Strabismus Research Update

ARVO Asia

(Association for Research in Vision and Ophthalmology)

Brisbane 2017

Lionel Kowal Melbourne

With help from recent Fellows
Drs Sheth, Kini, Mitchell

No financial conflicts

Today: Some of the advances in recent years that have changed or are changing the understanding & treatment protocols and options in sensory and motor strabismus

AMBLYOPIA

PEDIG & MOTAS

- Rx often based on quantifying the sensory asymmetry & treating it with asymmetric treatments
- Glasses alone sometimes effective
- Less treatment is often as effective as more
- **Atropine** [used for 100 yrs] & **opaque occlusion** [used for 300 yrs] : equivalent effect for many pts
- ***There are NO other treatments still used in medicine that are as old as these***

21st Century Amblyopia Rx
High Tech Asymmetric Rx 1

Binocular treatment of **amblyopia** using videogames (**BRAVO**): study protocol for a randomised controlled trial.

Guo CX, ….Kowal L….Trials. 2016 Oct 18;17(1):504

Using asymmetric high tech inputs

- Blurred video game to good eye
- Clear video game to amblyopic eye

Results expected in next few weeks

21st Century Amblyopia Rx 2

- Effect of a Binocular iPad Game vs Part-time Patching in Children Aged 5 to 12 Years With **Amblyopia**: A Randomized Clinical Trial.
- Holmes JM, ……PEDIG
- JAMA Ophthalmol. 2016 Dec 1;134(12):1391-1400

……

- **Binocular Treatment of Amblyopia in Children: Teething Problems on the Path to Clinical Practice.**
- Dahlmann-Noor A[1]. JAMA Ophthalmol. 2016 Nov 3

21st Century Amblyopia Rx 3

The role of Interactive Binocular Treatment system in amblyopia therapy.

J Curr Ophthalmol. 2016 Aug 9;28(4):217-222.

Rajavi Z[1], et alii

.....

- **Invited Commentary**
- **New Treatments for Amblyopia—To Patch or Play?**
- John Sloper,Moorfields, London
- *JAMA Ophthalmol.* Published online November 10, 2016. doi:10.1001/jamaophthalmol.2016.4296

Editorial

Treatment of amblyopia: the "eye pad," or the iPad?

David G. Hunter, MD, PhD

ter strabismus surgery thanks to binocular summa-

For more than 100 years, ophthalmologists have been wagging their fingers at reluctant, amblyopic children, urging them to wear an eye patch that they do not want to wear, while frightened parents have coaxed, begged, bribed, threatened, and cajoled their stubborn little ones to comply. In the current issue of the *Journal of AAPOS*[1] and in a recent issue of the journal *Eye*,[2] Birch and colleagues have conducted the first pediatric studies of a binocular therapy for amblyopia that allows parents to offer their children not an eye patch but an iPad. In both studies, children who played games on a handheld tablet computer equipped with red-green glasses had a statistically significant improvement in visual acuity in the amblyopic eye. Vision was gained with as little as 4 hours of treatment in some cases, with a few patients improving to 20/20. Are we ready, then, to abandon the burden of forced monocular occlusion in favor of encouraging our young patients to play binocular video games on their tablet computers? Unfortunately, no, we are not—not just yet, anyway.

Editorial
J AAPOS
Feb 2015

- Some published data. Many more papers presented @ meetings
- I expect this will a popular 1st treatment for amblyopia
- Commercial competition ++ expected.

Radiology of strabismus: Orbital pulleys

- Orbital pulleys have been recognised >100 yrs [‘poules’ in 19C French literature].
- Clinical relevance has been appreciated for ~20 years and practical application of the knowledge is growing fast

<u>Today:</u>

- Childhood pulley disorders
- Acquired pulley disorders – elderly and high myopes

<u>Pulley surgeries:</u>

- The medial rectus pulley
- The lateral rectus

Radiology of strabismus
Recent findings: orbital pulleys

Incomitant Strabismus Update

The Role of Extraocular Muscle Pulleys in Incomitant Non-Paralytic Strabismus

Robert A. Clark

Middle East African Journal of Ophthalmology, July-Sept, 2015, pp 279-285

Demer, Clark, Miller: Advances in Strabismology

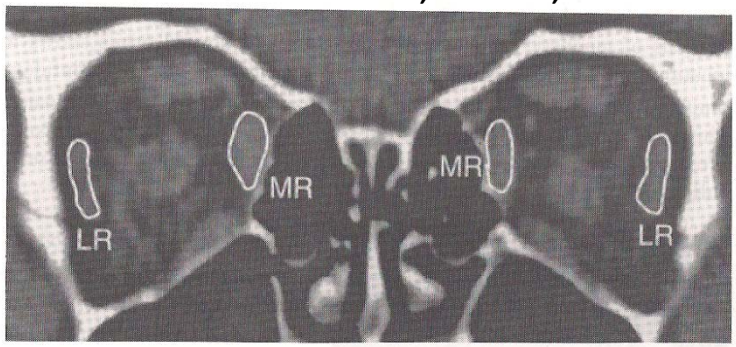


Fig. 2. 211 µm resolution, 1 mm thick coronal CT scan of the orbits of a 5 year old girl with large "V" esotropia and marked overelevation and underdepression of the right eye in adduction. Note inferior displacement of right LR more than left LR.

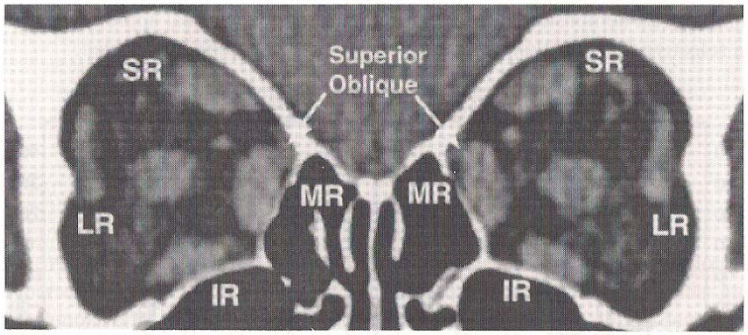


Fig. 3. CT scan of 6 year old girl with "A" pattern esotropia 60Δ greater in elevation than depression. Note LR displaced superiorly and SR displaced nasally in both eyes.

"V" pattern ET
Inf displacement of LR (R>L)
As if orbital contents EXtorted

"A"pattern ET
LR displaced sup to MR and
SR displaced nasal to IR
As if orbital contents INtorted

- Abnormal location of the pulleys could explain many cases of incomitant strabismus, conventionally [& without scientific justification] attributed to 'oblique muscle dysfunction'

J AAPOS

Major Articles

A 12-Year, Prospective Study of Extraocular Muscle Imaging in Complex Strabismus

Joseph L. Demer, MD, PhD,[a,b] Robert A. Clark, MD,[a] Reika Kono, MD, PhD,[c] Weldon Wright, MD,[a,d] Federico Velez, MD,[a] and Arthur L. Rosenbaum, MD[a]

Childhood pulley disorders

12 yo

previous LR & IO weakening for V - XT

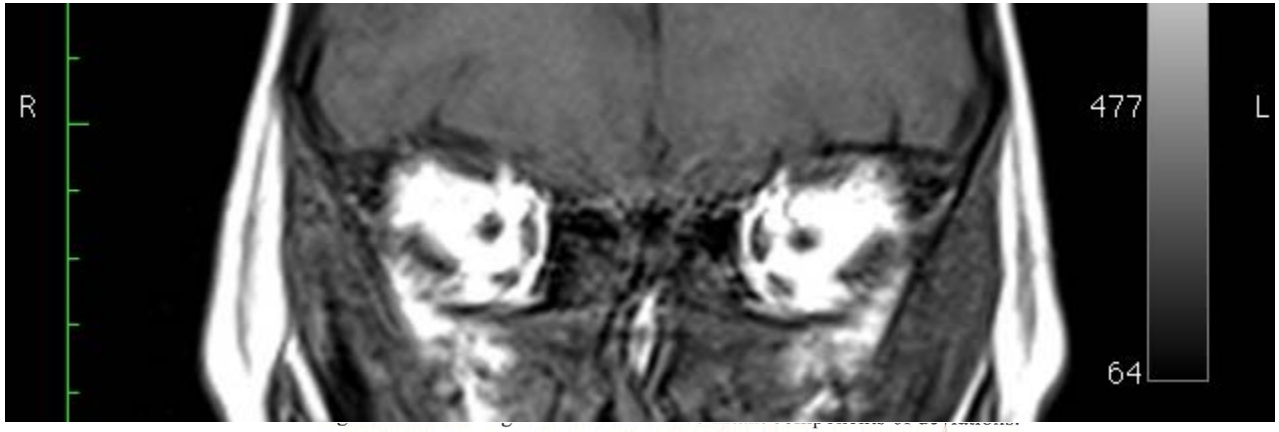
Recurrent / Residual

V- XT [UG 30, DG 10]

Minimal IO OA

No fundus torsion

Coronal MRI T1: inf positioning of LR (L>R), and nasal shift of IR



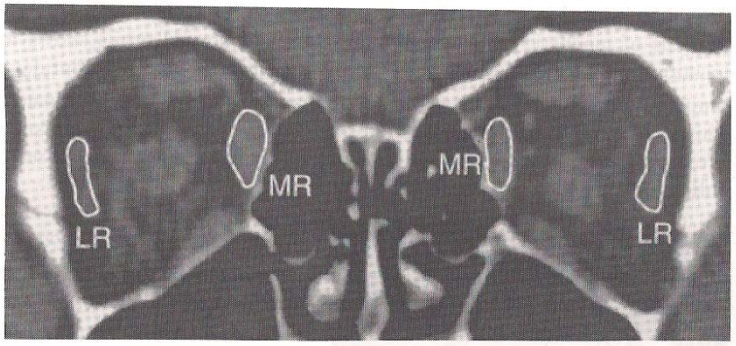


Fig. 2. 211 µm resolution, 1 mm thick coronal CT scan of the orbits of a 5 year old girl with large "V" esotropia and marked overelevation and underdepression of the right eye in adduction. Note inferior displacement of right LR more than left LR.

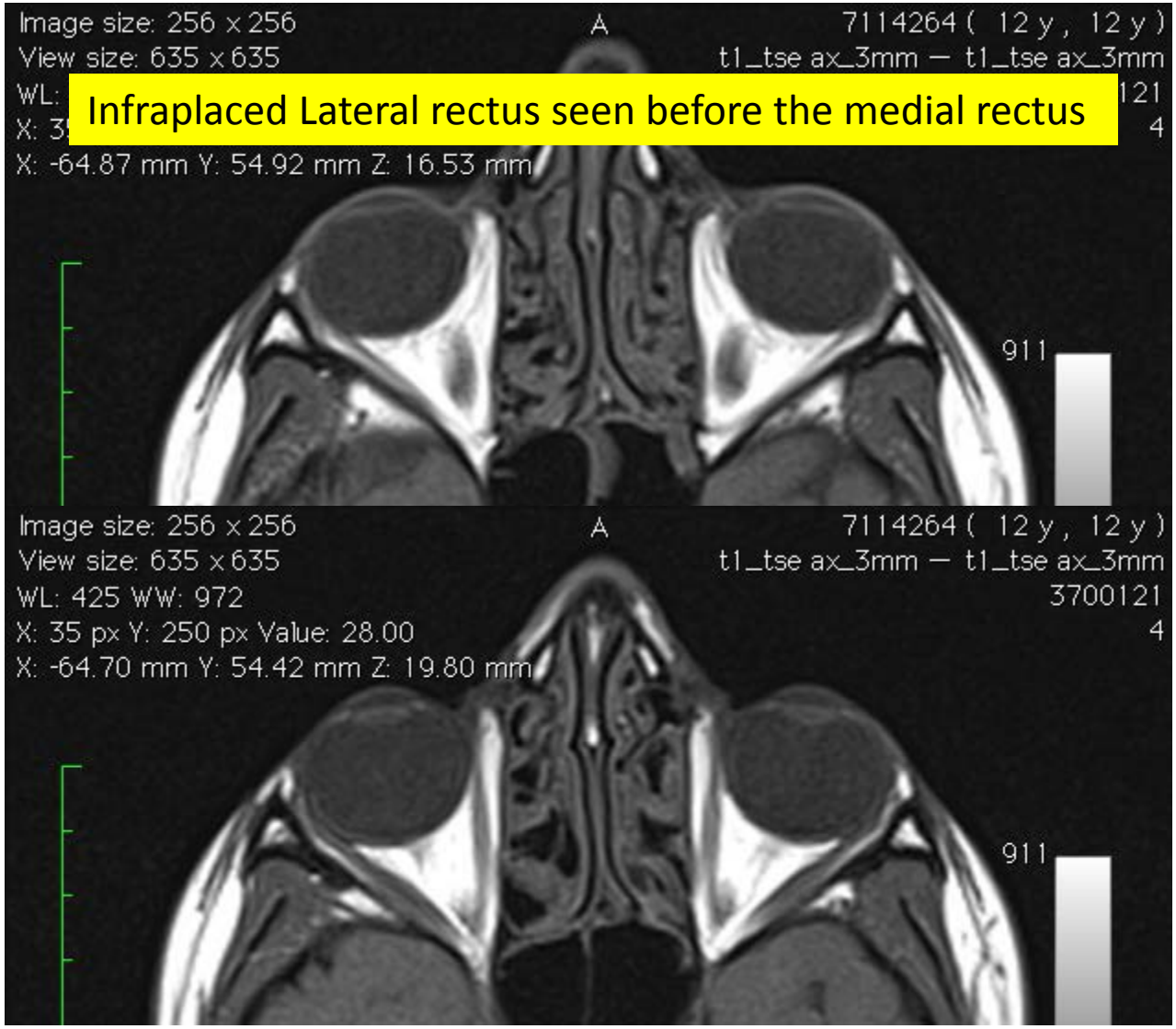
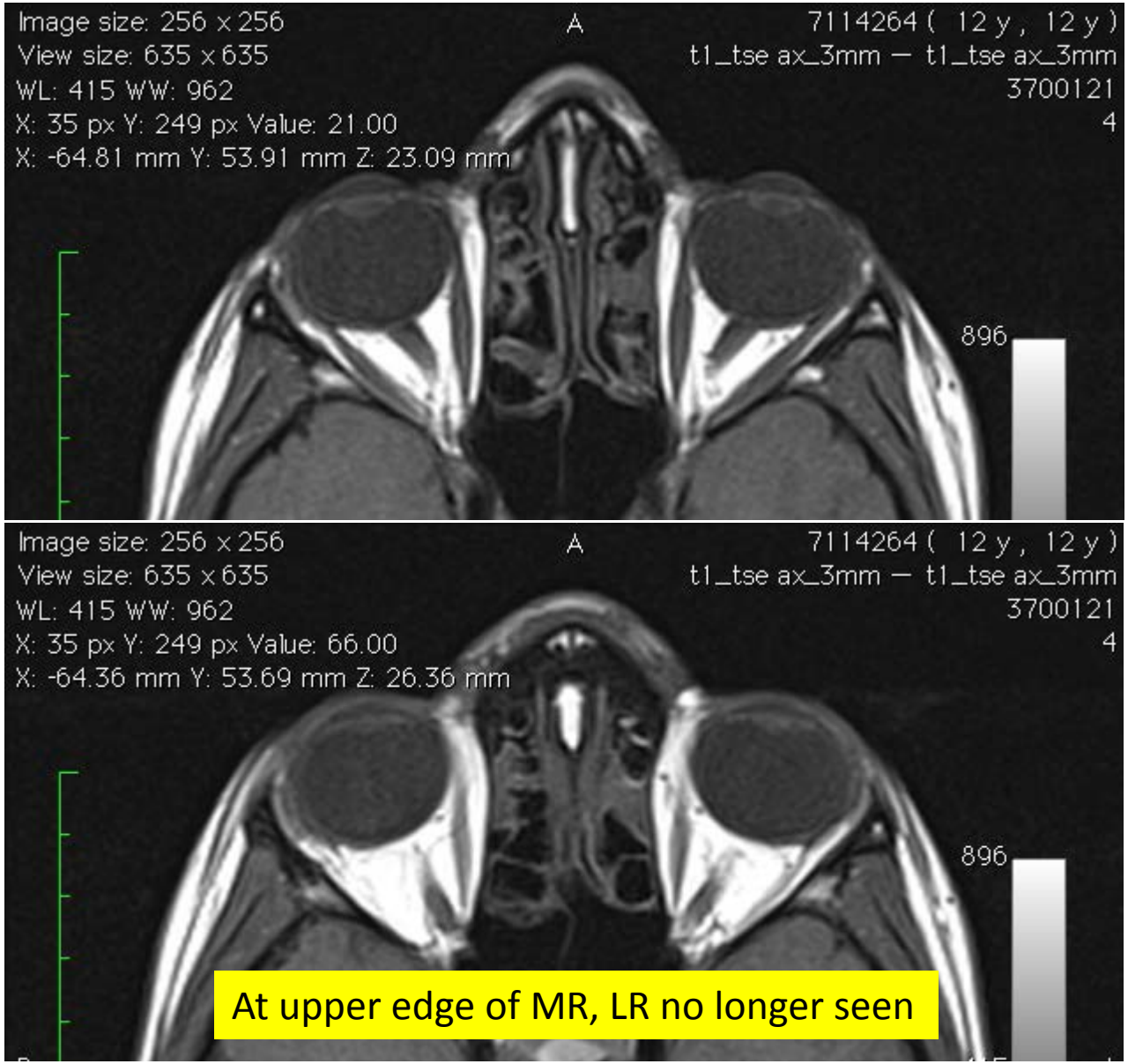


Image size: 256 x 256
View size: 635 x 635
A
7114264 (12 y , 12 y)
t1_tse ax_3mm — t1_tse ax_3mm
Infraplaced Lateral rectus seen before the medial rectus
X: -64.87 mm Y: 54.92 mm Z: 16.53 mm
911
Image size: 256 x 256
View size: 635 x 635
A
7114264 (12 y , 12 y)
t1_tse ax_3mm — t1_tse ax_3mm
WL: 425 WW: 972
X: 35 px Y: 250 px Value: 28.00
X: -64.70 mm Y: 54.42 mm Z: 19.80 mm
911



Childhood pulley disorders: unknown % of childhood strabismus esp incomitant strabismus

Acquired pulley disorders
Common(?est) cause of small angle ET +/- vertical in the healthy elderly

CLINICAL SCIENCES

Sagging Eye Syndrome

Connective Tissue Involution as a Cause of Horizontal and Vertical Strabismus in Older Patients

Zia Chaudhuri, MS, FRCS(Glasg); Joseph L. Demer, MD, PhD

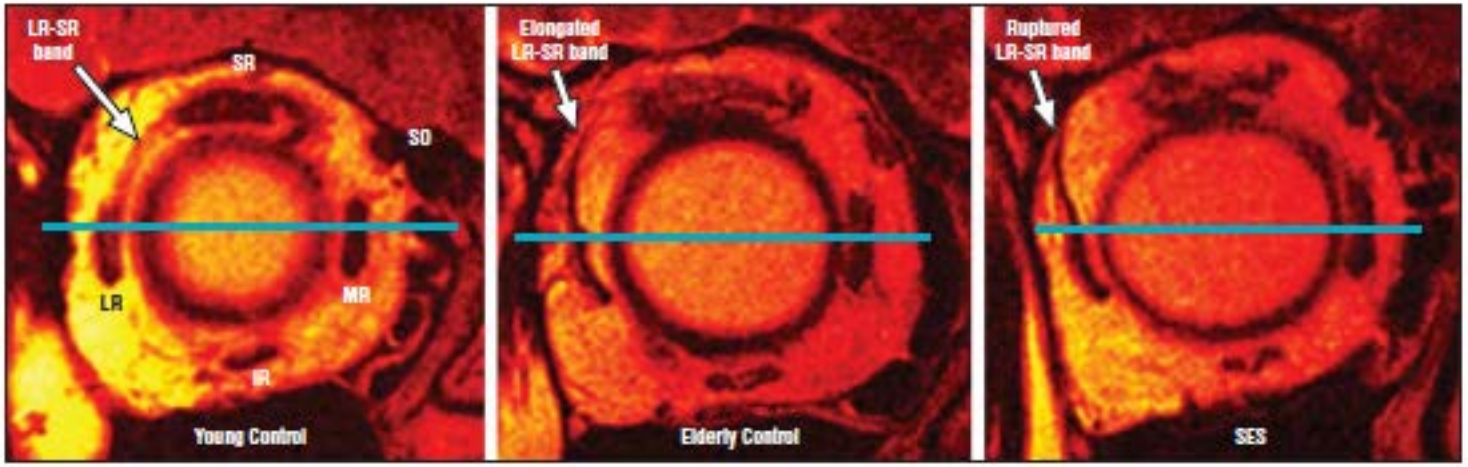
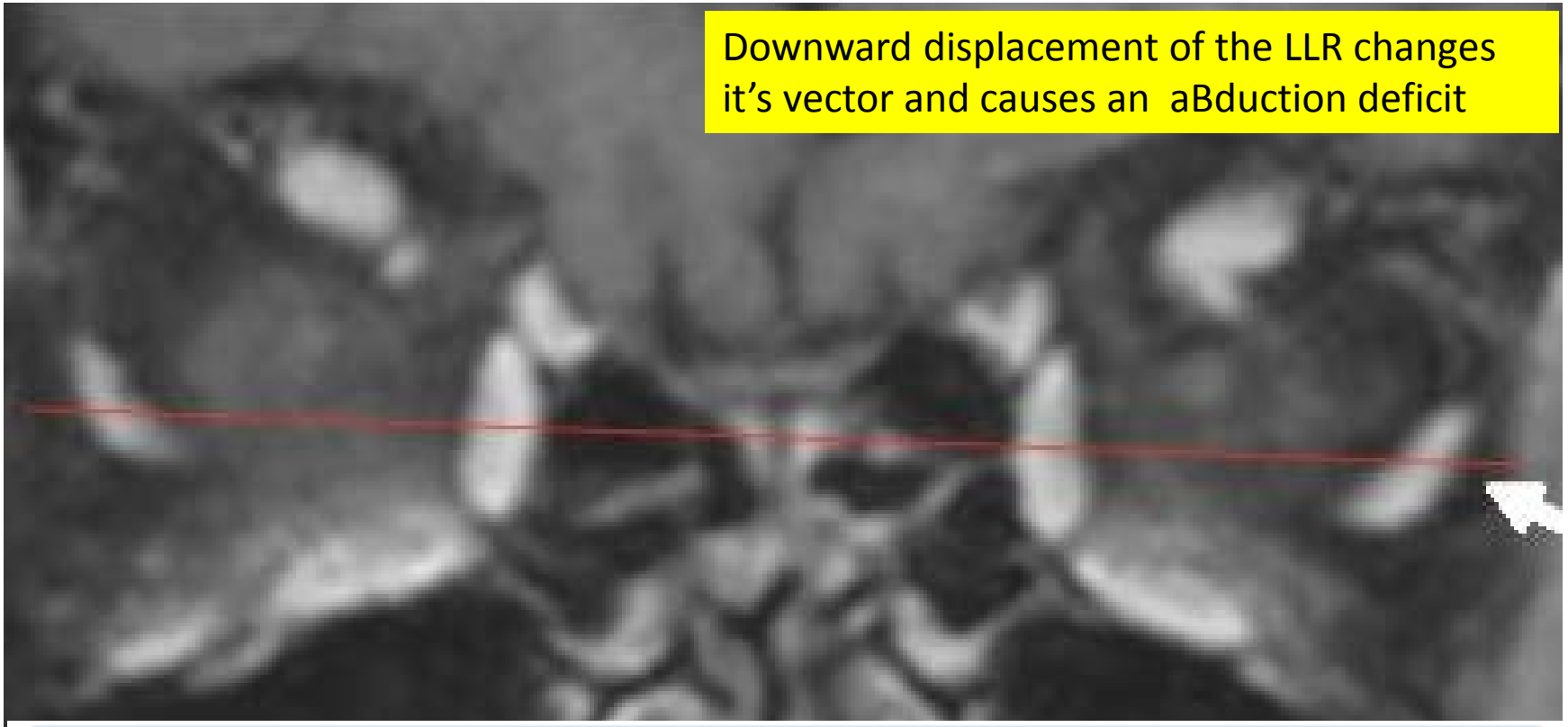


Figure 2. Fast spin-echo T2-weighted sequence quasi-coronal plane magnetic resonance imaging. Left, Younger control participant showing lateral rectus (LR)–superior rectus (SR) band. Note the normal morphology of LR muscle with respect to a horizontal reference line drawn through the globe center. Middle, Elderly control participant demonstrated marked elongation of LR-SR band associated with LR muscle sag. Right, Rupture of LR-SR band in sagging eye syndrome (SES) with resultant LR sag. IR indicates inferior rectus; MR, medial rectus; and SO, superior oblique.

Acquired L ET : Sagging LLR



< Previous Article October 2016 Volume 20, Issue 5, Pages 446.e1–446.e3 Next Article >

J AAPOS

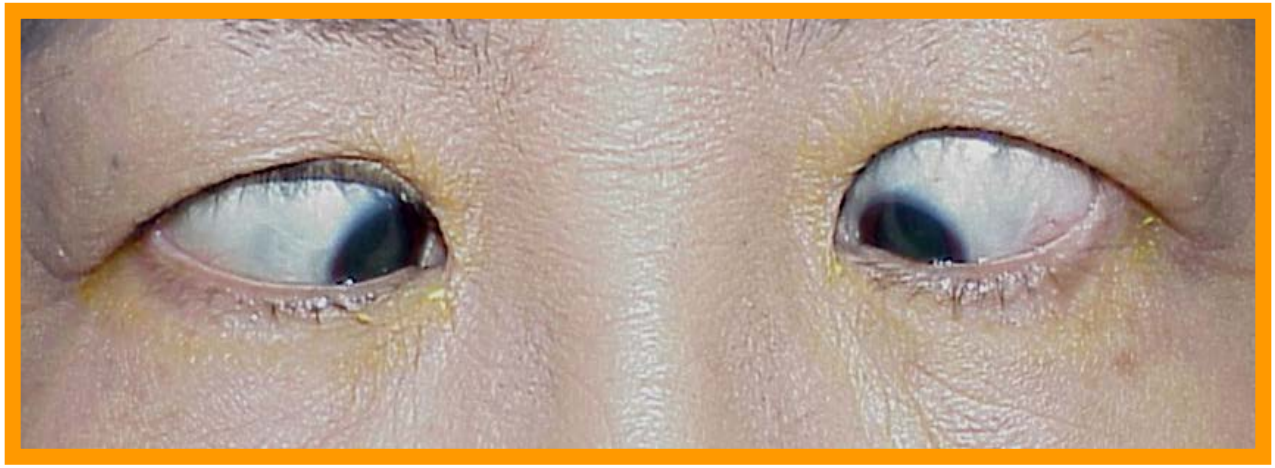
Surgical correction of an inferiorly displaced lateral rectus with equatorial myopexy

Tiana Y. Clark, Robert A. Clark, MD
Family Eye Medical Group, Long Beach, California

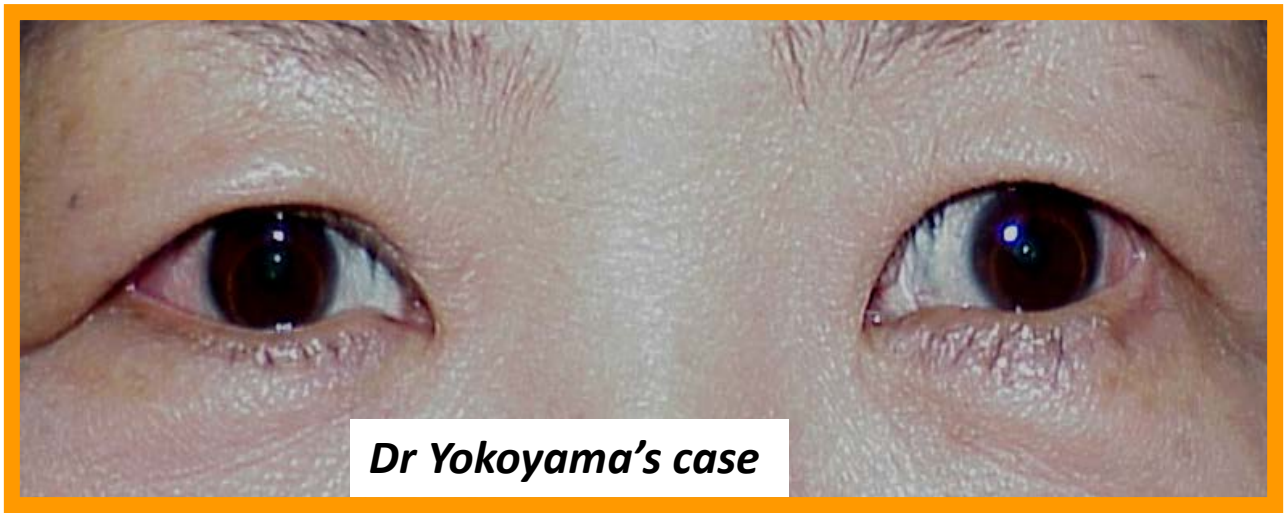
NEW!

Acquired pulley disorders:
Extreme Esotropia of High Myopia [aka Heavy Eye]

Preoperative

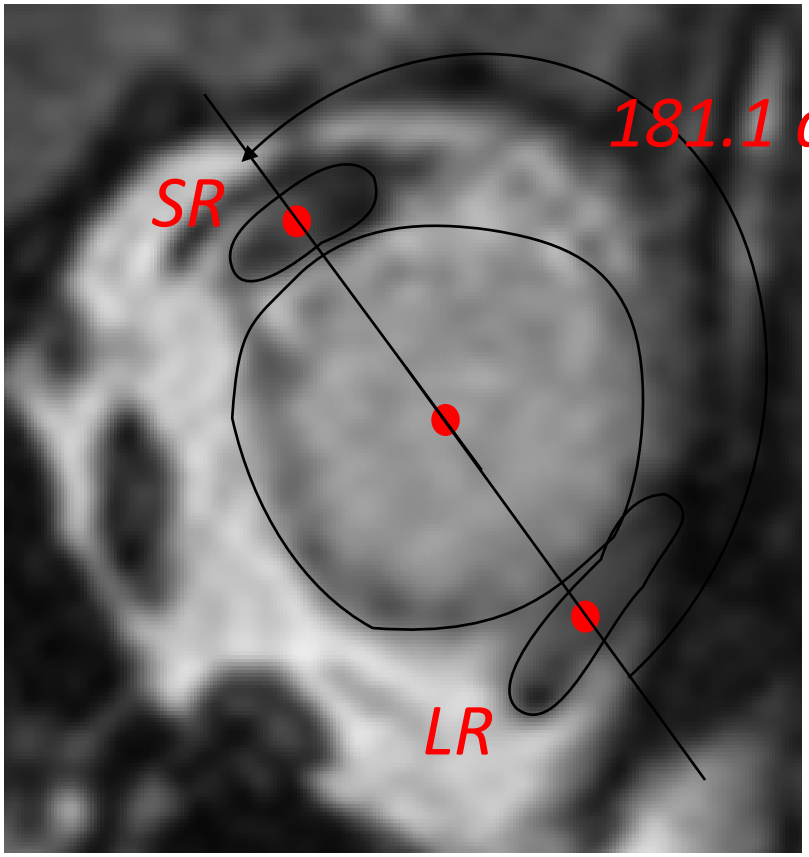


Postoperative (52 days after surgery)

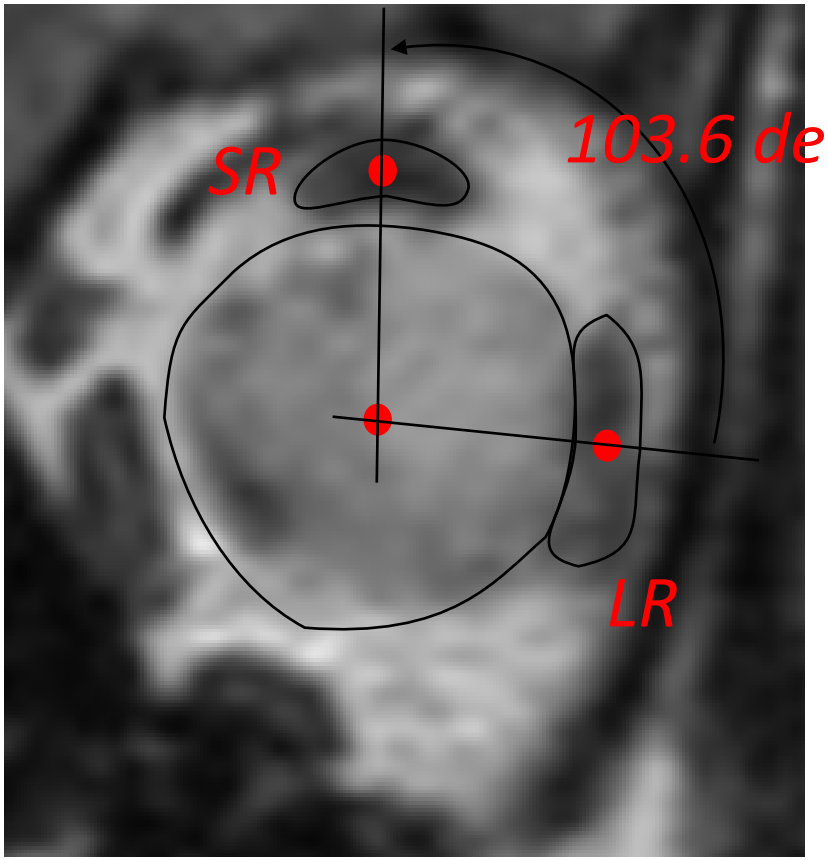


Extreme myopia:

LR displaced down, SR nasal



Preoperative



Postoperative

From Tsuranu Yokoyama

Pulley surgeries:

The medial rectus pulley suture: a safer alternative to posterior scleral fixation

Medial rectus muscle pulley posterior fixation sutures in accommodative and partially accommodative esotropia with convergence excess

Logan Mitchell, MBChB, FRANZCO,[a] and Lionel Kowal, MBBS, FRANZCO[a,b,c]

BACKGROUND The use of medial rectus pulley posterior fixation sutures to treat esotropia with convergence excess has limited support in the literature. We describe our results using this technique to treat patients with large near–distance disparities.

J AAPOS 2012

Each half of each EOM* has a unique non-overlapping nerve supply

Eye (2015) 29, 157–162

www.nature.com/eye

Compartmental-ization of extraocular muscle function

JL Demer

* Compartmentalization not [yet?] demonstrated for superior rectus

abducens motor neuron pools. Humans, monkeys, and other mammals demonstrate separate, nonoverlapping intramuscular nerve arborizations in the superior *vs* inferior compartments of the medial rectus (MR) and lateral rectus (LR) EOMs that could apply force at the superior *vs* inferior portions of scleral insertions, and in the medial *vs* lateral compartments of the superior oblique that act at the equatorial *vs* posterior scleral insertions that might preferentially implement incycloduction *vs* infraduction.

Clinical implications of EOM compartmentalization

- 1. Sup compartment LR atrophy:

Esotropia – of – obscure - cause, not- quite LR palsy

Not rare

- 2. Sup compartment MR atrophy

Progressive exotropia – of- obscure- cause

Rare – no published cases yet

- 3. Medial / Lateral Sup Obl compartment atrophy

Probably explains why some have vertical diplopia vs torsional diplopia vs both V & T

4. Probably Many more incomitant clinical scenarios waiting to be appreciated

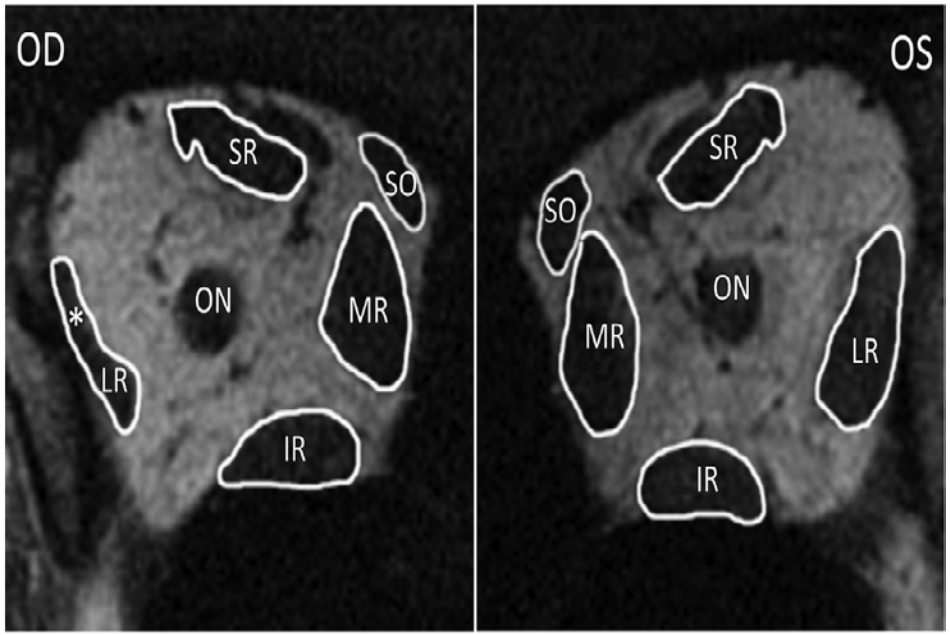
1. Esotropia & compartment hemi-atrophy

- Superior compartment atrophy of the LR produces a clinical condition that resembles LR paresis
- **Clinical picture: more LR function than complete palsy. Treatment implications uncertain**

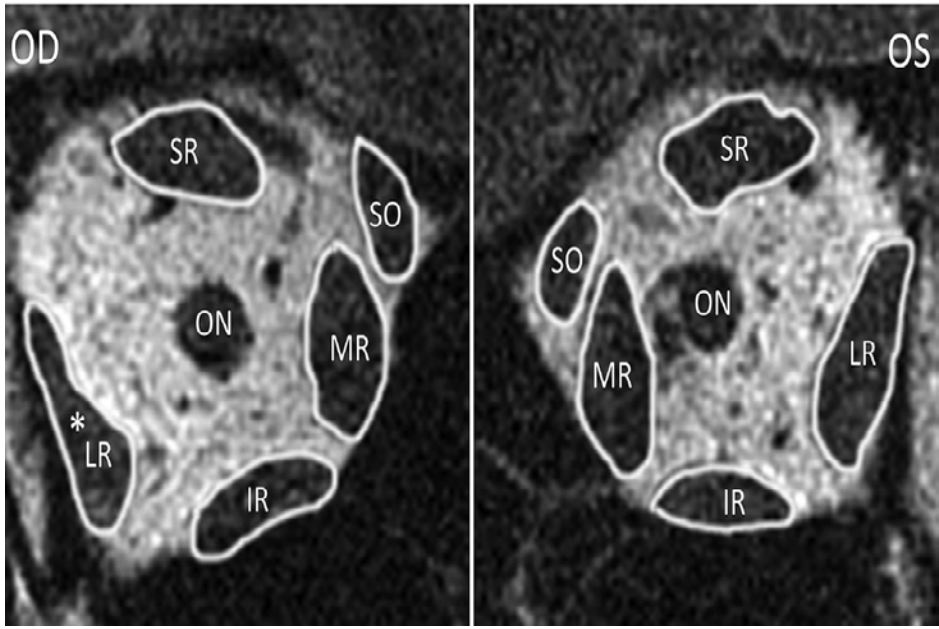
Lateral Rectus Superior Compartment Palsy

ROBERT A. CLARK AND JOSEPH L. DEMER

Clark, R. A., & Demer, J. L. (2014). Lateral rectus superior compartment palsy. American Journal of Ophthalmology, 157(2)



Total RLR atrophy = palsy

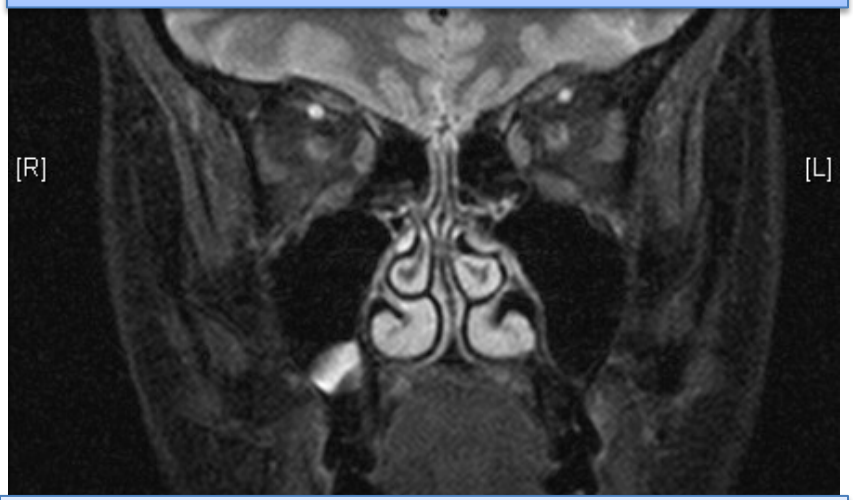


Sup compartment RLR palsy

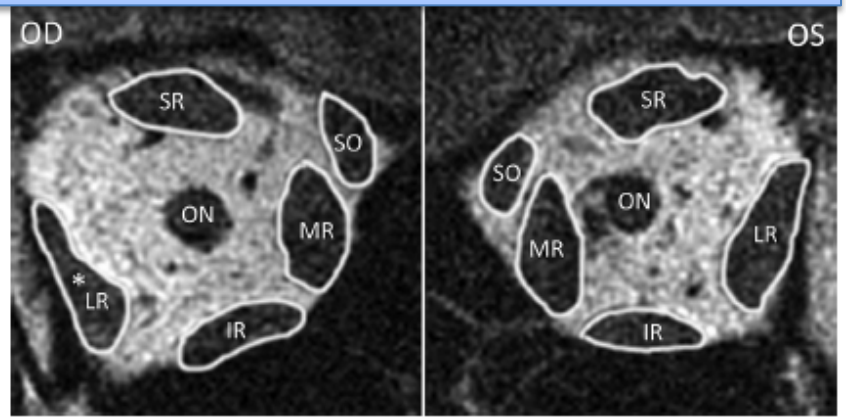
Clinical picture: more LR function than complete palsy. Treatment implications uncertain

Adult ET of uncertain cause
Delayed diagnosis of superior compartment LR paresis

2012 MRI re-read for purpose of a talk.
RLR has a triangular appearance



Clark & Demer Lateral Rectus Sup compartment palsy..
Amer J Ophth 2014; 157: Fig 2 on page 481

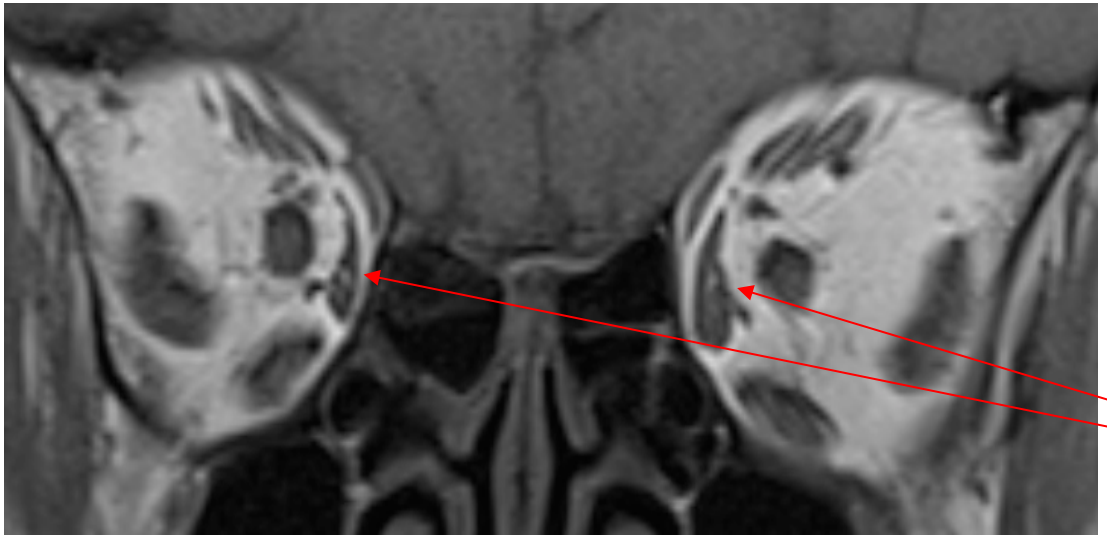


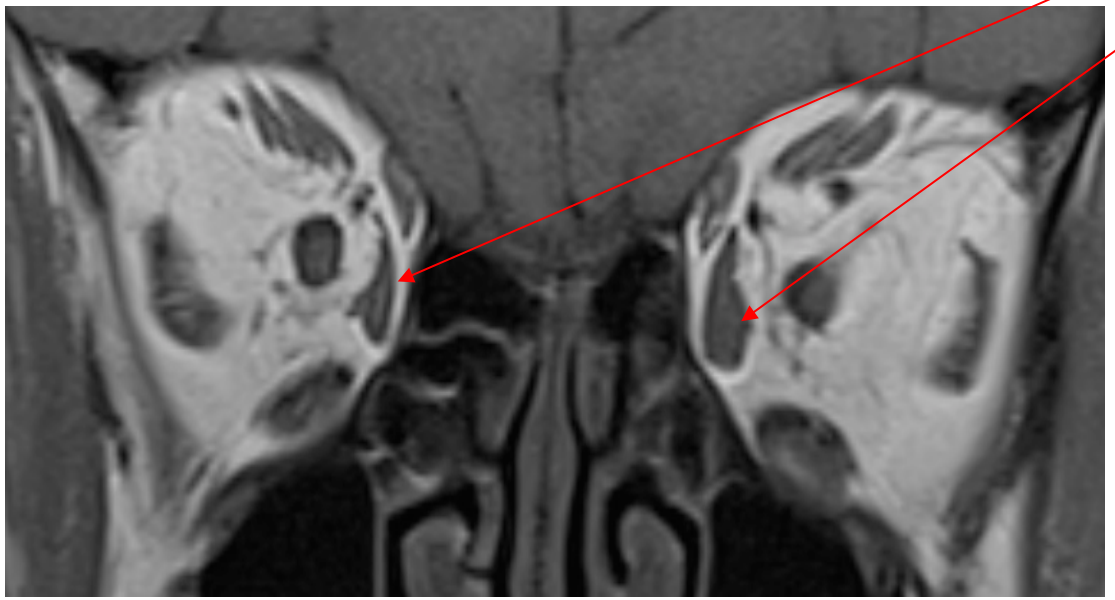
9 years after first presentation and 3 years after the last MRI and the 3rd horizontal rectus surgery, the diagnosis is clearer

2. **Exotropia and compartment hemi-atrophy**

- Diplopia onset 66 yo
- 68yo: increased prism to 10Δ
- 69yo: …to 24Δ
- 70yo: D:50Δ, N: 60Δ

- MR -2mm OU





Bilateral asymmetric atrophy of the superior half of medical rectus compared to inferior

Asymmetry can be expected to produce a small vertical.

Effective lowering of the MR vector might cause an ‘A’ pattern

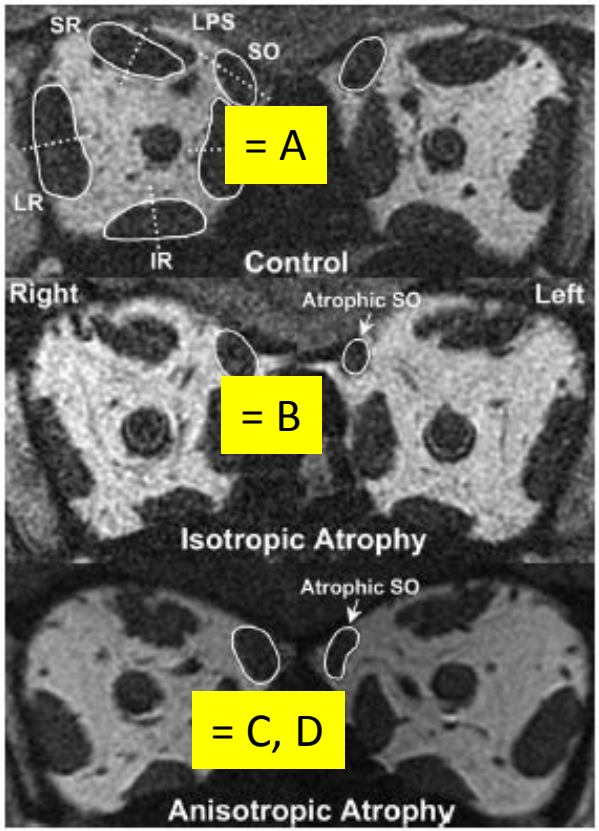
Surgery and Course.

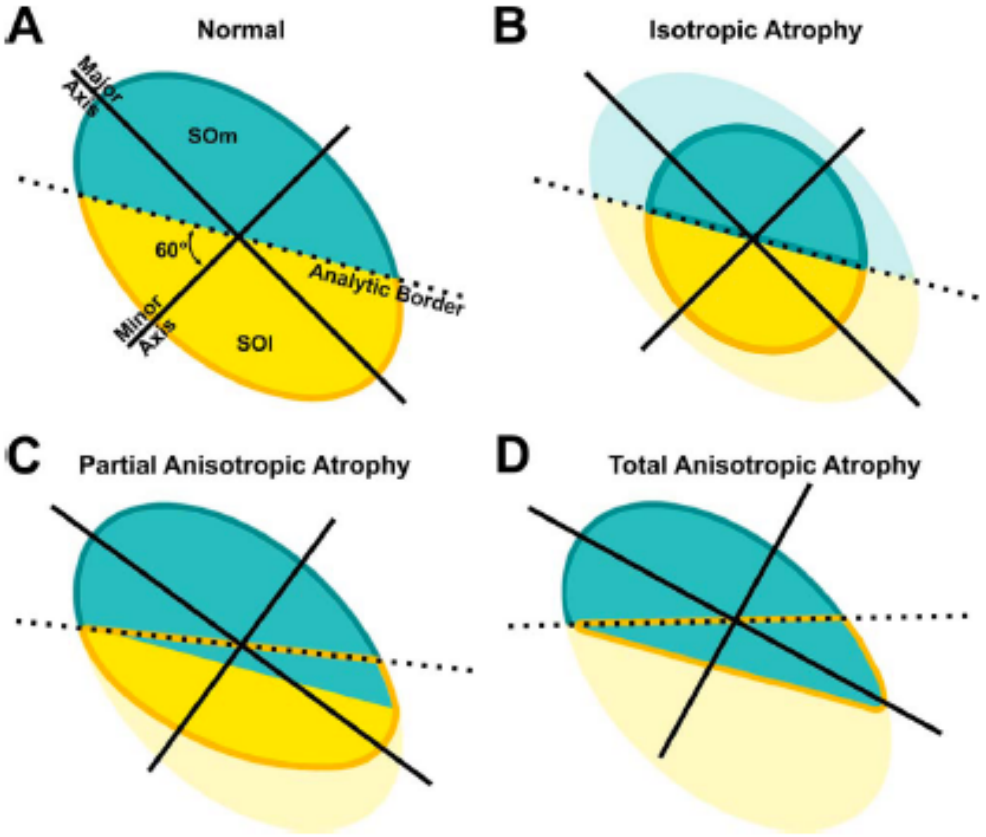
MR plicate/resect OU. LR recess x1. Adjustables.

10 w followup: single vision, small phorias

Different types of Superior Oblique Palsy/Paresis

IOVS | October 2016 | Vol. 57 | No. 13 | 5536





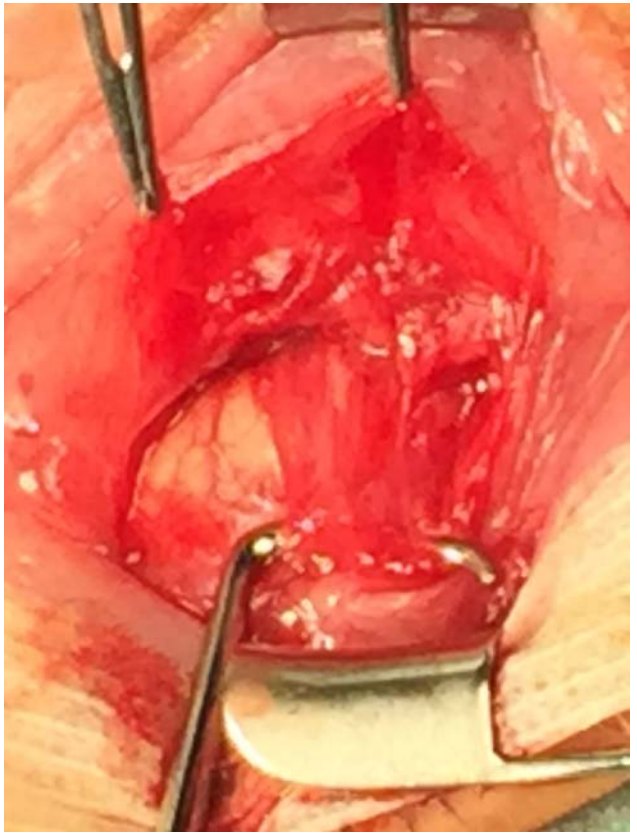
Medial compartment of SO [=SOm] controls *torsion*
Lateral ….[=SOl] controls *vertical* movement
B,C,D: 20% develop *floppy tendons* requiring tendon tightening surgery

Flap tear of the inferior rectus

Common / ? Commonest cause of vertical diplopia after orbital trauma

Normal [contralateral] IR

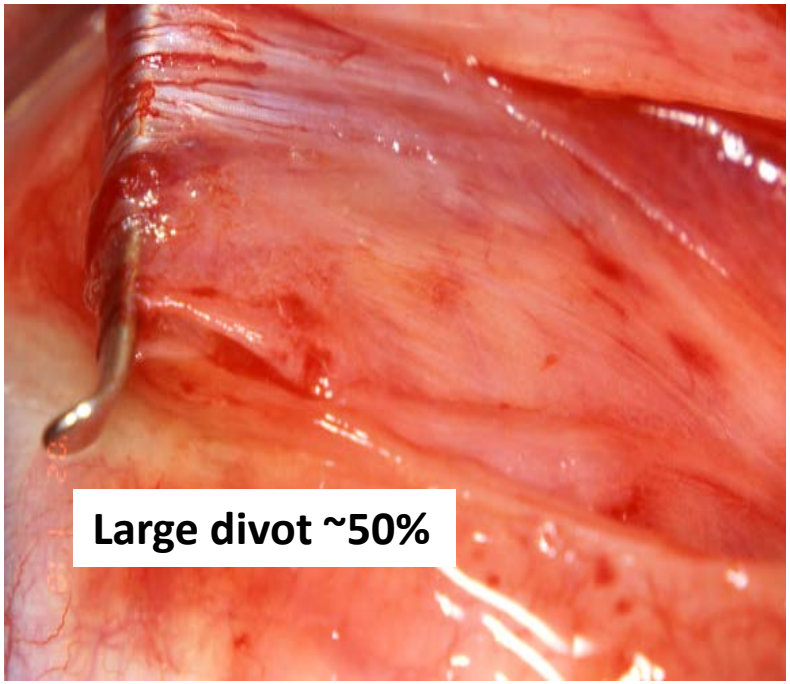
Superficial layer of inferior rectus ‘shaved’ off

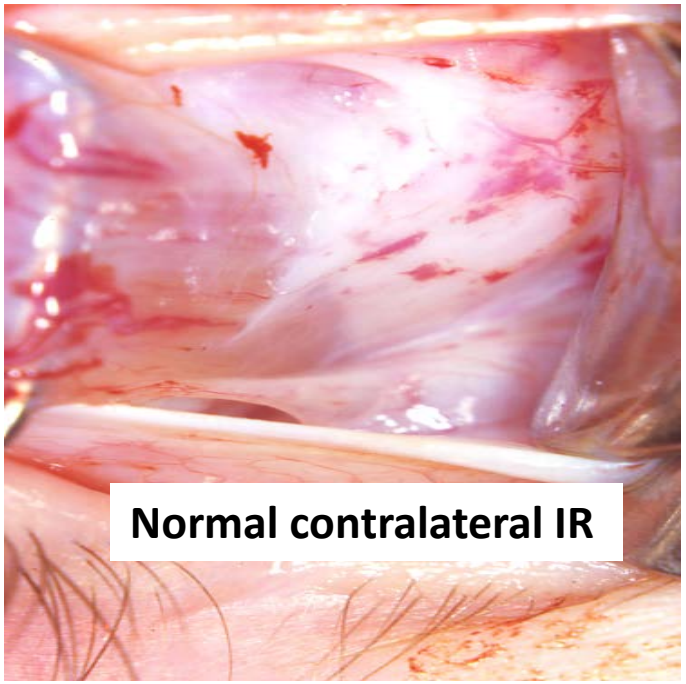


Affected IR
Outer ½ has been shaved off

From Irene Ludwig

Example where ‘divot’ of muscle has been ‘sliced’ off

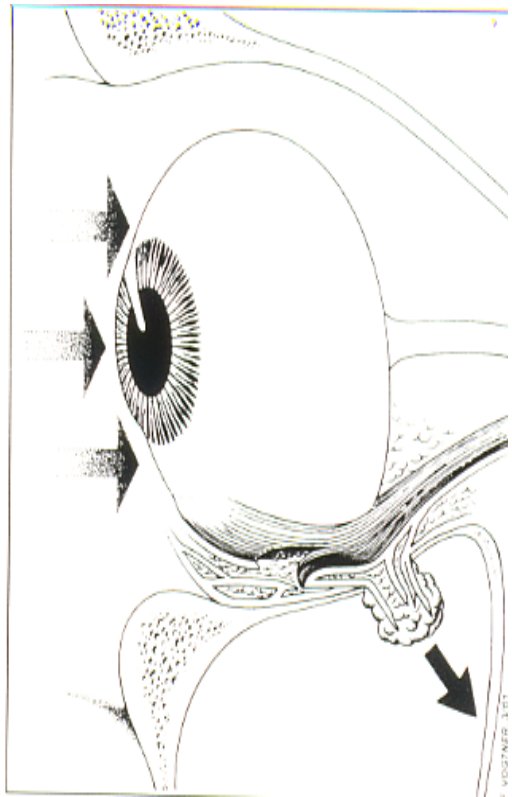


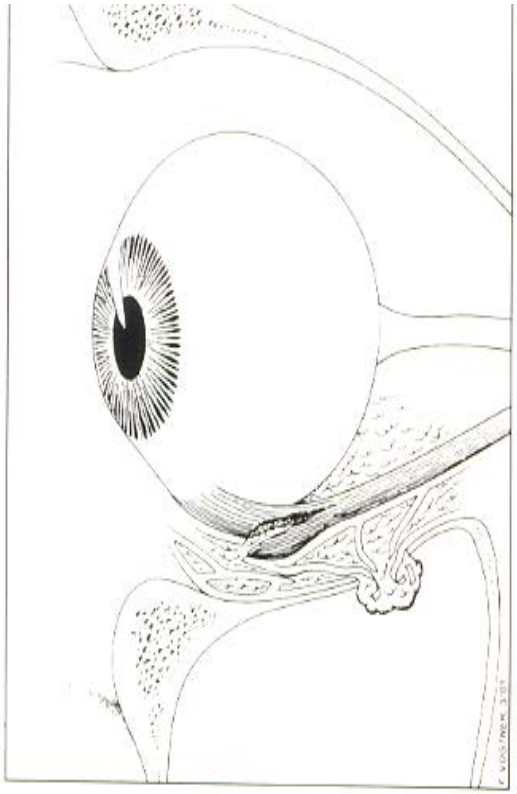


Flap Tear Hypothesis

From Irene Ludwig

- Blunt trauma causes outward traction on orbital septae.
- Orbital connective tissue, which attaches onto EOM pulls away portion of muscle & weakens it
- Flap can acts as a tether, further restricting & complicating motility.





2016 update ARVO & AAPOS MRI images of the flap tear

Validates Irene Ludwig's observations first published in 2001!

alone, do not seem to be adequate.
Conclusions: Patient no-show and same day cancellations have a significant financial impact on a university based pediatric ophthalmology practice. Practical methods should be explored to dramatically lower these rates.

046 Comparison of postoperative vertical drift in patients with thyroid eye disease with hypotropia: Vertical rectus muscle recession vs combined horizontal rectus muscle recession.
Bo Young Chun, Marcelle V. Freire, Dean M. Cestari
Introduction: To determine the postoperative vertical drift in thyroid eye disease (TED) patients with hypotropia who underwent vertical rectus recession alone and those with combined horizontal rectus recession.
Methods: A retrospective medical record review was done in 67 patients with TED who underwent strabismus surgery for hypotropia between 2006 and 2015. Group 1 had vertical rectus muscle recession only, while group 2 had vertical rectus muscle recession plus horizontal rectus muscle recession. Data collected included: age, pre- and postoperative sensorimotor details in primary position, distance and near. The amount of postoperative vertical drift for each group was calculated and compared between group 1 and 2.
Results: Mean preoperative hypotropia were $24.2^{\Delta} \pm 7.2^{\Delta}$ and $24.5^{\Delta} \pm 6.6^{\Delta}$ for group 1 ($n = 9$) and 2 ($n = 9$), respectively ($P > 0.05$). Mean vertical deviations on postoperative day 1 were $0.3^{\Delta} \pm 2.5^{\Delta}$ and $-2.2^{\Delta} \pm 6.2^{\Delta}$, and those of final measurements were $-0.9^{\Delta} \pm 4.5^{\Delta}$ and $-8.0^{\Delta} \pm 4.1^{\Delta}$, respectively ($P < 0.05$). Mean amount of postoperative vertical drift toward hypertropia were 1.2Δ and 6.8^{Δ}, respectively ($P < 0.05$).
Discussion: There was a statistically significant larger postoperative

to increased actin-myosin lattice spacing, so that density decreases. This effect is opposite that predicted from possible hemodynamic changes. Because volume change for SR and MR exceeds IR and LR, total rectus EOM volume increases in supraduction 41 ± 42 mm^3 (+3.7%) and adduction 32 ± 63 mm^3 (+2.3%).
Conclusions: Total EOM volume is not conserved, increasing with contraction and decreasing with relaxation.

048 Magnetic resonance imaging (MRI) of inferior rectus (IR) flap tears. Tina G. Damarjian, Joseph L. Demer
Introduction: Thus far, the only evidence for existence of flap tears in EOMs has been observations during surgical repair. This study employed MRI to investigate anatomy of flap tears of the IR.
Methods: Five adults (ages 25-68 years) who sustained trauma to the IR were studied prospectively using a 1.5 Tesla MRI scanner with surface coils and fixation targets. Sagittal and coronal T2 sequences were performed in upward, downward, and central gaze for each eye, permitting comparison with age-matched controls.
Results: Patients exhibited infraduction limitation greatest in abduction, and incomitant ipsilateral hypertropia greatest in infraversion. All but one had associated orbital fractures. Three torn IRs exhibited a longitudinal fissure separating the orbital (OL) and global layers (GL), with avulsion of the GL from the sclera in one case, and avulsion of the OL from its pulley in two cases. Two involved IRs exhibited a longitudinal fissure separating medial portion of the GL that was attached to the sclera, from the avulsed lateral portion. All cases manifested extensive inferior orbital scarring. Surgical repair was possible in 3 cases.
Discussion: Blunt trauma may cause longitudinal tears in the IR having variable orientations; longitudinal separation of OL from

Intramuscular injection of 3% Bupivacaine BP with Botox BT to treat strabismus

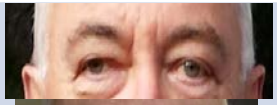
- The unwanted changes caused by accidental injection of local anaesthetic agents like Bupivacaine into EOM during ocular anaesthetic procedures can be exploited to treat the 'weak' muscle in strabismus eg the MR in consecutive XT [combined with Botox BT to the LR].

Pharmacologic injection treatment of comitant strabismus

Iara Debert, MD, PhD,[a,b,c,d] Joel M. Miller, PhD,[a,b] Kenneth K. Danh, BS,[a,b] and Alan B. Scott, MD[a,b]

PURPOSE To report the magnitude and stability of corrections in comitant horizontal strabismus achieved by injecting bupivacaine (BPX, optionally with epinephrine) and botulinum A toxin (BTXA) into extraocular muscles of alert adult subjects with electromyographic (EMG) guidance.

J AAPOS 2016

Time post injection	Evolution of RLR changes (post BT)	Evolution of RMR changes (post BP)	Evolution of alignment	
PRE	INJECTION →			
4 days				**BT yet to show effect, BP showing full anesthetic effect**
2 weeks				**Full effect of BT.** Anesthetic effect of BP worn off**, secondary changes to RMR begin**
3 weeks				
4 weeks				
5 weeks				
6 weeks				**BT effect worn off fully**
7 weeks				
9 weeks				**ET 4Δ Near, 6Δ Distance**
14 weeks				
17 weeks				**XT 12Δ Near, Ortho Distance**
6.5 months				**ET 1Δ Near(Variable), Ortho Distance**

Why does this transposition often work so well?

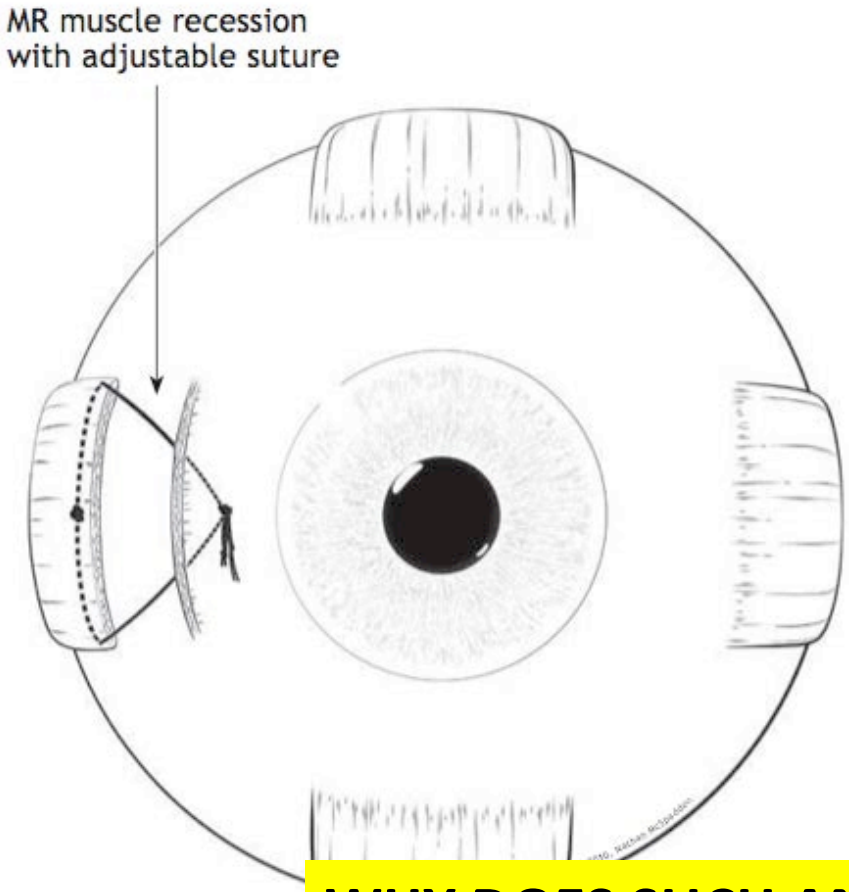
CLINICAL SCIENCES

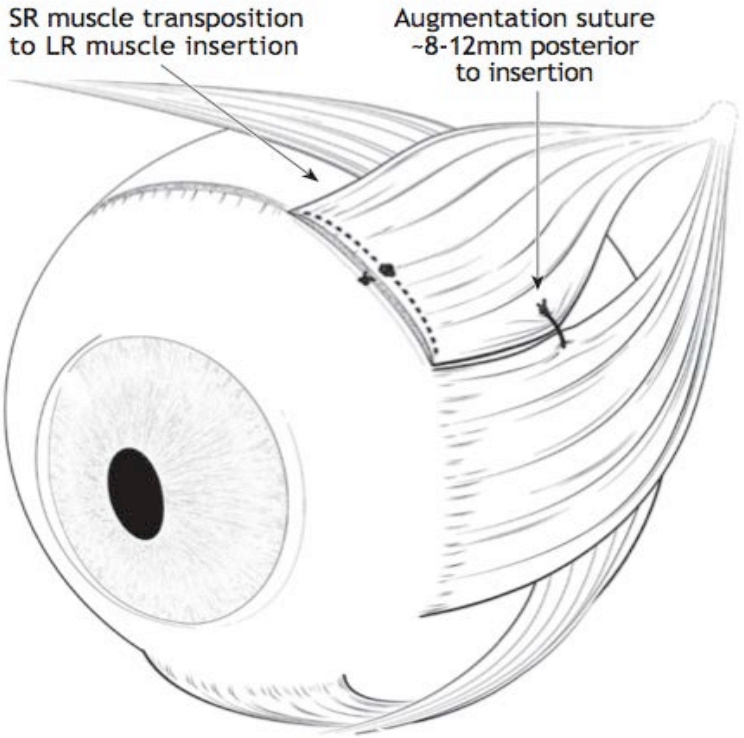
Superior Rectus Transposition and Medial Rectus Recession for Duane Syndrome and Sixth Nerve Palsy

Reshma A. Mehendale, MD; Linda R. Dagi, MD; Carolyn Wu, MD; Danielle Ledoux, MD; Suzanne Johnston, MD; David G. Hunter, MD, PhD

Innovator: Dr Earl Crouch
Validated by this paper from Harvard

Technique of SR transposition & LMR Rc





WHY DOES SUCH AN ASYMMETRIC OPERATION HAVE SO FEW UNEXPECTED CYCLOVERTICAL COMPLICATIONS?

Useful in traumatic 6ths

Augmented superior rectus transposition with medial rectus recession in patients with abducens nerve palsy

Preeti Patil-Chhablani, DNB,[a] Krishnapriya Kothamasu, VR, DO,[a] Ramesh Kekunnaya, FRCS,[a] Virender Sachdeva, MS,[b] and Vivek Warkad, MS[c]

PURPOSE To evaluate the surgical outcome of augmented superior rectus transposition (SRT) and medial rectus recession (MRc) in patients with abducens nerve palsy.

J AAPOS Dec 2016

WHY DOES SUCH AN ASYMMETRIC OPERATION HAVE SO FEW UNEXPECTED CYCLOVERTICAL COMPLICATIONS?.....SO MUCH MORE TO KNOW

köszönöm !תודה děkuji

mahalo 고맙습니다

thank you

merci 谢谢 danke

Eu شكر

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