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Magnetic Resonance Imaging Of Bilateral Split Lateral Rectus Transposition To the Medial Globe

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Abstract

Purpose—Medial transposition of the split or intact lateral rectus (LR) muscle in oculomotor palsy improves extreme exotropia. We studied rectus pulley positions using high-resolution surface coil MRI before and after LR split with medial transposition surgery in a patient with bilateral oculomotor and trochlear nerve palsies.

Methods—This is a report of a 14-year girl with 90Δ exotropia due to bilateral oculomotor and trochlear nerve palsies following traumatic midbrain infarction at age 6 years. Surgery comprised longitudinal division of each LR into a superior and inferior, threading of both halves between the inferior rectus and inferior oblique inferiorly, and inferior to the superior oblique and the superior rectus superiorly, with suturing of each 10 mm posterior to the medial rectus (MR) insertion.

Results—Pre-operative MRI of the orbit and extraocular muscles with thin 2 mm slices revealed bilateral atrophy of all EOMs supplied by the oculomotor and trochlear nerves. Post-operative MRI at 2 months demonstrated no significant changes in rectus EOM pulley positions compared with pre-operative values.

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Conflict of Interest Statement:
All authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript

Patient Consent Disclosure
The patient's guardian (mother) has consented to the submission of the case report for submission to the journal. This submission does not have any photograph that identifies the patient.

Conclusions—The LR pulley does not change position even after split LR transposition to the MR insertion, confirming the profound constraint of the connective tissue pulley system on the LR path.

Keywords

Lateral rectus splitting surgery; Oculomotor palsy; Magnetic resonance imaging; Strabismus surgery

Introduction

The lateral rectus (LR) muscle may be transposed medially for correction of exotropia in oculomotor palsy, with or without longitudinal splitting.[1–5] The procedure may be customized to correct associated hypertropia,[1,3] sometimes achieving a central diplopia-free zone, with improved cosmesis and reduction of ocular torticollis. [2,6, 7]

A major anatomical insight of the late 20th century was the recognition that connective tissue pulleys, consisting of rings of collagen and elastin in posterior Tenon's fascia, constrain the paths of the rectus extraocular muscles and serve as their functional mechanical origins.[8–13] One would there anticipate that rectus muscle transposition surgeries would be profoundly influenced by the locations and properties of the pulleys. Qualitative magnetic resonance imaging (MRI) performed shortly after this surgery has suggested little change in posterior LR path. [3] We aimed to quantify the constraint on LR transposition produced by its pulley by performing high resolution, surface coil MRI before and two months after medial transposition of the longitudinally split LR split in an adolescent with bilateral oculomotor and trochlear palsies.

Case Report

Clinical evaluation was performed in a 14-year old girl whose head had been crushed by a revolving door at age 6 years, resulting in central mid-brain infarction, and bilateral oculomotor and trochlear nerve palsy with fixed mydriasis and ptosis. Best-corrected visual acuity was 20/50 in the right and 20/30 in the left eye. There was no incycloduction on attempted infraduction in either eye. The patient had exotropia of approximately 90Δ, with no vertical duction in either eye and inability to adduct either eye even to the midline. The anterior 16–17 mm of the LR of each eye was divided surgically into superior and inferior halves that were passed between their respective oblique and vertical rectus muscles and the globe to its medial side, where they were sutured under tension using 6:0 Vicryl 10 mm from the medial rectus (MR) insertion. The anterior pulley connective tissues were divided along the superior and inferior margins of the LR as deeply as could be directly visualized from a standard limbal approach. Intraoperative indirect ophthalmoscopy demonstrated no retinal or choroidal detachment, or impaired optic nerve perfusion. Conjunctiva was sutured using 9:0 Vicryl.

Methods

Pre and post-operative 1.5 T surface coil MRI (GE Signa, Milwaukee, WI, USA) of the orbits was performed with T2 fast spin echo sequences in 2 mm slices and 312 micron resolution in quasi-coronal planes perpendicular to the long axis of each orbit, to define extraocular muscle (EOM) paths in a normalized, oculocentric co-ordinate system.[14] Pulley locations were quantified by their horizontal and vertical co-ordinates relative to the globe center in the pre- and post-operative data and compared to published norms. [15]

Results

Pre-operative MRI demonstrated bilateral atrophy of all EOMs supplied by the oculomotor nerve, bilateral superior oblique atrophy, and partial atrophy of the right LR.

Immediately post-operatively there was residual 16Δ exotropia in central gaze that increased to 30Δ at 3 months after surgery, which persisted at 24 months. MRI was repeated 2 months post-operatively. Blepharoptosis was later corrected bilaterally by frontalis suspension, 16 months following strabismus surgery. Post-operative MRI in both orbits demonstrated the split of the LR just anterior to the globe-optic nerve junction and subsequently its medial placement adjacent to the MR more anteriorly (Fig. 1). Pre-operatively, the right LR pulley was significantly displaced about 5.5 mm below normal, and the left MR pulley was about 2.5 mm more lateral and 3 mm inferior to normal (Table 1). Post-operatively, the right LR pulley shifted about 3 mm superiorly; the left MR pulley shifted about 7 mm inferiorly and the left IR pulley remained about 4 mm inferiorly as compared with normals. However, significantly, there was no nasal shift of either LR pulley.

Discussion

A mainstay of treatment of oculomotor palsy is weakening of LR abduction.[3,5] Multiple weakening approaches include LR extirpation or its fixation to the lateral periosteum. [16] Isolated reports of both complete and split nasal transposition of the LR to the MR to convert abducting force to adduction have reported 40–50 improvement of exotropia, with more augmented by MR tightening surgery. [1,5,17]Variations in the LR split technique including attachment site and use of adjustable sutures have been described. [3,6] We performed a procedure similar to that described originally by Kaufman.[4] Quantitative analysis confirms that the LR pulley, which constitutes the functional LR origin, is not changed by this aggressive surgery. This is a remarkable demonstration of the tenacious effect of the connective tissue pulley system, which largely prevented a major change in LR path despite aggressive effort to alter LR path by transposing its split hemi4 tendons some 5 clock hours. Only minimal shift in LR pulley location resulted, so that the transposed hemitendons still pulled towards the original site of the functional LR origin. Despite excellent initial reduction in exotropia to the tune of about 70Δ, there was partial recurrence over time. This is probably due to the continued powerful influence of the LR orbital layer on its pulley in maintaining abducting force despite nasal transposition of the LR tendon insertion. Perhaps the transposition operation could be augmented by more aggressive and systematic surgical modification of the pulley system, but this approach would require

surgery in the deep orbit in the vicinity of delicate structures critical to vision. A possible modification could be resecting the transposed halves of the LR before suturing them to the sclera. However, while this modification would tighten the transposed LR halves, it would not overcome the constraint of the LR pulley, so that LR pulling direction after transposition would be the same as without resection.

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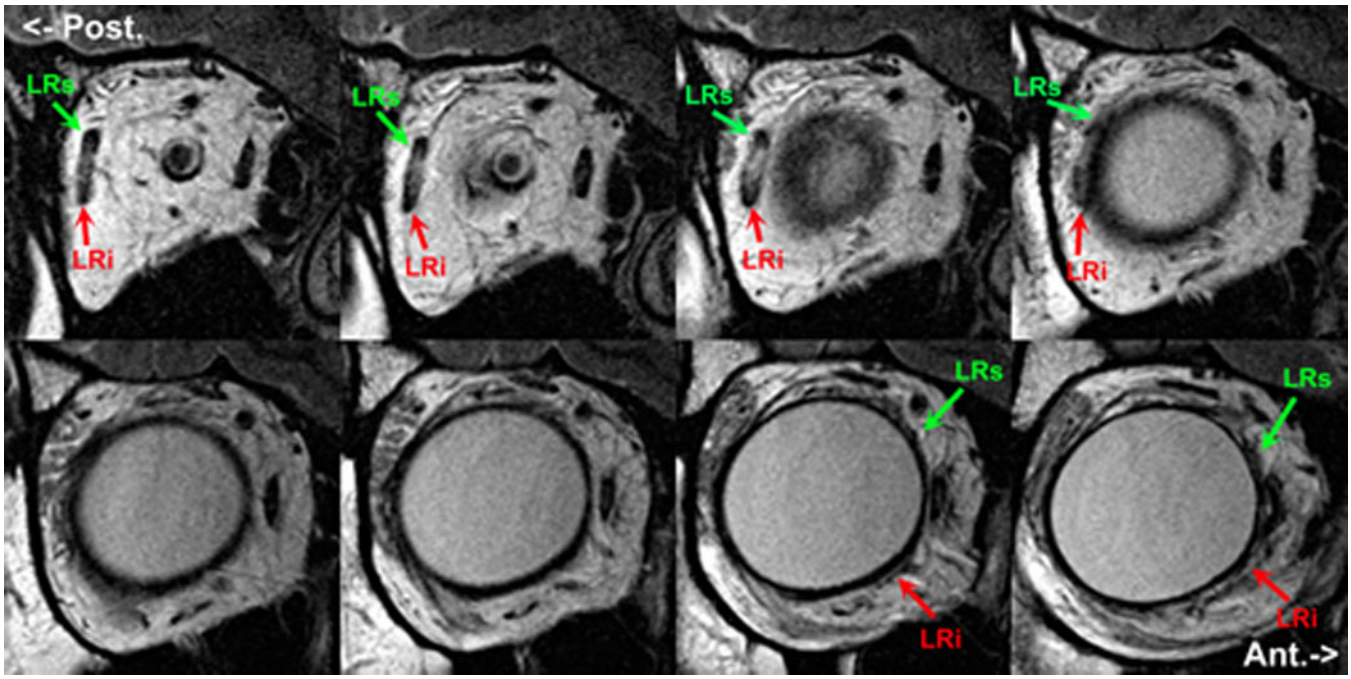

Fig. 1. High resolution orbital MRI of Post-operative LR split with medial transposition

Coronal MRI of the right orbit from posterior to anterior demonstrate the split LR extending from the globe–optic nerve junction to the nasal insertion near the MR muscle anteriorly. Note absence of displacement of the posterior LR path.

Table 1

Pre and Post-operative EOM Pulley Positions

Pulley Position (mm)	Right Eye				Left Eye				Normal (95% confidence interval)	
	Pre-operative		Post-operative		Pre-operative		Post-operative			
	Lateral	Superior	Lateral	Superior	Lateral	Superior	Lateral	Superior	Lateral	Superior
LR	10.27	**−5.81***	10.07	**−2.71***	**13.43***	0.51	**14.03***	**2.98***	10.1 ± 0.55	−0.3 ± 1.03
MR	−12.84	−0.7	−14.37	1.02	**−12.03***	**−2.99***	**−11.62***	**−6.28***	−14.41 ± 1.01	−0.11 ± 1.24
SR	−2.68	11.15	−2.3	**8.35***	−2.16	11.17	−2.77	10.44	−2.3 ± 0.88	11.8 ± 0.84
IR	−3.8	−14.05	−3.73	−11.73	**−0.18***	**−15.59***	**1.11***	**−15.98***	−5.36 ± 0.91	−12.22 ± 1.01

*EOM pulley positions significantly displaced from normal. [15] There was significant pre-operative right LR pulley sag reduced by about 3 mm post-operatively. (− sign denotes more inferior position and a more nasal position). Post-operatively, there was inferior SR pulley shift. Preoperatively in the left orbit there was significant lateral displacement of the LR, MR and IR pulleys, with significant MR and IR inferior pulley sag; post-operatively, these abnormal pulley positions were generally maintained, except that inferior sag of the MR pulley increased by about 4 mm, and the LR pulley shifted superiorly by about 2.5 mm.