Extraocular muscle fenestration: a novel weakening procedure

In 1922, Jameson introduced the scleral suturing technique as a graded method for extraocular muscle weakening, and since that time it has become the nidus for modern-day conventional recessions.[1] Recently, sutureless ocular surgeries have rapidly evolved and become more popular. In this report we describe a new sutureless strabismus surgical technique for weakening of the extraocular muscles that was conceived by the senior author (M.R.).

After sterilization and draping of the eyes, an eye speculum is inserted. The muscle is exposed and hooked through either a fornix-based or limbal-based incision. Careful dissection is carried out to delineate the muscle edge, under which another muscle hook is then passed. The 2 hooks are used to stretch the muscle fibers in between. A small Stevens' tenotomy hook is then used to create 2 peripheral muscle strips about 1.5 mm each. The peripheral muscle strips can be isolated with 5/0 silk sutures to separate them from the central part of the muscle, or just pulled away from the central part of the muscle using 2 small hooks. The length of the created peripheral strips determines the amount of muscle weakening. The senior author (M.R.) found that the length should be approximately 1 mm more than the standard amount of conventional recession. The planned site of excision is marked either by pen marker or diathermy burn. The 2 muscle strips are then separated on each side by 2 small hooks or by pulling on the 5/0 silk sutures, and the muscle belly in between is excised using Wescott scissors, leaving a bare sclera. The conjunctival incision is then repositioned and closed (Fig. 1 and Video 1).

Recession is the standard technique for weakening of extraocular muscles. Despite being the most common surgical procedure, complications related to suturing and muscle disinsertion may occur. In addition, disinsertion of rectus muscles interrupts the vascular supply of the anterior segment of the eye and might carry the risk of anterior segment ischemia if several muscles are disinserted.[2]

A number of muscle weakening techniques have been described as an alternative to standard recession. In 1857, von Graefe described marginal myotomy for treatment of strabismus.[3] Many variations of the technique have been reported in which one or more incisions are made across the margins of the muscle to lengthen the muscle and hence weaken it.[4–6] In 2000, Scott described "graded rectus muscle tenotomy," to treat small degrees of vertical strabismus.[7] Multiple successive small cuts are made

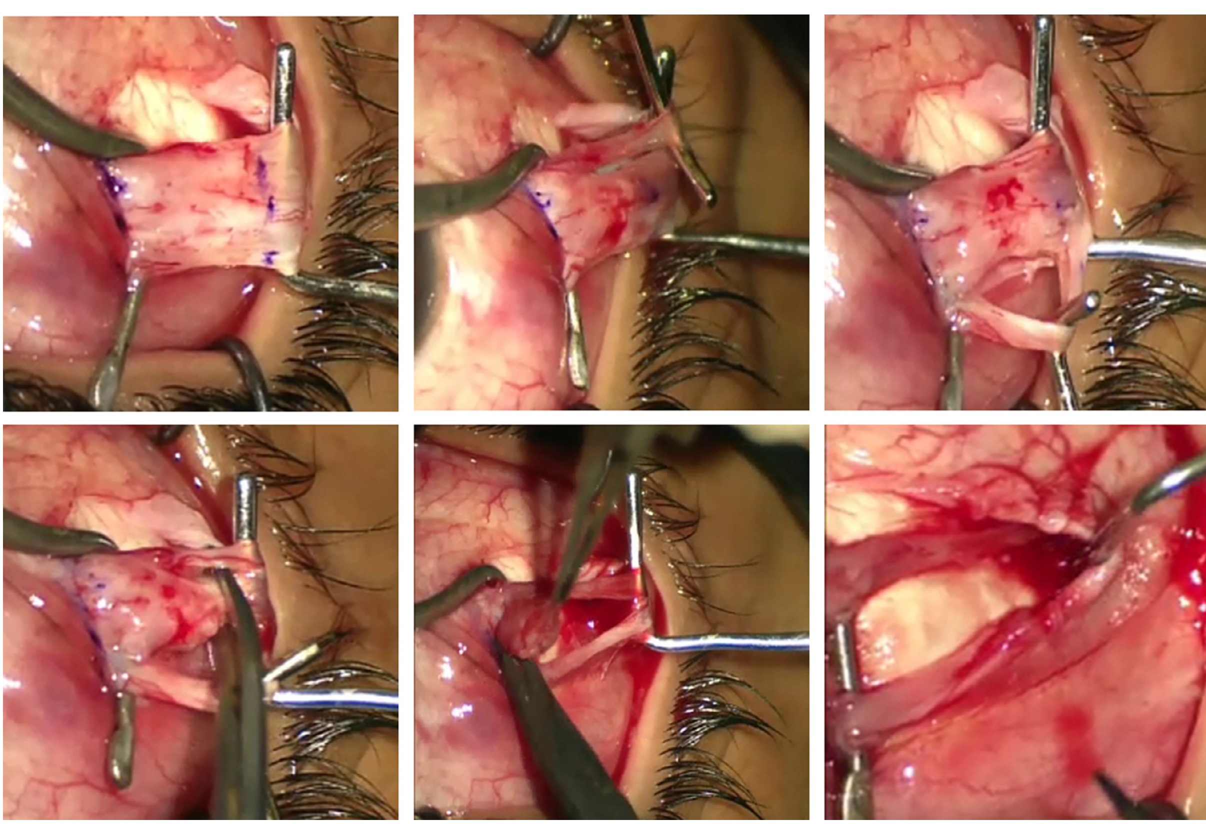

Fig. 1—Intraoperative photograph of the steps of muscle fenestration, upper left; marking the desired amount of muscle fenestration, upper middle; isolation of the upper strip of the muscle with a small hook, upper right; isolation of the lower strip of the muscle with a small hook, lower left; cutting of the central block at the posterior edge, lower middle, removal of the central block of the muscle, lower right, appearance of the muscle at the end of surgery.

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Table 1—Study characteristics of patients

No.	Age (y)	Sex	Diagnosis	Preoperative alignment	Surgery	Last follow-up (mo)	Postoperative alignment (last follow-up)
1	15	Male	Partially accommodative esotropia	Dcc: ET 25 PD Ncc: ET 25 PD Dsc: ET 35 PD Nsc: ET 25 PD	Bilateral medial rectus muscle fenestration 6 mm	7	Dcc: Ortho Ncc: Ortho Dsc: E(T) 5 PD Nsc: E(T) 5 PD
2	17	Female	Partially accommodative esotropia	Dcc: ET 35 PD Ncc: ET 40 PD Dsc: ET 45 PD Nsc: ET 50 PD	Bilateral medial rectus muscle fenestration 7 mm	4	Dcc: Ortho Ncc: E(T) 5 PD Dsc: E(T) 10 PD Nsc: E(T) 15 PD
3	11	Male	Partially accommodative esotropia	Dcc: ET 25 PD Ncc: ET 30 PD Dsc: ET 40 PD Nsc: ET 40 PD	Bilateral medial rectus muscle fenestration 5.5 mm	4	Dcc: Ortho Ncc: Ortho Dsc: E(T) 10 PD Nsc: E(T) 15 PD
4	9	Female	Partially accommodative esotropia	Dcc: ET 20 PD Ncc: ET 25 PD Dsc: ET 40 PD Nsc: ET 45 PD	Bilateral medial rectus muscle fenestration 5.5 mm	3	Dcc: Ortho Ncc: E(T) 8 PD Dsc: E(T) 15 PD Nsc: ET 20 PD
5	10	Male	Partially accommodative esotropia	Dcc: ET 25 PD Ncc: ET 35 PD Dsc: ET 40 PD Nsc: ET 45 PD	Bilateral medial rectus muscle fenestration 6.5 mm	3	Dcc: Ortho Ncc: Ortho Dsc: E(T) 15 PD Nsc: ET 15 PD
6	8	Female	Partially accommodative esotropia	Dcc: ET 25 PD Ncc: ET 30 PD Dsc: ET 45 PD Nsc: ET 45 PD	Bilateral medial rectus muscle fenestration 6 mm	3	Dcc: Ortho Ncc: Ortho Dsc: E(T) 10 PD Nsc: E(T) 10 PD
7	12	Female	Partially accommodative esotropia	Dcc: ET 30 PD Ncc: ET 35 PD Dsc: ET 40 PD Nsc: ET 40 PD	Bilateral medial rectus muscle fenestration 6.5 mm	4	Dcc: Ortho Ncc: E 5 Dsc: E(T) 10 PD Nsc: E(T) 10 PD
8	20	Male	Sensory esotropia	Dsc: ET 30 PD Nsc: ET 30 PD	Bilateral medial rectus muscle fenestration 5.5 mm	4	Dsc: Ortho Ncc: Ortho
9	28	Female	Sensory esotropia	Dsc: ET 40 PD Nsc: ET 40 PD	Bilateral medial rectus muscle fenestration 6.5 mm	2	Dsc: ET 10 PO Ncc: ET 10 PD
10	20	Male	Sensory esotropia	Dcc: ET 35 PD Ncc: ET 35 PD Dsc: ET 35 PD Nsc: ET 35 PD	Bilateral medial rectus muscle fenestration 6.0 mm	4	Dcc: Ortho Ncc: ET 10 PD Dsc: Ortho Ncc: ET 8 PD
11	20	Male	Acquired nonaccommodative esotropia	Dcc: ET 25 PD Ncc: ET 25 PD Dsc: ET 25 PD Nsc: ET 25 PD	Bilateral medial rectus muscle fenestration 5.0 mm	4	Dcc: ET 5 PD Ncc: ET 8 PD Dsc: ET 5 PD Ncc: ET 10 PD
12	19	Male	Acquired nonaccommodative esotropia	Dcc: ET 25 PD Ncc: ET 25 PD Dsc: ET 25 PD Nsc: ET 25 PD	Bilateral medial rectus muscle fenestration 5.0 mm	2	Dcc: Ortho Ncc: E(T) 5 PD Dsc: ET 5 PD Ncc: ET 5 PD
13	14	Female	Acquired nonaccommodative esotropia	Dcc: ET 30 PD Ncc: ET 30 PD Dsc: ET 30 PD Nsc: ET 30 PD	Bilateral medial rectus muscle fenestration 5.5 mm	5	Dcc: Ortho Ncc: Ortho Dsc: Ortho Ncc: Ortho
14	28	Female	Sensory exotropia	Dsc: XT 30 PD Nsc: XT 30 PD	Bilateral lateral rectus muscle fenestration 8.0 mm	2	Dsc: XT 8 PO Ncc: XT 8 PD
15	20	Male	Sensory exotropia	Dsc: XT 35 PD Nsc: XT 35 PD	Bilateral lateral rectus muscle fenestration 8.5 mm	2	Dsc: XT 15 PO Ncc: XT 15 PD
16	15	Female	Intermittent exotropia	Dcc: X(T) 25 PD Ncc: X(T) 25 PD Dsc: X(T) 25 PD Nsc: X(T) 25 PD	Bilateral lateral rectus muscle fenestration 7.0 mm	2	Dcc: X(T) 15 PD Ncc: X(T) 10 PD Dsc: X(T) 15 PO Ncc: X(T) 10 PD
17	12	Female	Intermittent exotropia	Dcc: X(T) 25 PD Ncc: X(T) 25 PD Dsc: X(T) 25 PD Nsc: X(T) 25 PD	Bilateral lateral rectus muscle fenestration 7.0 mm	3	Dcc: X(T) 8 PD Ncc: X(T) 6 PD Dsc: X(T) 8 PO Ncc: X(T) 6 PD
18	10	Male	Intermittent exotropia	Dcc: X(T) 20 PD Ncc: X(T) 20 PD Dsc: X(T) 20 PD Nsc: X(T) 20 PD	Bilateral lateral rectus muscle fenestration 6.0 mm	2	Dcc: X(T) 5 PD Ncc: X(T) 5 PD Dsc: X(T) 8 PO Ncc: X(T) 5 PD
19	12	Male	Bilateral dissociated vertical deviation	RH(T) 15 PD LH(T) 15 PD	Bilateral superior rectus muscle fenestration 7.5 mm	3	RH(T) 4 PD LH(T) 6 PD
20	23	Feale	Left dissociated vertical deviation	LH(T) 15 PD	Left superior rectus muscle fenestration 7.5 mm	2	Ortho
21	21	Female	Left dissociated vertical deviation	LH(T) 15 PD	Left superior rectus muscle fenestration 7.5 mm	3	LH(T) 4 PD

Dcc, distance angle with correction; Dsc, distance angle without correction; E, esophoria; ET, constant esotropia; E(T), intermittent esotropia; LH(T), intermittent left hypertropia; Ncc, near angle with correction; Nsc, near angle without correction; ortho, orthophoric; PD, prism diopters; RH(T), intermittent right hypertropia; XT, constant exotropia; X (T), intermittent exotropia.

across the tendon of a rectus muscle under topical anaesthesia until satisfactory alignment is achieved. Wright described the "mini-tenotomy" for the treatment of small-angle strabismus by removing the central 3−4 mm of the tendon of the rectus muscle.[8]

The principle of muscle fenestration differs from these weakening procedures in that it reduces the muscle force by removing a block of muscle belly close to its insertion, thus reducing the number of contracting fibers, leaving the peripheral muscle poles intact, rather than just making cuts across the muscle. The length of the block removed can be graded to achieve the weakening effect needed.

In addition to being simple, keeping the muscle in its place reduces the incidence of accidental transposition of muscle during recession, which might induce vertical deviation or result in new strabismus patterns. The connections between the muscle and check ligaments remain intact, and this avoids postoperative widening of palpebral fissure, particularly in vertical muscle surgery.

The technique was performed on 21 cases so far (Table 1) with a mean age 16.3 years and a median follow-up of 3 months (range 2−7 months). In esotropia (13 cases), alignment within 8 Prism Diopters (PD) was achieved in 12 cases (92%). In exotropia (5 cases), alignment within 8 PD was achieved in 3 cases (60%). In dissociated vertical deviation (3 cases), the deviation was reduced to ≤6 PD in all cases. None of the 21 cases developed overcorrection, or limitation of ocular motility after surgery. No intraoperative of postoperative complications were reported.

The currently described technique leaves the muscle with only limited attachment to the sclera, as compared with conventional recession where the muscle is broadly fixed to the sclera. This might carry the risk of muscle slippage or loss. However, this was not encountered in the current study. Moreover, the possible risk of undercorrection and overcorrection, and how can they be managed should be considered. Finally, although stripping and removal of a part of the muscle might carry the risk of bleeding, this bleeding can be minimized by marking the site of excision using diathermy. Nevertheless, no significant bleeding was encountered in our series.

The technique might be of particular benefit in partially accommodative esotropia as it maintains the arc of contact of the muscle with the sclera, and this might reduce the late risk of consecutive exotropia especially with larger recessions. In addition, we found it helpful in vertical muscle surgery such as in dissociated vertical deviations, as the connections between the muscle and the eyelid can be kept intact, thus avoiding changes in the palpebral fissure width. The technique also allows selective sparring of the muscular arteries by including them in the peripheral strips if needed, and thus might be helpful in reducing the risk of anterior segment ischemia in selected cases.

In conclusion, muscle fenestration is a novel procedure for extraocular muscle weakening that requires further studies on a larger number of patients to evaluate its long-term efficacy and safety. However, the possible risk of intraoperative as well as late postoperative complications, and how they can be managed, should be considered.

Video 1—Video illustrating muscle fenestration performed on the right lateral rectus muscle though a fornix approach.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jcjo.2020.05.018.

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Footnotes and Disclosure

The authors have no proprietary or commercial interest in any materials discussed in this article.