Strabismus after Deep Lateral Wall Orbital Decompression in Thyroid-Related Orbitopathy Patients Using Automated Hess Screen

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Purpose: To evaluate the effect of deep lateral wall orbital decompression with intraconal fat debulking on strabismus in thyroid-related orbitopathy (TRO) patients using automated Hess screen (AHS).

Design: Prospective nonrandomized clinical study.

Participants: Eleven TRO patients (19 surgeries) operated on at the Jules Stein Eye Institute from January, 2004, through December, 2004.

Methods: Automated Hess screen testing was performed in all patients before surgery and 3 months after surgery; all patients received surgery in the nonactive phase of the disease.

Main Outcome Measures: Amplitude of horizontal and vertical deviations (prism diopters) in all standard positions of gaze.

Results: Eleven TRO patients (7 females; mean age, 47 years) were included in the study; 8 patients underwent bilateral surgery. After surgery, exophthalmos decreased an average (±standard deviation) of 2.7 mm (±2.5 mm; $P = 0.003$). Before surgery, 7 patients (63%) reported primary gaze diplopia, whereas only 2 patients (18%) showed diplopia in primary gaze after surgery ($P = 0.03$, chi-square analysis). Orbital decompression had no statistically significant effect on horizontal and vertical ocular deviations measured by AHS. Mean amplitude of deviation in primary gaze was 1.2 prism diopters (PD) esotropia and 0.07 PD hypotropia before surgery, and 2.5 PD exotropia with 0.6 PD hypertropia after surgery ($\delta = 3.7$ PD for horizontal deviation and -0.7 for vertical deviation; $P = 0.051$, paired samples t test for horizontal difference and P not significant for vertical difference). Nonsignificant P values were obtained in all 9 positions of gaze. Most patients had periocular numbness that resolved spontaneously 2 to 6 months after surgery.

Conclusions: Deep lateral wall orbital decompression with intraconal fat debulking had no statistically significant effect on horizontal and vertical deviations measured by the AHS. Patients may demonstrate small angle exotropia shift, but this finding was not clinically significant. *Ophthalmology 2006;113:1050–1055 © 2006 by the American Academy of Ophthalmology.*

Orbital decompression is an important cornerstone in the surgical rehabilitation of thyroid-related orbitopathy (TRO) patients. It is performed to treat disfiguring proptosis,[1] along with corneal exposure and optic neuropathy.[2,3]

Several surgical options are considered in orbital decompressions, including removing the medial, inferior, or deep lateral orbital wall, with or without intraconal fat debulking.[4–8] Surgery is tailored to each patient, and often patients with more severe proptosis will require additional and extensive tissue removal, with removal of bone, intraconal fat, or both. Surgery is performed only during the nonactive phase of the disease, initially with orbital decompression, followed by eye muscle surgery and some type of eyelid retraction procedures with or without upper eyelid blepharoplasty.[9,10]

One of the more common complications associated with orbital decompression is development or worsening of diplopia, with primary or downgaze diplopia being most cumbersome.[8,11–14] Medial wall and floor decompression surgeries are associated with up to 30% of new-onset strabismus,[4] whereas deep lateral wall decompression may be associated with a much lower rate of new-onset diplopia (2%–15%).[6,15–17] Recently, we published results that showed a new-onset primary gaze diplopia rate of only 2.6% in patients with mild to moderate TRO undergoing deep lateral wall decompression with intraconal fat debulking.[15]

To understand the biomechanics of this surgical technique and to analyze its influence on ocular deviations, we

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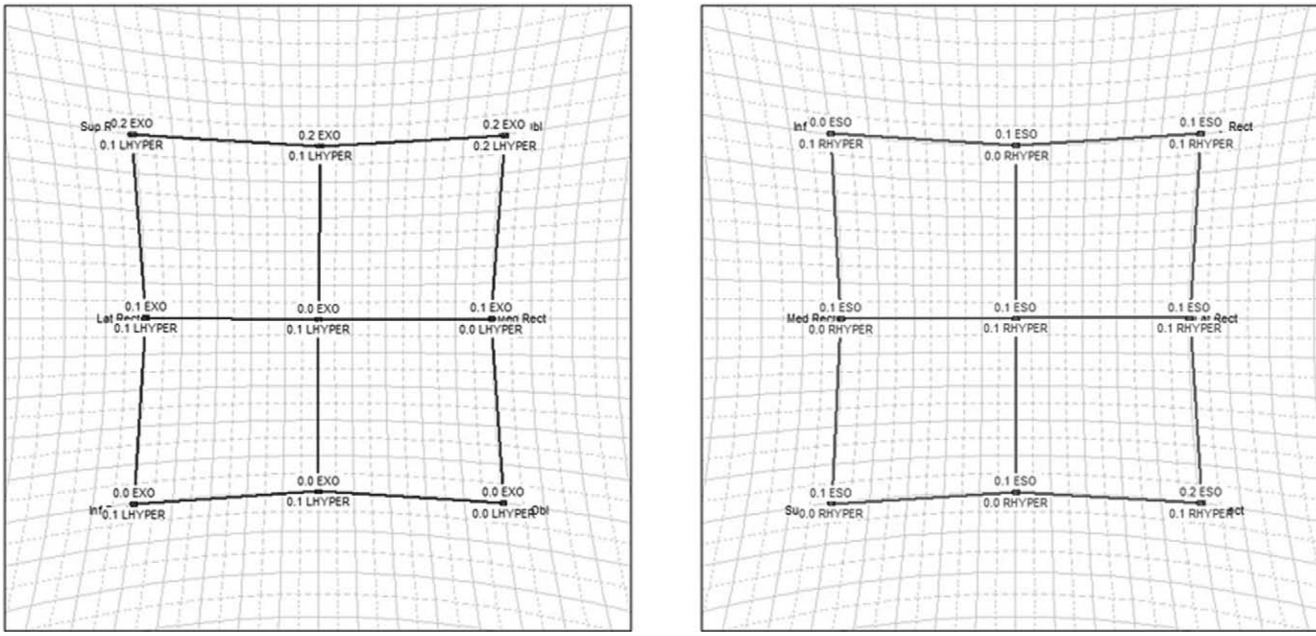

Figure 1. Output of automated Hess screen (AHS) used in the current study in a healthy participant. Left image shows field of the left eye (right eye fixating), and right image shows field of the right eye (left eye fixating). Horizontal and vertical strabismus measurements (amplitude of deviations) in prism diopters are shown in all 9 positions of gaze. ESO = esotropia; EXO = exotropia; LHYPER = left hypertropia; RHYPER = right hypertropia.

used an automated Hess screen (AHS)[18] before surgery and after surgery in TRO patients undergoing deep lateral wall decompression. The purpose of the current study was to describe surgical effect on ocular deviations as assessed by AHS testing.

Patients and Methods

We evaluated in a prospective fashion 11 consecutive TRO patients who were scheduled to undergo deep lateral wall orbital decompression with intraconal fat debulking at the Jules Stein Eye Institute from January, 2004, through December, 2004. Comprehensive eye examination was performed in all patients. Automated Hess screen testing was performed 2 to 4 weeks before surgery. All patients were operated on during the nonactive phase of the disease. The AHS test was repeated 3 months after surgery, and amplitudes of horizontal and vertical deviations in all 9 positions of gaze were recorded. The study was approved by the local institutional review board. The indications for decompression surgery in these patients were mostly cosmetic, although some had pressure pain associated with thyroid eye disease.

Automated Hess Screen

We used the AHS testing by Lifelearn Eyecare (School of Optometry, University of Waterloo, Waterloo, Canada; Thompson Software Solutions, City University, London, UK). Testing was performed as follows. The patient was seated with his/her head restrained 30 cm from a 17-inch color monitor and viewed the screen through red–blue goggles.[18] A red target (small circle) was displayed on the screen, and the patient was instructed to move a blue stimulus (larger circle) using a mouse control until the target appeared to be centered on the stimulus. When the patient pressed the left mouse button, the computer registered the relative position of the target and stimulus. This procedure was repeated for a range of target locations (9 positions of gaze), and the entire routine then was repeated with the other eye fixing, by reversing the color of the target and stimulus. The amplitude of horizontal and vertical deviation in each position of gaze of was calculated and displayed on the monitor along with the AHS results. Patients were given 1 to 2 practice tests to acclimate to the use of the AHS testing. Figure 1 shows an example of AHS testing in a normal participant.

Each point on the AHS was numbered 1 through 9 to match preoperative and postoperative points. Esodeviation was marked as positive horizontal deviation (+), and exodeviation was marked as negative horizontal deviation (−). Similarly, hypertropia (right over left for the right eye and left over right for the left eye) was assigned as a positive vertical deviation, whereas hypotropia was marked as a negative (−) vertical deviation. We calculated the difference between horizontal values (before surgery minus after surgery) in all 9 positions of gaze and in vertical values (before surgery minus after surgery) in all 9 positions of gaze. Cyclodeviations were not measured in the current study.

Surgical Technique

The surgical technique was described previously.[5] The orbital surface of the sphenoid bone was exposed through an eyelid crease incision. Using a high-speed neurosurgical drill, cortical bone was removed from the lacrimal gland fossa, the marrow space of the sphenoid between the superior and inferior orbital fissure, and the zygomatic marrow space on the anterior rim of the inferior orbital fissure. The extent of bone removal was individualized: patients with substantial proptosis (for example, more than 26 mm) underwent maximal bone removal from each of the 3 areas, but patients with lesser degrees of proptosis were treated with a more conservative bone removal. In all patients, the maximal available intraconal fat, located between the lateral and inferior rectus muscle, was dissected bluntly out of the muscle cone and was excised. The volume of fat removed ranged from 1.5 to 3 ml.

Table 1. Preoperative and Postoperative Data from 11 Thyroid-Related Orbitopathy Patients Undergoing Deep Lateral Wall Orbital Decompression at the Jules Stein Eye Institute, January, 2004, through December, 2004

	Preoperative	Postoperative	P Value
Exophthalmos (mm)	23.1	20.4	0.003
Visual acuity	20/25	20/20	NS
IOP (mmHg)	19.2	16.8	NS
IOP (upgaze)	22.4	22.2	NS
Primary gaze diplopia	7 (63%)	2 (18%)	0.03

IOP = intraocular pressure; NS = not significant.

Statistical Analysis

The Wilcoxon signed-rank test was used to compare preoperative and postoperative values of visual acuity, intraocular pressure, and exophthalmos. A paired samples *t* test was used to calculate the difference in ocular deviations measured by AHS testing; one sample *t* test was used to calculate δ values of amplitudes of deviations. Cross tabs and chi-square analysis was used to calculated proportion difference for patients with primary gaze diplopia before surgery and after surgery. Pearson bivariate correlation was used to evaluate preoperative and postoperative amplitudes of deviations in all positions of gaze. Conversion of Snellen acuity to a logarithm of the minimum angle of resolution value was performed. Statistical analysis was carried out using Microsoft Excel 2003 (Microsoft Corporation, Redmond, WA) and SPSS software version 13.0 (SPSS, Inc., Chicago, IL).

Results

Eleven TRO patients (7 females; mean age, 47 years) who underwent 19 deep lateral wall orbital decompressions with intraconal fat debulking surgeries were included in the study; 8 patients underwent bilateral surgery. After surgery, exophthalmos decreased an average ($\pm$standard deviation) of 2.7 mm ($\pm$2.5 mm; $P = 0.003$, Wilcoxon signed-rank test). Visual acuity remained unchanged after surgery (δ logarithm of the minimum angle of resolution visual acuity, 0.03; $P = 0.2$, one-sample *t* test; Table 1).

Before surgery, 7 patients (63%) reported primary gaze diplopia, whereas only 2 patients (18%) showed diplopia in primary gaze after surgery ($P = 0.03$, chi-square analysis). Only 2 patients had clinically significant postoperative strabismus and required eye muscle surgery after undergoing orbital decompression.

Overall, patients showed a very low degree of strabismus before and after surgery with amplitudes of deviations ranging from 1.6 PD exotropia to 1.2 PD esotropia and 1.1 PD hypertropia to 2.2 PD hypotropia before surgery and 2.5 PD exotropia to 0.7 PD esotropia with 1.2 PD of hypertropia to -2.8 PD of hypotropia after surgery. Positive correlation was found between preoperative and postoperative vertical deviations ($R = 0.87$; $P = 0.002$, Pearson bivariate correlation), but not in horizontal deviations (Fig 2).

Orbital decompression had no statistically significant effect on horizontal and vertical ocular deviations measured by automated Hess screen. Mean amplitudes of deviations in primary gaze were 1.2 PD esotropia and 0.07 PD hypotropia before surgery, and 2.5 PD exotropia with 0.6 PD hypertropia after surgery ($\delta = 3.7$ PD for horizontal strabismus and -0.7 for vertical strabismus; $P = 0.051$, paired samples *t* test for horizontal difference and *P* not significant for vertical difference). Nonsignificant *P* values were obtained in all 9 positions of gaze (Table 2); the lack of statistically significant influence of surgery on postoperative horizontal and vertical strabismus is reflected by low δ values and nonsignificant *P* values as shown in Table 2 (paired samples *t* test).

Interestingly, the largest δ value was measured in horizontal strabismus in primary gaze (3.7-PD exotropia shift); this small angle deviation, however, does not represent clinically significant strabismus. Subgroup analysis of patients with no preoperative primary gaze diplopia showed similar results, with no effect of surgery on horizontal and vertical strabismus in all positions of gaze; none of the *P* values were significant (data not shown). No correlation was found between the changes in ocular deviation and preoperative exophthalmos (Pearson bivariate correlation).

No severe complications such as visual loss, cerebrospinal fluid leak, or death occurred in this group of patients. Most patients reported periocular sensory anesthesia that resolved spontaneously 2 to 6 months after surgery.

Discussion

The current study shows that deep lateral wall orbital decompression with intraconal fat debulking had no statistical effect on horizontal and vertical ocular deviations measured by AHS testing. These results support our previous report[15] and our assumption that minimal to no ocular shift occurs with this type of orbital decompression.

Automated Hess screen testing using a personal computer was found to be a viable alternative to electronic Hess screen testing and showed similar amplitudes of deviation in patients with a wide range of oculomotor problems.[18] We used AHS testing in the current study for its simplicity to operate, and it can be performed by the treating physician as a part of a comprehensive eye and orbital evaluation of the TRO patients. The average time for each test was 5 to 10 minutes, and this time diminishes with repeated tests. We believe that the AHS is a good test for follow-up of TRO patients with ocular motility disturbances; however, this was not assessed in the current study.

A recent study[19] examined the mechanism of ocular motility disturbances after orbital decompression surgery. The investigators used magnetic resonance imaging to measure the positions and the displacements of the anterior rectus muscle paths. In general, postoperative muscle path positions were similar to preoperative positions and to those of normal participants. However, centrifugal displacement of the inferior rectus and the medial rectus muscles was noted. The amount of muscle displacement (inferior rectus or medial rectus) was directly correlated with severity of vertical and horizontal diplopia. The authors concluded that the anterior orbital connective tissue is capable of keeping the rectus muscle path aligned after orbital decompression surgery except for the inferior rectus and medial rectus muscles. Their results may be explained by the type of decompression surgery used in their study, which included translid (2 walls: medial and inferior) or coronal (bilateral 3 walls: medial, inferior, and deep lateral) approaches. Interestingly, patients in our study displayed more exotropia after surgery. This may reflect a small lateral displacement or lateral rotation of the globe after tissue has been removed from the deep lateral wall, more specifically the marrow space between the superior and inferior orbital fissures and

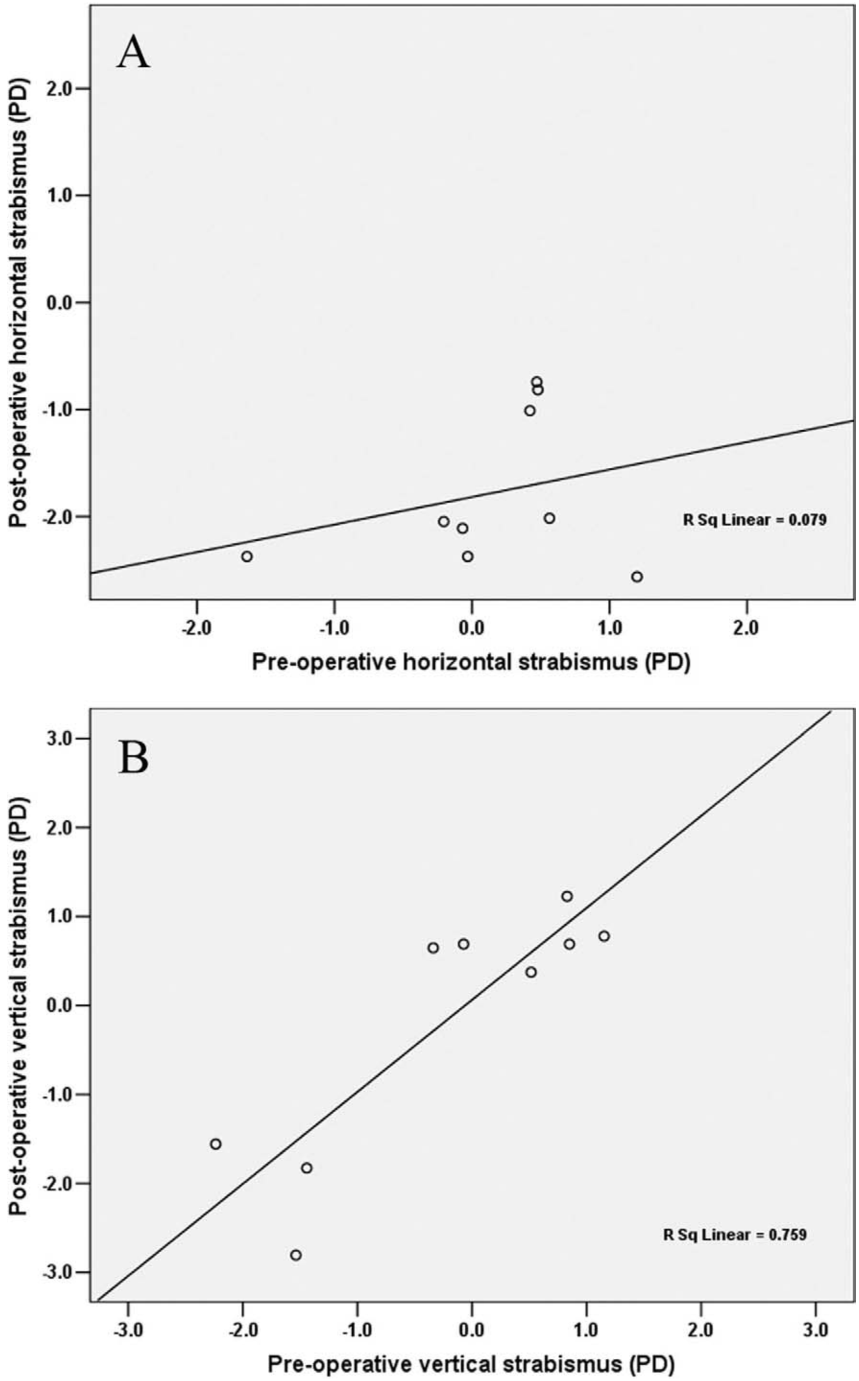

Figure 2. Scatter plots of preoperative and postoperative (**A**) horizontal and (**B**) vertical strabismus in 11 thyroid-related orbitopathy patients who underwent deep lateral wall orbital decompression. Positive correlation was found between preoperative and postoperative vertical strabismus. Amplitudes of deviations were obtained using automated Hess screen and are shown in prism diopters (PD). Negative values imply exotropia or hypotropia, whereas positive values imply esotropia or hypertropia.

intraconal fat between the lateral and inferior recti muscles. This is only a small angle deviation that may not imply any clinically evident strabismus.[15] Automated Hess screen testing is inexpensive and can be implemented easily in routine ocular examinations of TRO patients. It seems to provide accurate measurements of ocular deviations and should be considered as a routine test in TRO patients, especially those with ocular motility disturbances.

Orbital decompression surgery involving removal of the medial and inferior orbital walls may be associated with a relatively high rate of postoperative new onset strabismus.[4,20,21] This can be lowered by preservation of the

Table 2. Preoperative and Postoperative Automated Hess Screen for 11 Thyroid-Related Orbitopathy Patients Who Underwent 19 Orbital Decompression Surgeries

Pair*	Preoperative (Δ)	Postoperative (Δ)	Delta (Δ)	P Value
1				
H1	−0.06	−2.1	2.0	NS
V1	−1.9	−2.8	0.9	
2 (upgaze)				
H2	−0.03	−2.3	2.3	NS
V2	−1.8	−1.8	0.2	
3				
H3	−1.6	−2.3	0.7	NS
V3	−2.2	−1.5	0.6	
4				
H4	0.15	−1.9	1.6	NS
V4	−0.3	0.6	−0.9	
5 (primary gaze)				
H5	1.2	−2.5	3.7	0.051
V5	−0.07	0.6	−0.7	NS
6				
H6	0.5	−2.0	2.5	NS
V6	0.5	0.3	0.1	
7				
H7	0.4	−0.8	1.1	NS
V7	0.8	1.1	−0.4	0.01
8 (downgaze)				
H8	0.4	−1.0	1.4	NS
V8	1.1	0.7	0.3	
9				
H9	0.4	−0.8	1.2	NS
V9	0.8	0.6	0.1	

H = horizontal; NS = not significant; V = vertical; Δ = prism diopters. Data represent average amplitudes of deviations for all patients.
*Nine measurements were obtained by automated Hess test, in each point horizontal (H) and vertical (V) deviations, are shown. Positive values refer to esodeviation, whereas negative values refer to exodeviation; for vertical strabismus, positive values refer to hypertropia, whereas negative values refer to hypotropia depending on the tested eye. Pair 5 represents primary gaze strabismus, pair 2 represents upgaze, and pair 8 represents downgaze.

maxilloethmoidal strut or by performing a balanced decompression of the medial and deep lateral orbital walls.[8,16,17] Patients with mild to moderate proptosis may benefit from deep lateral wall orbital decompressions with or without intraconal fat debulking. This surgery was shown to be associated with a relatively low rate of new-onset primary gaze diplopia.[15] Orbital decompression may be the first step in the rehabilitation of TRO patients with eye muscle surgery, if needed and performed at a later stage. Interestingly, one study described eye muscle surgery performed at the same session of orbital decompression to reduce the rate of postoperative diplopia.[22] Eyelid retraction surgery is usually reserved as the last step (with or without concurrent blepharoplasty) because large recessions of vertical muscles may alter eyelid positions. We recently showed that eyelid retraction surgery may be performed simultaneously with deep lateral wall orbital decompression without affecting functional and cosmetic outcomes.[10]

We do not claim that AHS testing is a better method for evaluating postoperative strabismus than testing the field of binocular vision. It is a relatively simple test, is inexpensive, and can be performed at the clinic by the treating ophthalmologist or by an ophthalmic technician. It may offer a more accurate way of following up ocular deviations in patients rather than using an arbitrary scale, as is commonly used in many ophthalmic plastic clinics. In addition, it is less time consuming than measuring ocular deviations using prisms. One of the main purposes of the manuscript was to examine the effect of deep lateral wall orbital decompression on ocular deviations; AHS was used for this purpose. We do not claim by any means that it is superior to standard prism testing. It adds to our armamentarium of evaluating TRO patients, and we believe that should be implemented in the routine ocular examination of these patients.

In summary, we suggest the use of AHS testing to monitor ocular motility disturbances and ocular deviations after orbital decompression in TRO patients. Using this test, we showed that deep lateral wall orbital decompression with intraconal fat debulking, although proving effective in proptosis reduction, is not associated with horizontal and vertical ocular deviations in all positions of gaze. Primary gaze small-angle exotropia may ensue after deep lateral wall decompression, but this may not be clinically apparent.

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