry. A subcutaneous injection of local anesthetic of lidocaine hydrochloride with epinephrine in a concentration of 1:100,000 or 1:200,000 is administered to provide sensory anesthesia of the upper eyelid while preserving the motility of the lid.

A 5-0 silk suture is passed through the upper eyelid margin in the pupillary plane, then through the skin, orbicularis muscle, and anterior tarsus, as a source of traction during the procedure. An incision is made through the skin at the previously marked skin incision site. The orbicularis muscle at the upper margin of the tarsus is tented anteriorly with a toothed forceps, and a cut is made centrally with scissors. One blade of the Westcott scissors is introduced into the posterior orbicular fascial plane, and the orbicularis muscle is incised medially and laterally along the entire horizontal length of the incision with scissors, entering the suborbicularis space.

The skin and orbicularis muscle is then dissected from the levator aponeurosis along its anterior surface, in the suborbicular fascia plane. The septum is opened in its entirety, and retraction of the preaponeurotic fat exposes the anterior surface of the levator aponeurosis up to Whitnall’s ligament (Figure 1). Once the levator aponeurosis is exposed, it is disinserted from the tarsal plate. The dissection is started at its insertion to the tarsal plate in the lateral part of the levator aponeurosis and extended medially for the entire horizontal length of the aponeurosis (Figure 2). The lateral and medial horns of the levator aponeurosis and any adhesions are severed, dividing and transecting it completely (Figure 3). The levator aponeurosis is then disinserted as one complex. Müller’s muscle is then visualized posterior to the levator aponeurosis (Figure 4). The levator aponeurosis is then dissected from Müller’s muscle by sharp and blunt dissection superiorly to Whitnall’s ligament, which results in complete mobilization of the levator aponeurosis (Figure 5). Wet cotton-tipped applicators can be used to bluntly dissect the levator aponeurosis from its loose attachment to Müller’s muscle. Frequent, Müller’s muscle is infiltrated with fat and fibrous cicatricial tissue, which makes this dissection more difficult (Figure 6). Care is taken to avoid the lacrimal gland and the lacrimal ductules laterally.

When Müller’s muscle is infiltrated with fat and fibrous cicatricial tissue, release of the levator aponeurosis alone will rarely produce enough recession to allow lowering of the eyelid to the desired level, due to the remaining cicatricial attachments of the
involved Müller’s muscle. This can generally be predicted preoperatively by the traction test of the upper eyelid, which generally demonstrates a resistance to inferior displacement of the upper eyelid. If involved, Müller’s muscle must be released from its cicatricial attachments to the tarsus and the underlying conjunctiva, and then excised (Figure 6).

FIGURE 1
The graded levator hinge procedure. The skin and orbicularis muscle have been incised and retracted superiorly. The septum has been opened and the preaponeurotic fat is retracted with a Desmarres retractor, exposing the entire anterior surface of the levator aponeurosis up to Whitnall’s ligament.

FIGURE 2
The graded levator hinge procedure. The levator aponeurosis has been disinserted from the tarsal plate, the medical and lateral horns have been severed, and its inferior border is being held in forceps, exposing the underlying Müller’s muscle. The septum and orbicularis muscle are being retracted superior, exposing the preaponeurotic fat.

FIGURE 3
The graded levator hinge procedure. The medial and lateral horns of the levator aponeurosis have been severed. The levator aponeurosis is shown reflected superiorly with forceps, and the levator aponeurosis will then be dissected from Müller’s muscle. The traction suture, which keeps the eyelid on stretch, facilitating the surgical dissection, can be seen.

FIGURE 4
The graded levator hinge procedure. The medial and lateral horns of the levator aponeurosis are held in forceps as it is being dissected from Müller’s muscle, releasing its attachments completely.

When Müller’s muscle is infiltrated, it is then dissected sharply and bluntly from the underlying conjunctiva from a level immediately above the superior border of the tarsus to Whitnall’s ligament, without opening the conjunctiva. Care is taken to prevent
buttonholing the conjunctiva. Then Müller’s muscle and the fatty, fibrous cicatricial infiltrate is excised (Figure 6). This complete dissection and release of the levator aponeurosis and Müller’s muscle allows complete release of the upper eyelid, especially the lateral temporal flare, and also allows adjustment of the eyelid contour. Meticulous dissection is performed to separate Müller’s muscle from the underlying conjunctiva and the levator aponeurosis. Meticulous care is taken to dissect all fibers inserting on the tarsal plate and conjunctiva and to dissect fully all adhesions between the upper eyelid retractors and the lateral canthal ligament. Müller’s muscle fibers and all fibrotic strands inferior to the lacrimal gland region should be divided and transected extensively to relieve temporal flare. Disinsertion is continued until the upper eyelid is completely free along its entire horizontal length. In the lateral upper eyelid, the levator aponeurosis and Müller’s muscle bisect the lacrimal gland into the palpebral and orbital lobes. Care must be taken in this area to avoid damage to the lacrimal gland parenchyma and ductules. Inadequate dissection and recession in this area can result in the persistence of postoperative temporal flare. Hemostasis is achieved throughout the procedure with bipolar or unipolar cautery. Minimal cautery should be used with caution, since excess application may cause contraction of the conjunctiva and shortening of the posterior lamella of the upper eyelid (Figure 7).

Once the upper eyelid is completely freed, the only remaining attachment of the upper eyelid is the conjunctiva. A muscle hook can be placed in the superior fornix, while inferior traction is placed on the eyelid margin to ensure that the upper eyelid is completely freed, or the traction suture is pulled inferior, and palpation is performed to detect any remaining attachment (Figure 8). Any
remaining traction due to remnants of Müller’s muscle, levator aponeurosis, or cicatricial changes can be felt as a tugging or band. This maneuver identifies and ensures that all attachments have been released and helps to avoid postoperative temporal flare. After all the fibrous tractions and cicatricial bands are released, then the graded levator hinge procedure can be performed.

The preaponeurotic fat pads are then analyzed. The medial fat pad is trimmed and then sculpted in patients who need debulking, and then the central and lateral fat pads are trimmed and sculpted as indicated. Again, care is taken to avoid the lacrimal gland. If the lacrimal gland is prolapsed, anterior to the superolateral orbital rim, it is repositioned behind the orbital rim and sutured with a 5-0 polyglactin suture passed through the lacrimal gland and posterior to the arcus marginalis in the superior temporal quadrant.

An upper eyelid blepharoplasty with fat removal or sculpting can be performed at the time of the graded levator hinge procedure. Care must be taken in the removal of the preaponeurotic fat, since excessive removal can result in the formation of a second, higher eyelid crease that is difficult to correct. Blepharoplasty, if indicated, is performed more conservatively, to avoid vertical shortening of the anterior lamella of the eyelid. These patients require a more aggressive excision of the anterior medial orbital and brow fat pads, and a more conservative excision of the often thickened vertical skin, to avoid the complication of lagophthalmos.

To perform the graded levator hinge procedure, the lateral one-third of the distal levator aponeurosis is fashioned into a flap that is rotated 90 degrees inferiorly and then attached to the tarsal plate. The levator aponeurosis is grasped with forceps at its inferior lateral margin and placed on stretch. The Westcott scissors are then placed laterally and aimed medially. The levator aponeurosis is then incised 6 mm superior to its inferior edge, in a lateral to medial direction, staying horizontal and parallel to the inferior edge of the levator aponeurosis to about one-third to one-half of its horizontal length (Figure 9). The temporal cut edge of the levator aponeurosis is then sutured to the tarsal plate with a 5-0 uncoated, braided polyester suture, just medial to the midline as in a ptosis repair. This hinged levator adds the required vertical length to the levator aponeurosis. The more medial the flap is incised, the greater the length of hinge obtained from the levator aponeurosis, allowing the required correction of the upper eyelid retraction (Figures 10 and 11).

This step in the procedure generates the graded aspect of the graded levator hinge procedure. The maximal limit in the size of the hinge is the horizontal length of the levator aponeurosis, which was always of adequate length to correct for the vertical retraction in all patients. The suture is then tied temporarily with a slipknot (Figure 12). The scleral lens is removed, and the patient is then placed in the sitting position by raising the head of the operating table. With the patient’s cooperation, the eyelid is then observed for lid height and contour in primary gaze and then up and down positions of gaze. If the lid is still retracted, the levator is further incised medially, to extend the hinge, until the desired height is achieved. This gradual lengthening of the hinge allows the retraction of the eyelid to be corrected precisely and adjusted until both the desired lid height and a smooth, curvilinear contour are achieved. If the contour is not appropriate, the contour of the lid can be adjusted by placing the tarsal suture of the levator hinge more medial or lateral to achieve the desired contour. The judgment of the final height is made with the patient in the sitting position. The lid should be set about 1 mm below the final desired height to compensate for mild postoperative contracture and the effects of epinephrine in the anesthetic, which can cause some lid retraction. Once the correct position has been obtained, the sutures are tied permanently and cut. If the eyelid is overcorrected, this can be easily detected at surgery and corrected by suturing higher up on the hinge of the levator aponeurosis as is necessary to modulate the observed lid height. These adjustments are continued until the desired lid height and arch are obtained.

Intraoperative variables are carefully taken into account. There may be some elevation of the eyelid from an anesthetized orbicularis muscle or from patient anxiety and increased sympathetic tone. There may be some depression of the eyelid from an anesthetized levator, patient squinting due to discomfort or brightness of the lights, hemorrhage or edema, or sedation. Also to be
considered are ocular dominance, the effect of Hering’s law, and increased inflammation expected postoperatively in thyroid-related orbitopathy patients. In an attempt to adjust for the influence of these diverse factors, an overcorrection of the eyelid height by 1 to 2 mm is made intraoperatively. An attempt to minimize these influences is important and indicated. Minimal or no sedation, and no more than 1.0 to 1.5 mL of local anesthetic, is suggested. Intraoperative assessment of the eyelid height and contour in both the supine and sitting positions in primary gaze, upgaze, and downgaze is advised. Once the desired height, contour, and symmetry are achieved, the knot is tied. The skin is closed as in a ptosis procedure, with 3 sutures incorporating a bite through the superior tarsal tissue in the midline, the medial one-third, and the lateral one-third of the eyelid for the creation of a well-defined upper eyelid crease. The rest of the incision is reaproximated with interrupted sutures.

**FIGURE 9**
The graded levator hinge procedure. The inferior edge of the levator aponeurosis is grasped with forceps, placing the levator aponeurosis on stretch. The aponeurosis is then incised 6 mm superior to its inferior edge from a temporal to medial approach.

**FIGURE 10**
The graded levator hinge procedure. The incision is continued parallel to the inferior edge of the aponeurosis to about one-third to one-half of its horizontal length, depending on the vertical lengthening desired. One can see the large amount of vertical length that can be obtained.

**FIGURE 11**
The graded levator hinge procedure. The levator aponeurosis has been incised or hinged for one-half of its horizontal length. The more medial the flap is incised, the greater the vertical length obtained. One can see the marked increased vertical length that can be obtained.

**FIGURE 12**
The graded levator hinge procedure. The levator flap is temporarily tied with a slipknot to the tarsus, just medial to midline and about 2 to 3 mm below the superior tarsal border. The suture and the flap are adjusted until the desired eyelid height and contour are achieved.
The silk traction suture that was placed in the upper eyelid at the beginning of the case is taped to the patient’s cheek to place the eyelid on stretch, and a light pressure dressing is applied. On the first postoperative day, the traction suture is untapped from the cheek and taped above the eyebrow. The level and contour of the upper eyelid are evaluated in primary gaze position and in up and down gazes. If the upper eyelid is at the desired height or lower, the suture is removed. If the eyelid is higher than the desired height, the lid is stretched and the traction suture is taped again to the cheek. It is expected that the lid level will be ptotic in the initial postoperative period and gradually rise during the next 3 to 4 weeks.

Treatment with antibiotic ointment is continued for 3 to 4 weeks, and lubricating tears and ointment are continued as indicated. Cold compresses are applied gently for 48 to 72 hours, and then hot compresses. Some swelling will last several weeks or more, and a 1- to 2-mm overcorrection is expected during this early postoperative period.

Careful surgical technique and attention to eyelid anatomy are essential in decreasing the incidence of postoperative complications. No definite complication related to the lateral canthoplasty procedure, such as rounding or dystopia of the lateral canthus, was observed (Figure 13).

![Figure 13](image)

The graded levator hinge procedure. The appearance of the lateral canthus, 10 days postoperatively when the sutures were removed. The canthoplasty technique produces a nice angle and level to the lateral canthus.

It is expected that the lid will be slightly ptotic in the initial postoperative period but will gradually elevate during the next 3 to 4 weeks postoperatively. If the eyelid is slightly higher than the desired level, or begins to retract, the level may be maintained by downward massage of the eyelid, or stretching the eyelid over a Desmarres retractor during this period of postoperative inflammation and contraction.

Patients were followed until their eyelid levels ceased to change and their measurements stabilized. This was considered the final result.

Despite optimal surgical technique, eyelid retraction can recur, depending on the reparative processes following surgery. Thyroid-related orbitopathy may progress, or reactivate, leading to recurrence of eyelid retraction after a good operative result. Follow-up over long periods is important in thyroid-related orbitopathy patients, since their thyroid-related orbitopathy may activate years later. Two patients in this study with eyelid retraction secondary to thyroid-related orbitopathy had excellent surgical result. Four years later, their thyroid-related orbitopathy flared up again, leading to retraction of their eyelids.

**STATISTICAL METHODS**

Data obtained on preoperative and postoperative palpebral fissure height measurements were tabulated for statistical analysis. Analysis of variance and post hoc t tests were performed with a criterion significance level of $P = .05$. The statistical package in Origin (version 6.1, MicroCal, North Hampton, Massachusetts) was used to quantitatively evaluate outcomes in this study and to plot all original graphs.

**RESULTS**

The driving hypothesis for this study is that the graded levator hinge procedure combined, when indicated, with Müllerectomy and/or lateral canthoplasty leads to good surgical management of upper lid retraction secondary to diverse physiological and anatomical causes, at one surgical setting. All patients were evaluated preoperatively and postoperatively and operated on by a single surgeon. The fact that all patients were evaluated and operated on by a single surgeon minimized variance due to uncontrolled variables that would otherwise exist in a multiple investigator study.

**PATIENT DEMOGRAPHICS**

Thirty-two consecutive patients with varying degrees of upper eyelid retraction, with varying etiologies, underwent surgical correction to treat eyelid retraction between 1995 and 2005. The graded levator hinge procedure was performed on 48 eyelids of 32 consecutive patients, with follow-up of at least 6 months (range, 6 months to 8 years). Mean patient age was 46.6 years ($\pm 2.8$; range, 5-89 years). There were 27 females (84.4%) and 5 males (15.6%). Causes of the eyelid retraction were as follows: thyroid-related orbitopathy in 25
patients (78.1%); ptosis surgery performed elsewhere in 3 (9.3%); congenital in 1 (3.1%) (a complete medical workup was within normal limits); Duane’s syndrome in 1 (3.1%); 7th cranial nerve paralysis in 1 (3.1%); and unknown in 1 (3.1%) (a complete medical work up was within normal limits). There were 16 unilateral (50%) and 16 bilateral (50%) cases performed (Table 1).

For the 25 patients with eyelid retraction secondary to thyroid-related orbitopathy, the time interval from diagnosis of thyroid-related orbitopathy and surgical correction of eyelid retraction was 1 to 25 years, with most being greater than 2 years (mean, 8.5 years). The treatment of the thyroid disease was radioactive I\textsuperscript{131} in 14 patients, thyroidectomy in 6 patients (2 of which initially had a partial thyroidectomy and later required a total thyroidectomy), and medical therapy in 5 patients.

Of the 25 patients with thyroid-related orbitopathy, 9 required prior orbital decompression (Figure 14), one of which was only unilateral due to the asymmetry of her ocular manifestation of thyroid-related orbitopathy (Figure 15). Three of these patients required prior strabismus surgery (patients 9, 14, and 23; Tables 1 and 2). One of the patients with thyroid-related orbitopathy retraction of the upper eyelid (patient 15; Tables 1 and 2) had a previous correction elsewhere with the use of fascia lata as a spacer. The graded levator hinge procedure was performed on this patient, except that after the fascia lata graft was released, it was hinged as described for the levator aponeurosis. The postoperative interpupillary fissure level of the operated eye was within 0.5 mm of the fellow eyelid. One of the patients with the eyelid retraction secondary to prior ptosis surgery (patient 8; Tables 1 and 2) also had an entropion secondary to shortening of the posterior lamellae. This was corrected with the graded levator hinge procedure in combination with a marginal rotation with a suture technique. The postoperative results were good, with the upper eyelid margin being 1 mm lower than the fellow eyelid.

**FIGURE 14**

The graded levator hinge procedure. Left, The preoperative appearance of a patient with thyroid-related orbitopathy before surgical intervention. Notice the marked proptosis, marked eyelid retraction, and marked temporal flare. Right, The patient underwent a bilateral orbital decompression. Once the patient was stable after the decompression, a bilateral levator hinge procedure, combined with a Müllerectomy and lateral canthoplasty, was performed with a marked improvement of the eyelid retraction and temporal flare.

**FIGURE 15**

The graded levator hinge procedure. Left, The preoperative appearance of a patient with asymmetrical proptosis, eyelid retraction, and temporal flare secondary to thyroid-related orbitopathy, before surgical intervention. Right, The patient underwent a right orbital decompression, and once stable, a right levator hinge procedure, combined with a Müllerectomy and lateral canthoplasty, was performed. There was a marked improvement of the eyelid retraction and temporal flare, with a good contour, eyelid height, and symmetrical crease and fold.
The graded levator hinge procedure was performed alone in 4 patients (5 eyelids), in combination with a Müllerectomy in 1 patient (1 eyelid), in combination with a lateral canthoplasty in 6 patients (6 eyelids) (Figure 16), in combination with a marginal rotation in 1 patient (1 eyelid), and in combination with a Müllerectomy and lateral canthoplasty in 20 patients (35 eyelids) (Figure 17). Sixteen patients had asymmetric eyelid retraction and required only unilateral surgery (Table 1). Since lower-lid surgery was not performed in any of these patients during or after the graded levator hinge procedure, the difference between the preoperative and postoperative palpebral fissures was the amount of correction measured in this study as the palpebral fissure height. No definite complication related to the lateral canthoplasty procedure, such as rounding or dystopia of the lateral canthus, was observed (Figure 13).

**FIGURE 16**
The graded levator hinge procedure. Left, The preoperative appearance of a patient with unilateral eyelid retraction secondary to thyroid-related orbitopathy. Notice the marked retraction of the upper eyelid, superior sclera show, temporal flare, and increased horizontal length of the palpebral fissure. Right, The patient underwent a levator hinge procedure combined with a lateral canthoplasty. Notice the marked improvement of the eyelid retraction, temporal flare, with a good symmetrical contour to the upper eyelid.

**FIGURE 17**
The graded levator hinge procedure. Left, The preoperative appearance of a patient with marked proptosis, eyelid retraction, and temporal flare secondary to thyroid-related orbitopathy before any surgical correction. Middle, The patient status following bilateral orbital decompression. Note the marked improvement of the proptosis but the remaining marked eyelid retraction and temporal flare. Right, Once the postoperative period stabilized, a bilateral levator hinge procedure, combined with a Müllerectomy and lateral canthoplasty, was performed. Notice the improvement of the eyelid retraction and temporal flare. A normal eyelid contour, position, lid crease, and fold were obtained.

**OUTCOMES ANALYSIS**
The average palpebral fissure height was 13 mm before surgery and 9 mm after surgery, with an average of 4.5 mm reduction in the palpebral fissure height after the procedures (range, 1-10 mm) (Table 2).

The means and standard deviations for the total patient database are shown (Figure 18, left; Table 3). Analysis of the total patient data set finds similar mean levels of preoperative palpebral fissure height between right and left eyes and similar mean levels of postoperative palpebral fissure height between right and left eyes (Table 3). While right and left eyes of both preoperative and postoperative conditions had similar means, there was a clear reduction in the postoperative means relative to the preoperative palpebral fissure height means. Analysis of variance (ANOVA) was applied to the total patient palpebral fissure height database, and the null hypothesis, that all means were the same, was refuted ($P = .0$). Post hoc $t$ tests showed that the means of the right and left eye preoperative measurements were not significantly different ($P = .759$). Similarly, a $t$ test showed that the means of the right and left eye postoperative measurements were not significantly different ($P = .433$). Given statistical equivalence, the right and left eye data were pooled for each of the preoperative and postoperative palpebral fissure height measurements, respectively. This allows a statistical comparison between the total preoperative vs postoperative palpebral fissure height measures (Figure 18, right). There is a
4.6-mm ± reduction in mean palpebral fissure height between the preoperative vs postoperative conditions and this difference is statistically significant ($P < .001$). In addition, the means of the preoperative asymmetry ($2.41 \pm 0.29$ mm) and the postoperative asymmetry ($0.59 \pm 0.09$ mm) were significantly different ($P < .001$) (Figure 18, left). This indicates that there is a substantial and statistically significant improvement in palpebral fissure height differences between the 2 eyes of all patients in the study. In order to further dissect these global differences statistically, we explored the findings in two of the major data sets, those subjected to bilateral or unilateral surgical correction of lid retraction.

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Of the 32 patients, 8 (25%) were even, within 0 mm of the fellow side, 14 (43.8%) were within 0.5 mm of the fellow side, 7 (21.9%) were within 1 mm difference from the fellow side, and 2 (6.3%) were at 2 mm of the fellow side. Of the total 32 cases, 22 (68.8%) were within 0.5 mm of the fellow side, and 29 (90.6%) were within 1 mm of the fellow side.

Mean and standard deviation of palpebral fissure height for all patients that had bilateral surgical procedures are shown (Figure 19, left; Table 3). ANOVA was performed on this data set, and the null hypothesis that the means were all the same was refuted ($P = .0$). As found for the total patient data set, for patients receiving bilateral graded levator hinge procedures, the mean preoperative palpebral fissure heights of the right and left eyes were not significantly different ($P = .872$). Similarly, the mean palpebral fissure height measures of the right and left eyes were not significantly different postoperatively ($P = .388$). The means of the preoperative and postoperative asymmetry of the palpebral fissure height measures were also not significantly different ($P = .103$). The data of the right and left eyes were pooled for a comparison of preoperative palpebral fissure height vs postoperative palpebral fissure height means (Figure 19, right). The mean postoperative bilateral palpebral fissure height ($9.39 \pm 0.27$ mm) was significantly smaller than the mean preoperative bilateral palpebral fissure height ($14.53 \pm 0.57$ mm) by 5.14 mm ($P < .001$). This analysis shows that the bilateral graded levator hinge procedure substantially and significantly reduced the palpebral fissure height, without any significant change in preoperative vs postoperative symmetry.

Of the 16 bilateral cases, 6 (37.5%) were at even levels, 3 (18.8%) were within 0.5 mm of the fellow eyelid, 5 (31.3%) were at 1 mm of the fellow side, and 2 (12.5%) were at 2 mm of the fellow eyelid. Of the 16 bilateral cases, 9 (56.3%) were within 0.5 mm of the fellow side and 14 (87.5%) were within 1 mm of the fellow side. Of the 2 patients who were at 2 mm of the fellow side, 1 eyelid was overcorrected and 1 eyelid was undercorrected, requiring a second surgical procedure, which was successful.
The graded levator hinge procedure. Left, Data analysis on the total patient database for all preoperative conditions and all procedures. The mean palpebral fissure height measurement and the standard deviations (SD bars) are shown for preoperative conditions of the right and left eyes and postoperative conditions of the right and left eyes. Also shown are the mean palpebral fissure height ± standard deviation of asymmetry preoperatively and postoperatively, which were significantly different. Right, Given that both the preoperative right and left eye means were not statistically different and both the postoperative right and left eye means were not statistically different, the right and left eye preoperative and right and left eye postoperative measures were pooled and statistically evaluated (means ± standard deviation). The means were significantly different by \( t \) test.

Mean and standard deviation of palpebral fissure height for all patients that had unilateral surgical procedures is shown (Figure 20, left; Table 3). ANOVA was performed on this data set, and the null hypothesis that the means were all the same was refuted (\( P = .0 \)). As found for the total and bilateral patient data sets, for patients receiving unilateral graded levator hinge procedures, the mean preoperative palpebral fissure heights of the right and left eyes were not significantly different (\( P = .69 \)). Similarly, the mean palpebral fissure height measurements of the right and left eyes were not significantly different postoperatively (\( P = .79 \)). Mean asymmetry between the vertical height of the palpebral fissure of the right and left eyes in 16 unilateral cases preoperatively was 3.88 mm (range, 2-5 mm). Asymmetry was reduced to a mean of 0.59 mm (range, 0-2 mm) postoperatively. The means of the preoperative and postoperative asymmetry of the palpebral fissure height measures were, as in the total data set, significantly different (\( P < .001 \)). The data of the right and left eyes were pooled for a comparison of preoperative palpebral fissure height vs postoperative palpebral fissure height means (Figure 20, right). The mean postoperative unilateral palpebral fissure height (8.64 ± 0.28 mm) was significantly smaller than the mean preoperative unilateral palpebral fissure height (10.25 ± 0.46 mm) by 1.61 mm (\( P = .004 \)). This analysis shows that unilateral graded levator hinge procedure significantly reduced the palpebral fissure height, with a statistically significant improvement in postoperative vs preoperative symmetry.

Of the 16 unilateral cases, 2 (12.5%) were at even levels (0 mm) postoperatively, 11 (68.8%) were within 0.5 mm of the fellow eyelid level, and 2 (12.5%) were within 1 mm of the fellow eyelid level. One patient had a difference of 2 mm postoperatively, which was due to an increase of the ptosis of the fellow eyelid. The treated eyelid was actually at the desired level, and the patient later underwent a ptosis correction of the fellow eyelid with a final excellent symmetrical result. Of the 16 unilateral cases 13 (81.3%) were within 0.5 mm of the fellow eyelid, and 15 (93.8%) were within 1 mm of the fellow eyelid. If one disregards the increased ptosis of the fellow eyelid (Hering’s law), 100% were within 1 mm of the fellow side.

Patients with thyroid-related orbitopathy occupy the bulk (78.1%) of the patients in the total study group. Therefore, it is prudent to explore the outcomes in this study group of 25 individuals. The mean palpebral fissure heights and asymmetry data for preoperative and postoperative conditions are shown (Figure 21, left; Table 3). ANOVA was applied to this data set, and the null hypothesis of all means being the same was refuted (\( P = .0 \)). Post hoc \( t \) tests found that the mean values of palpebral fissure height for right and left eyes both preoperatively (\( P = .75 \)) and postoperatively (\( P = .42 \)) were not significantly different. Again, right and left eyes were pooled for preoperative (13.2 mm) and postoperative (9.25 mm) measurements, and the means (Figure 21, right; Table 3) were found to be statistically significantly different when compared by \( t \) test (\( P < .001 \)). The mean asymmetry between the right and left eyes was 2.0 mm preoperatively and 0.62 mm postoperatively, and this result was statistically significant (\( P < .001 \)). Thus, for the thyroid-related orbitopathy patient subset there is a substantial and significant reduction in palpebral fissure height measure by the graded levator hinge procedure and a significant reduction in asymmetry.
### TABLE 3. EYELID RETRACTION: MEANS AND STANDARD DEVIATION OF THE MEAN (SD) FOR ALL GRAPHICAL DATA SETS

(ALL DATA IN MM)

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Asym, asymmetry; gLHp, graded levator hinge procedure; LC, lateral canthoplasty; ME, Müllerectomy.
**FIGURE 19**
The graded levator hinge procedure. Left, Data analysis on the database of the subset of patients receiving bilateral graded levator hinge procedures for all preoperative conditions and all procedures. The mean palpebral fissure height measurement and the standard deviation (SD bars) are shown for preoperative conditions of the right and left eyes and postoperative conditions of the right and left eyes. Also shown are the mean palpebral fissure height ± standard deviation of asymmetry preoperatively and postoperatively, which were not significantly different. Right, Given that both the preoperative right and left eye means were not statistically different and both the postoperative right and left eye means were not statistically different, the right and left eye preoperative and right and left eye postoperative measures were pooled and statistically evaluated (means ± standard deviation). The means were significantly different by \( t \) test.

**FIGURE 20**
The graded levator hinge procedure. Left, Data analysis on the database of the subset of patients receiving unilateral graded levator hinge procedures for all preoperative conditions and all procedures. The mean palpebral fissure height measurement and the standard deviation (SD bars) are shown for preoperative conditions of the right and left eyes and postoperative conditions of the right and left eyes. Also shown are the mean palpebral fissure height ± standard deviation of asymmetry preoperatively and postoperatively, which were significantly different. Right, Given that both the preoperative right and left eye means were not statistically different and both the postoperative right and left eye means were not statistically different, the right and left eye preoperative and right and left eye postoperative measures were pooled and statistically evaluated (means ± standard deviation). The means were significantly different by \( t \) test.
Schaefer

FIGURE 21

The graded levator hinge procedure. Left, Data analysis on the database of the subset of patients with thyroid-related orbitopathy receiving all procedures. The mean palpebral fissure height measurement and the standard deviation (SD bars) are shown for preoperative conditions of the right and left eyes and postoperative conditions of the right and left eyes. Also shown are the mean palpebral fissure height ± standard deviation of asymmetry preoperatively and postoperatively, which were significantly different. Right, Given that both the preoperative right and left eye means were not statistically different and both the postoperative right and left eye means were not statistically different, the right and left eye preoperative and right and left eye postoperative measures were pooled and statistically evaluated (means ± standard deviation). The means were significantly different by t test.

Patients receiving the graded levator hinge procedure combined with Müllerectomy and lateral canthoplasty (19 of 32) occupy a substantial portion (59.3%) of the total study group. Therefore, it is also prudent to explore the outcomes in this study group separately. The mean palpebral fissure heights and asymmetry data for preoperative and postoperative conditions are shown (Figure 22, left; Table 3). ANOVA was applied to this data set, and the null hypothesis of all means being the same was refuted (P = .0). Post hoc t tests found that the mean values of palpebral fissure height for right and left eyes both preoperatively (P = .80) and postoperatively (P = .29) were not significantly different. Again, right and left eyes were pooled for preoperative (12.76 mm) and postoperative (8.95 mm) measures, and the means (Figure 22, right; Table 3) were found to be statistically significantly different when compared by t test (P < .001). The mean asymmetry between the right and left eyes was 1.84 mm preoperatively and 0.52 mm postoperatively, and this result was statistically significant (P < .001). Thus, for the subset of patients receiving graded levator hinge procedure with Müllerectomy and lateral canthoplasty, there is a substantial and statistically significant reduction in palpebral fissure height measure by the graded levator hinge procedure and a significant reduction in asymmetry.

Patients receiving the graded levator hinge procedure combined with lateral canthoplasty alone (6 of 32) occupy a smaller portion (18.75%) of the total study group. Nevertheless, we explored the outcomes in this study group separately. The mean palpebral fissure heights and asymmetry data for preoperative and postoperative conditions are shown (Figure 23, left). ANOVA was applied to this data set, and the null hypothesis of all means being the same was refuted (P < .001). Post hoc t tests found that the mean values of palpebral fissure height for right and left eyes both preoperatively (P = 1.0) and postoperatively (P = .91) were not significantly different. Again, right and left eyes were pooled for preoperative (10.83 mm) and postoperative (9.25 mm) measures, and the means (Figure 23, right; see Table 3) were found not to be significantly different when compared by t test (P = .185). The mean asymmetry between the right and left eyes was 4.33 mm preoperatively and 0.83 mm postoperatively, and this result was statistically significant (P < .001). Thus, for the smaller subset of patients receiving graded levator hinge procedure and lateral canthoplasty alone, although there is not a significant reduction in palpebral fissure height measures between the preoperative and postoperative conditions, there is, nonetheless, a substantial and statistically significant reduction in asymmetry, which is a sound clinical and surgical outcome.

For other conditions (eg, Duane’s retraction) and other procedures (eg, graded levator hinge procedure with Müllerectomy alone), there were too few entries in the database to conduct isolated statistical analyses. Patients and eyelids that fell into these groups were analyzed in other total or subset analyses.

The graded levator hinge procedure compares favorably with other techniques in terms of its predictability: 90.6% of all eyelids were within 1 mm of the desired postoperative level and a reoperation rate of 6.2%. There were no cases of unacceptable contour of the eyelid requiring reoperation. All of the preoperative symptoms were resolved or improved by the procedures, indicating the effectiveness of these procedures. There was a reduction of exposure keratopathy in all patients. All the patients were pleased with the postoperative cosmetic results, and the majority reported a marked improvement in or abolition of ocular discomfort and ocular symptoms. There were no eyelid or ocular surface complications in any patient, and the eyelids showed only slight inflammation as...
normally expected after surgery. There were no infectious complications. Visual acuity, ocular ductions, and intraocular pressures remained unchanged after surgery.

**FIGURE 22**
The graded levator hinge procedure. Left, Data analysis on the database of the subset of all patients who received graded levator hinge procedure with Müllerectomy and lateral canthoplasty. The mean palpebral fissure height measurement and the standard deviation (SD bars) are shown for preoperative conditions of the right and left eyes and postoperative conditions of the right and left eyes. Also shown are the mean palpebral fissure height ± standard deviation of asymmetry preoperatively and postoperatively, which were significantly different. Right, Given that both the preoperative right and left eye means were not statistically different and both the postoperative right and left eye means were not statistically different, the right and left eye preoperative and right and left eye postoperative measures were pooled and statistically evaluated (means ± standard deviation). The means were significantly different by t test.

**FIGURE 23**
The graded levator hinge procedure. Left, Data analysis on the database of the subset of all patients who received graded levator hinge procedure with lateral canthoplasty alone. The mean palpebral fissure height measurement and the standard deviation (SD bars) are shown for preoperative conditions of the right and left eyes and postoperative conditions of the right and left eyes. Also shown are the mean palpebral fissure height ± standard deviation of asymmetry preoperatively and postoperatively, which were significantly different. Right, Given that both the preoperative right and left eye means were not statistically different and both the postoperative right and left eye means were not statistically different, the right and left eye preoperative and right and left eye postoperative measures were pooled and statistically evaluated (means ± standard deviation). The means were not significantly different by t test.
Given the analysis above, the graded levator hinge procedure is consistently successful at reducing asymmetry and reducing the mean size of the palpebral fissure height in diverse etiologies of upper lid retraction. We accept the initial hypothesis that the graded levator hinge procedure, combined with a Müllerectomy and/or lateral canthoplasty, when indicated, leads to good surgical management of upper lid retraction secondary to diverse physiological and anatomical causes.

**DISCUSSION**

The surgical treatment of upper eyelid retraction requires careful patient examination and timing of the surgical intervention. The surgery should be tailored to the degree of involvement in each individual patient and the patient’s desires and concerns, as modulated by the surgeon’s realistic views.

The numerous and varied surgical techniques employed for the correction of upper eyelid retraction indicate the difficulty of treating this disease process and the difficulty of finding the ideal procedure. The ideal procedure should yield the desired postoperative eyelid level, while maintaining or creating a normal contour, eyelid crease, and fold, with a predictable and reliable technique, preferably under local anesthesia, while preserving normal eyelid function.

Surgery should always be individualized to the patient’s specific needs and according to the various causes of eyelid retraction, especially in thyroid-related orbitopathy, where there are various manifestations of the disease process. The least invasive approach should be selected to reduce complications. Variables that affect the surgical decision-making process include the amount of eyelid retraction, involvement of Müller’s muscle, and the horizontal palpebral fissure. Treatment planning should take into account the individualized nature of each patient. Eyelid retraction presents as a manifestation of diverse disease processes, especially in thyroid-related orbitopathy, and a “one size fits all” surgical approach must be discouraged. The goal is to surgically treat the tissues that are involved pathologically by the disease process. Monitored local anesthesia preserves both the active motility of the eyelid and the cooperation of the patient. Intraoperative adjustments are possible to modulate the procedure to embrace the various tissue changes present for each patient.

The primary indication for surgical correction of upper eyelid retraction is to produce a functional eyelid to protect the globe and secondarily to improve the cosmetic appearance. This correction should be directed toward the underlying cause. The location of scarring or pathological process within the eyelid should be determined; this may occur in the anterior or posterior lamella or both.

Consideration should be given to the degree of exophthalmos, horizontal eyelid tension, lateral canthal angle position, and the length and tension of the retractors of the eyelid in the surgical correction of eyelid retraction. In patients with unilateral or highly asymmetric proptosis, orbital decompression with fat removal and/or bone removal should be considered for an optimal functional and aesthetic result. Also, patients with marked proptosis, optic neuropathy, or subluxation of the globe should be considered for orbital decompression first if indicated.

The surgical approaches to the correction of upper eyelid retraction should be directed at the underlying pathophysiological changes or defects. Skin grafts and rotational flaps may be required to correct anterior lamellar deficiencies (which were not included in this study); various procedures, interpositional grafts, and recession of the eyelid retractors have been proposed. The various donor graft materials create the possibility of complication by immune reactions, transmission of infectious diseases, recurrence of eyelid retraction, graft necrosis, and unpredictable shrinkage and absorption, and sometimes give a thickened appearance to the eyelid, which is cosmetically displeasing.

Eyelid contour and symmetry of the eyelid crease and fold are other criteria that are important in assessing postoperative results in the surgical correction of eyelid retraction. Postoperative patients may have an excellent lid level, but the contour, temporal flare, lid fold, and crease variations may produce an aesthetically unacceptable result in that the lid still looks quite abnormal. In reviewing the postoperative results, the eyelid crease and contour results, which were not quantified in this study, were compared to the preoperative status. These results are highly subjective, but all patients were pleased with their final result.

In some cases of eyelid retraction, especially in thyroid-related orbitopathy where cicatricial and mechanical muscle restriction plays a role, specially adapted corrective surgery is required. The operative procedure must be carefully tailored to the findings in each patient. The tissue changes present to a different extent and a varying degree in each individual, all of which act to impair eyelid function and promote the development of exposure. Because of the varied anatomical and functional changes of the affected muscles and tissues, the impact of individual surgical intervention is often unknown preoperatively and difficult to predict. However, under monitored, local anesthesia, active motility of the muscles is not impaired, and it is possible for the surgeon to intraoperatively modulate the surgical procedure to achieve the desired functional and cosmetic outcomes, thereby optimizing the surgical intervention.

More lateral than medial lengthening of the lid is almost always necessary in the surgical management of upper lid retraction. Consideration of the degree of exophthalmos, horizontal eyelid tension, and lateral canthal angle position should be given in the surgical correction of eyelid retraction in addition to the length and tension of the eyelid retractors. The addition of a lateral canthoplasty procedure will assist in the correction of these manifestations.

Different surgical approaches have been developed for the correction of eyelid retraction. In keeping with the mechanical nature of the retraction of the upper eyelid, an attempt is made to eliminate retraction by surgically lengthening the retractors. However, because of the various degrees and different structures of the upper eyelid that are affected with the various causes of eyelid retraction, the usual rules for a preoperatively defined amount of recession have only a relative significance. The surgeon must have a contingency plan with a set of operative procedures and modulate that plan, dependent upon the surgical anatomical and functional findings of...
measured motility and restrictive impairment, in order to generate predictable surgical outcomes. The preoperative measurements of the amount of eyelid retraction and levator function are considered, but the extent of the amount and the procedure(s) combined with the graded levator hinge procedure (Müllerectomy and/or lateral canthoplasty when indicated) were decided intraoperatively by testing eyelid level and excursions. Active cooperation of the patients was, therefore, necessary for the proper adjustment, so that the best intraoperative correction could be made. The procedure was performed under general anesthesia for only one patient (5 years old) in this study. The results were positive in that the patient’s functional eyelid levels as well as cosmesis were restored to a great extent.

The combination of procedures used here—the graded levator hinge procedure combined with a Müllerectomy and/or lateral canthoplasty, when indicated—addresses the diffuse nature of eyelid retraction and the possible involvement of all layers of the eyelid, including conjunctival fibrosis. Thyroid-related orbitopathy, the most common form of eyelid retraction, and the causes of disease in most of the patients in this study, can diffusely affect all layers of the eyelid, including the skin, levator aponeurosis, levator muscle, Müller’s muscle, and conjunctiva.102,103

This procedure reattaches the levator aponeurosis directly into its normal anatomical insertion site, the tarsus, although at an extended position. This maintains an efficient transfer of muscle contracture into eyelid movement, thus aiding surgical quantification and predictability, and maintains the contour of the upper eyelid. It permits control over and gradation of the amount of correction during the operation.

The levator hinge acts like a vascularized spacer without the problem of resorption. The procedure does not require implantation of foreign material, another surgical site, or the harvesting of various grafts. The levator hinge provides a normal anatomical continuity of the levator mechanism, and function is maintained. The procedure recedes the levator aponeurosis beyond the tarsal border while remaining directly attached to the tarsus by an extension of the levator aponeurosis created by a hinged rotation flap. This anatomical retention of the levator aponeurosis attachment to the tarsus enhanced transfer of muscle contracture into eyelid movement.

Advantages of the graded levator hinge procedure are that the hinge flap is the patient’s natural tissue that is not resorbed over time, the flap is readily available and easy to dissect, the flap length can be varied to modulate the extent of correction, results are predictable, and the normal anatomical continuity can be restored functionally. Height and contour are predictable, the upper eyelid crease is preserved, and spacers are avoided, with less postoperative eyelid thickening and reaction.

There are several elements of the graded levator hinge procedure that are crucial to its success. First, the levator aponeurosis must be completely disinserted from the tarsus and Müller’s muscle. Second, Müller’s muscle, when involved by cicatrical fibrosis or fatty infiltrate, must be disinserted from the tarsal plate and dissected from the underlying conjunctiva. Müller’s muscle must be excised in a meticulous fashion, completely freeing all attachments from the underlying conjunctiva and surrounding tissues. Third, all the fibrotic bands that form between Müller’s muscle and the conjunctiva, which develop from the inflammatory effects of thyroid-related orbitopathy or the various causes of eyelid retraction, must be severed in order to completely release the upper eyelid and prevent residual eyelid retraction and/or temporal flare. Finally, lateral temporal flare is also corrected by cutting the lateral horn of the levator aponeurosis and addressing the cicatrical reaction of the levator aponeurosis in this area.

The graded levator hinge procedure is based on anatomical and physiologic principles, is tailored to the individual patient’s preoperative and intraoperative findings, and is demonstrated in this clinical trial to yield consistently good results. The graded levator hinge procedure and associated procedures generate few complications and will successfully correct eyelid retraction secondary to a variety of causes. Acceptable postoperative eyelid levels, symmetry, and reduction in exposure keratopathy can be easily achieved. Reduction in postoperative morbidity and complications can be obtained with prudent surgical evaluation and intervention in multiple tissue planes, including the levator aponeurosis, orbital septum and fat pads, Müller muscle, and conjunctiva when involved. Evaluation and maintenance of these relationships substantially reduces iatrogenic postoperative eyelid deformities. In thyroid-related orbitopathy patients, evaluation of the conjunctival substantia propria for fibrosis and its removal and/or release also improves the outcomes.

The addition of the lateral canthoplasty, whenever indicated, helps to reduce upper eyelid retraction, especially the temporal flare component. The incidence and amount of residual temporal flare has been markedly reduced in the graded levator hinge procedure described in this study. Insufficient relaxation of the lateral canthal ligament in thyroid-related orbitopathy patients who are proptotic and have a horizontally tight eyelid with a posteriorly placed lateral canthus will promote increased temporal flare. In addition to reducing temporal flare, the lateral canthoplasty provides better coverage for the globe. This lateral canthal advancement combined with a canthoplasty procedure is an effective adjunct to retractor recession when horizontal tightness of the eyelid is present, when the horizontal palpebral fissure is greater than 35 to 37 mm, or when there is lateral canthal dystopia. Care must be taken not to shorten the horizontal palpebral fissure and to place the lateral canthus at the appropriate level, so as not to elevate or depress the lateral aspect of the lateral canthal angle.

The transcutaneous or anterior approach is preferred over the conjunctival approach because of better visualization of the affected retractors and all tissues that could possibly be involved in the disease process, allowing the surgical correction of the affected tissues. Another advantage of the transcutaneous approach is the ability to perform a blepharoplasty while correcting the eyelid retraction, if indicated.

Many aspects of these procedures are similar to other operations used for the treatment of eyelid retraction. The success rates for treatment of eyelids have been reported in the range of 20% to 50%, and the use of adjustable techniques and early postoperative adjustment increases the success rate in up to 84% of cases.29,41,57,78,82,112 There are, however, important differences. A Müllerectomy is performed only if there is involvement of the muscle with cicatrical or fibrotic changes or fatty infiltrate. Spacers are not needed, since the hinged levator aponeurosis acts as the spacer, thus greatly simplifying the procedure. The graded levator hinge procedure can be used for all degrees of eyelid retraction and for all the various causes of eyelid retraction. The surgeon tailors the procedures...
(levator hinge with a Müllerectomy if indicated, and with a lateral canthoplasty if indicated) to the degrees of retraction and the intraoperative findings at surgery.

A similar technique by Ceisler and colleagues was developed independent from the author and has been described previously. The use of this procedure was encouraged for the treatment of moderate to severe eyelid retraction. The investigators performed the procedure on 72 eyelids (37 patients); 35 procedures were bilateral, and all eyelid retraction was secondary to thyroid-related orbitopathy. They reported a success rate of 86.5% for eyelid symmetry within 1.5 mm of the fellow eyelid; an excellent result in 80.6%, which they describe as the eyelid above the pupil and 1 mm or more below the superior limbus; good results in 18.1%, which they describe as the eyelid on the pupil or less than 1 mm from the superior limbus; and poor results in 2.7%, which they describe as the eyelid below the limbus. There were 10 patients (90.6%) who were within 1 mm of the eyelid level and 95% of eyelids within 1.5 mm of the desired eyelid level. Levine in 1991 reported a success rate of 87% of cases within 1 mm and 95% of eyelids within 1.5 mm of the desired eyelid level.

The procedures are well tolerated by patients, and the results with these procedures appear more predictable than other procedures. The graded levator hinge procedure combines a graded levator hinged procedure, a Müllerectomy when indicated, and a lateral canthoplasty if indicated) to the degrees of retraction and the intraoperative findings at surgery.

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**SUMMARY**

The graded levator hinge procedure combines a graded levator hinged procedure, a Müllerectomy when indicated, and a lateral canthoplasty when indicated. Since each and every eyelid retraction patient is different, the surgical procedures described correct for various eyelid malformations and are tapered to each individual. The patient is approached from both an anatomical and pathophysiological viewpoint. The graded levator hinge procedure allows for more predictable, successful, and simultaneous correction of the eyelid height, contour, and horizontal palpebral fissure. The levator hinge is used as a spacer to allow adjustment of eyelid height. Its area of attachment to the tarsus determines the contour of the eyelid. With the patient sitting up during the procedure,
individual adjustments can be made by increasing the levator hinge progressively until the desired lid level and contour are achieved. Overcorrections and undercorrections can be recognized during the surgical procedure and corrected by reattaching the levator hinge at a higher level or increasing the hinge to obtain the desired eyelid height. The Müllerectomy adjunct procedure, when indicated, has an effect to lower the eyelid, release the cicatricial areas of retraction, and decrease the incidences of temporal flare. The graded levator hinge procedure is very successful in vertically lengthening the eyelid, releasing and/or excising fibrotic and cicatricial tissue, and achieving the desired eyelid height and contour, particularly laterally. The results are predictable, are tailored to unique conditions present in each patient at surgery, and allow for correction of eyelid height and contour in patients with moderate to severe eyelid retraction secondary to diverse causes. The graded levator hinge procedure yields excellent functional and aesthetic results and is reproducible across a set of patients with a common underlying problem (eg, thyroid-related orbitopathy).

Our success rate of 90.6% is an improvement when compared with those of other reports that employed different surgical methods and techniques. Our low reoperation rate, 2 of 48 procedures (6.2%), may be attributable to the success of surgery performed when analyzing and treating all the layers of the eyelid affected by thyroid-related orbitopathy. The unique approach conveniently allows the surgeon to evaluate and treat, during the same surgical setting, all the possible manifestations of thyroid-related orbitopathy of the eyelid causing eyelid retraction. The fact that all patients were evaluated and operated on by a single surgeon minimized other biases. The effect of the experience accumulated over the years by the single surgeon in this trial cannot be accounted for but demonstrates what can be achieved in a dedicated practice.

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REFERENCES


Levator Hinge Procedure And Upper Eyelid Retraction