

## Surgical Management of Near-Far Disparity Esotropia

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**Abstract:** Contention in the management of CEET has been progressed over the years and the surgical management represents a demanding and challenging problem Up till now the best and the most effective technique with stable results is still under research. Bilateral medial rectus recession. Augmented medial rectus recession bilateral medial rectus recession with retro equatorial myopexy (faden procedure) MR resection combined with recession, y splitting recession and slanted rectus recession are different methods for the surgical treatment. Many studies provided increasing suggestion that Bilateral medial rectus recession is an effective and secure operation in treating esotropia with near far disparity NFD. If correction depend on the far angle of deviation, high degrees of under correction can progress and if based on the near angle, consecutive exotropia can progress.

**Keywords:** Surgical Management, near far, disparity esotropia

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### Introduction

Distance–near disparity (DND) esotropias were described by Donders in 1864.<sup>1</sup> A review of the literature reveals numerous studies where outcome analysis has not been helped by the bundling together of patients with different clinicopathological entities.<sup>2</sup> This lack of aetiological homogeneity in many published studies has complicated the development of a best practice framework that may arguably benefit from ‘DND’ subclassification so as to more accurately reflect and understand the sensory, motor, and psychosocial outcomes of each subgroup and develop and apply current surgical and non-surgical therapies optimally.

DND esotropia includes patients with high gradient AC/A ratio (classical convergence excess) esotropias, those with normal AC/A ratios (the non-accommodative convergence excess group), those with a low AC/A ratio with a remote near point of accommodation (NPA) known as hypoaccommodative convergence excess,<sup>3</sup> partially accommodative distance esotropes with a high gradient AC/A ratio, patients with acquired or early-onset strabismus with a manifest distance esotropia with/without oblique dysfunction, and other miscellaneous cases.

Refractive or fully accommodative esotropia arguably represents an ideal 'best achievable' comparator for motor and sensory outcomes to the DND esodeviations. Amblyopia and anisometropia are common in the former at diagnosis. High grades of stereovision can be expected in up to 25% with fusion achievable in up to 75% of cases, especially in the many whose esotropia onset is after 2 years of age and spontaneous consecutive exotropia occurs in 5 to 6% of cases often after years of prior successful spectacle wear.<sup>4</sup>

### **Shrinking the gap**

The successful management of the DND esotropias hinges on the optimal application of surgical and non-surgical therapies, where 'shrinking the gap' means achieving a residual angle of misalignment at distance and near that renders an individual asymptomatic or considerably improved with demonstrable stereovision and/or fusion in conjunction with a phoria or microtropia at all fixation distances while wearing an appropriate monofocal lens.

There should be a careful analysis of and emphasis on generating a preplanned target range that, if achieved, can be associated with a likelihood of successful ocular realignment. To this end, a knowledge of preoperative characteristics that might predict the likelihood of success/failure (eg, degree of hyperopia and refraction stability; magnitude of the measured gradient AC/A, the magnitude of the DND, and the response to prism adaptation) are of value.<sup>5, 6</sup>

The most popular way of estimating the DND in North America is to compare the magnitudes of the distance and near heterophorias/heterotropias and consider a high AC/A ratio as an alignment at 1/3rd m, that is, 10 prism diopters (PD) more convergent than that at distance fixation.<sup>7</sup> This method is popular and requires no additional clinical tasks or calculations. Havertape *et al*<sup>8</sup> advised that the use of this difference to determine a high AC/A ratios can be inaccurate, as the AC/A relationship was normal when measured by the gradient method in many patients with an abnormal DND. Likewise, von-Noorden *et al*,<sup>9</sup> observed in a study designed to examine the role of bifocals in the treatment of accommodative esotropia, noted that some of these patients measured more overconvergence at near than at distance when simply using the distance–near comparison while their gradient AC/A ratio was low and their response to bifocal therapy was poor.

It is standard to formally measure the AC/A ratio in the United Kingdom using the gradient AC/A measurement. It takes a little longer and has been reported as near eliminating proximal convergence from consideration.<sup>10, 11</sup>

### **Hypo accommodative convergence excess**

Hypo accommodative convergence excess is uncommon. Arnoldi,<sup>12</sup> in a review of 77 cases with a DND, reported a 1% incidence. Costenbader<sup>3</sup> in 1958 described this group of strabismic patients characterised by a much reduced NPA and a low AC/A ratio. He postulated that they used excessive accommodative effort to see clearly at near, and in doing so, exhibited an undesired excessive convergence of the eyes. It is managed with hypermetropic spectacle lenses. von Noorden and Jenkins<sup>13</sup> re-evaluated this condition after fusing teenagers who had successfully worn bifocals for a mean duration of 4.3 years had an unexpectedly high frequency (25%) of poor accommodative

amplitudes and presbyopic symptoms. This study could not confirm whether the reduced accommodation occurred during or antedated bifocal therapy.

Fresina *et al*<sup>14</sup> in a prospective age-matched control study noted that deficient accommodation (slightly lower than average) was present in 10/28 of their bifocal patients but in none of the controls. The NPA abnormalities predated bifocal wear and did not deteriorate while wearing bifocals over 4 years. This small prospective study supported the existence of a pre-existing NPA deficit. Attempts to more routinely assess the NPA in children before and during bifocal therapy may prove clinically practical and have prognostic relevance, in that the excessive convergence at near is related to increased accommodative effort and a normal or near-normal AC/A, where prospective surgery may be potentially deleterious where there is a protracted requirement for reading or bifocal lenses, while 'bridging' the distance–near alignment gap.<sup>13</sup>

### Hypermetropic undercorrection

Classically, the refractive error in high gradient AC/A ratio esotropia tends to be lower than that of fully accommodative esotropia where patients can be deliberately undercorrected by an amount gauged to the ease with which esodeviation is controlled. However, one needs to be mindful that in cases with a high gradient AC/A minor degrees of hypermetropic undercorrection can result in classification and diagnostic errors and inaccurate diagnoses. Black<sup>15</sup> observed that a significant minority of patients in his study with an abnormal distance-near relationship ( $\geq 10$  PD) ultimately did not need bifocal glasses following an increase of 0.5–0.75 D in their monofocal lenses and normalisation of the DND. He reported that 19 of 51 patients had their DND normalised in this way, where the mean DND for this specific subgroup was 12 PD.

### Convergence excess esotropia with high gradient AC/A ratio: orthotropia/microtropia at distance

This is the quintessential DND esodeviation that can be managed with bifocals, strabismus surgery, and, indeed, both where spontaneous deterioration or iatrogenic overcorrection, while visually immature, may result in a permanent loss of binocular single vision (BSV) including bifoveal fixation in a minority.<sup>5</sup>

Garretty<sup>16</sup> reported an annual incidence in Leeds of six new cases per year (city population=443 000). Kutschke and Keech<sup>17</sup> measured the gradient AC/A ratio in 62% of their DND cases. It was abnormally high in just 19%, whereas Black<sup>15</sup> reported that 22% of patients in their DND series responded to bifocals.

Leitch *et al*<sup>18</sup> described the sensory outcomes of 31 children managed by primary surgery at a mean age of 5.7 (range 2.5–9.0) years. The majority (75%) achieved peripheral fusion/subnormal stereovision, 16% achieved central or higher levels of stereovision, and 9% had no detectable fusion. There was a modest postsurgery improvement in sensory status in 67%. Pratt-Johnson and Tillson<sup>19, 20</sup> analysed the outcomes in 80 bifocal users with a minimum 4-year follow-up, with similar sensory outcomes, where 76% achieved peripheral, 9% central, and a further 15% no detectable fusion. These data are approaching but inferior to the sensory outcomes described by Berk for Refractive Accommodative Esotropes.<sup>4</sup>

The maintenance of distance BSV during visual maturation is an important principle when attempting to improve on the sensory and motor outcomes from earlier studies,<sup>18, 19, 20</sup> where earlier surgery is an increasingly appealing modern-day alternative to protracted bifocal wear because it potentially offers speedier alignment but risks added complications.

Current popular surgical strategies are augmented medial rectus recessions based on the magnitude of the near-angle,<sup>5, 21, 22</sup> preoperative prism adaptation for the near-angle<sup>23</sup> and primary position sparing surgery.<sup>24</sup> It is the surgeon's preference rather than clinical findings that in a large part determine the operation selected, where the aim is to reduce the DND so that any residual deviation at near and at distance lies within that individual's fusional amplitudes. Otherwise, the likelihood of persisting symptomatic undercorrections at near and symptomatic overcorrections at distance and near increase.

Relatively few publications have segregated DND patients into meaningful homogeneous subgroups. Arnoldi and Shainberg<sup>5</sup> analysed 37 such children who underwent augmented medial rectus recessions based on the larger near angle prospectively over 5 years. The age at primary surgery was  $3.9 \pm 0.2$  years. There was an 80% success at 4 months defined as no documented loss of BSV and alignment within 8 PD of orthotropia at near and at distance without the need for bifocals that reduced to 30% at 5 years with the recurrence of an increasing gradient AC/A within a year. There was a 43% near esotropia recurrence and a 27% consecutive distance exotropia rate and a mean of 2 operations per patient (range 1–5), where only 2 of the 19 patients who required >1 operation being eventually defined as a success.

The mean DND reduced from 23 to 12 PD ( $P < 0.01$ ). The mean gradient AC/A ratio reduced by 3.2 units. Binocular function was lost in 14% (including a child who had bifoveal fixation at baseline), remained stable in 59%, and improved in 26%. The successes differed statistically from failures at baseline in three ways. They had a larger distance deviation at outset  $13 \pm 3$  vs  $6 \pm 3$  PDs ( $P < 0.05$ ), a significantly lower AC/A ratio at outset  $7.3 \pm 0.5$  vs  $8.6 \pm 0.4$  ( $P < 0.05$ ), and a lower refractive error  $1.56 \pm 0.7$  vs  $4.16 \pm 0.6$  D ( $P < 0.01$ ).

Lueder and Norman<sup>23</sup> reported retrospectively on 16 visually mature high AC/A ratio esotropes who were bifocal dependent or indicated a preference to discontinue them. They underwent augmented bilateral medial rectus recessions based on prism adaptation for their near angle at a mean age of 8.3 years, and outcomes were defined as successful if they had a microtropia at near and at distance and maintained fusion without bifocals at a mean of 2.5 years.

There was an average of 1.3 (range 1–2) operations per patient and a mean increase of 11 PD in the surgical target angle during prism adaptation. Further surgery was more likely in the prism adaptation non-responder subgroup: 60% for consecutive exotropia and 40% for recurrent/persistent esotropia. Bifocals were eliminated in all with stable or improved binocular functions. Some 50% discarded spectacles entirely. Kushner<sup>25</sup> cautioned disappointingly regarding the poor long-term (>5 years) outcomes in overcorrected partially accommodative esotropes whose hyperopia was  $> +2.50$  D when managed with postoperative spectacle manipulation.

Peterseim and Buckley<sup>24</sup> performed bilateral medial rectus fadenoperations on 16 bifocal-dependent high gradient AC/A esotropes with a mean follow-up of 3 years and a mean age at surgery of 8.4 years. There were no reoperations or distance overcorrections but 18% were sufficiently undercorrected to intermittently require bifocals. Surgery resulted in a 71% reduction in the DND from 24 to 7 PD, a 61% reduction in mean gradient AC/A (7.4–2.9) and improved binocular functions with 70% achieving at least 400 s of stereovision compared with 44% preoperatively. They described a 70% and 36% (8–5.6 PD) reduction in the near and distance angles, respectively, whereas Akar *et al*<sup>26</sup> described an 81 and 69% reduction in a partially accommodative esotropia subgroup.

All three procedures reduced the DND, the gradient AC/A, and the near and distance angles. There were no pulley fixation surgery<sup>27, 28, 29</sup> reports for this homogeneous subgroup. Augmented medial rectus recessions are technically easier, whereas fadenoperations are challenging. On the other hand, isolated fadenoperations may be more prone to undercorrection but unlikely to overcorrect, whereas augmented surgery based on prism adaptation may by identifying prism builders reduce undercorrections but increase the long-term risks of overcorrection.<sup>23</sup> The literature is unclear regarding the relative merits of sequential bifocal stabilisation followed by surgery near/after visual maturity compared with primary surgery at a younger age.

Preoperative prism adaptation should intuitively facilitate preoperative planning. It helps determine the smallest correctable target angle at near that is compatible with the achievement of comfortable BSV and the maximal change to the distance angle that can be tolerated by one's motor fusion, as prism adaptation in patients who have BSV is designed to 'stress test motor fusion at distance and near' so as to select a target range for surgery. Arnoldi and Shainberg's<sup>5</sup> supporting data described a potential protective effect from a larger underlying preoperative distance esodeviation. The most appropriate procedure could then be augmented medial rectus recessions, isolated faden operations, or combinations of both based on the relationship between the amount of misalignment that is deemed to require correction and the estimated fusional amplitudes, the DND, and the magnitude of the distance deviation (JP Burke, Personal Communication).

Bifocals are important to the management of children with a high AC/A ratio esotropia and are an especially practicable alternative to early surgery in the young visually immature child with distance BSV and limited cooperation. The further aim of bifocal wear is to promote the stabilisation or even expansion of fusional amplitudes so that patients can spontaneously discontinue the need for ongoing bifocal wear which currently occurs in a minority.<sup>9, 30</sup> They should also be considered as an important alternative next step in the stabilisation and management of initial surgical undercorrections.

Contention in the management of CEET has been progressed over the years and the surgical management represents a demanding and challenging problem<sup>(28)</sup>. Up till now the best and the most effective technique with stable results is still under research. Bilateral medial rectus recession<sup>(29)(30)</sup> Augmented medial rectus recession<sup>(31)</sup>, bilateral medial rectus recession with retro equatorial myopexy (faden procedure)<sup>(32)(33)</sup>, MR resection combined with recession<sup>(34)(32)(35)</sup>, y splitting recession<sup>(36) (37)</sup>and slanted rectus recession<sup>(34)(38)(39)</sup> are

different methods for the surgical treatment(32) .Many studies provided increasing suggestion that Bilateral medial rectus recession is an effective and secure operation in treating esotropia with near far disparity NFD(29)(32)(40). If correction depend on the far angle of deviation, high degrees of under correction can progress and if based on the near angle, consecutive exotropia can progress (30)(29)

### Bilateral Medial rectus MUSCLE RECESSION

In near far disparity NFD esotropia the amount of recession can be calculated according to the far angle of deviation or the near angle or an average between them.(28)

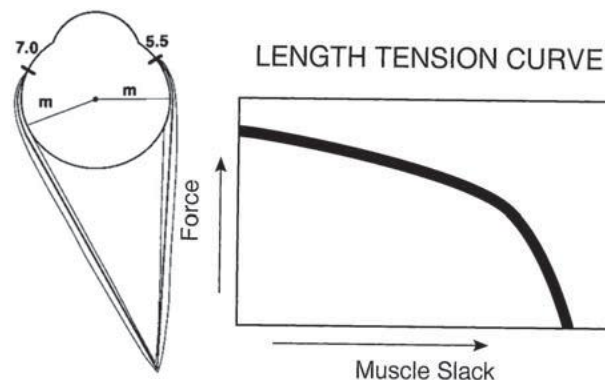
#### *mechanism of action*

The rotational force is the force produced when the muscle contracts. It is directly proportional to the length of the moment arm ( $m$ ) (*Figure. 1 A*) and the force of the muscle contraction ( $F$ ) (*Figure. 1 B*).

$$\text{Rotational force} = m \times F$$

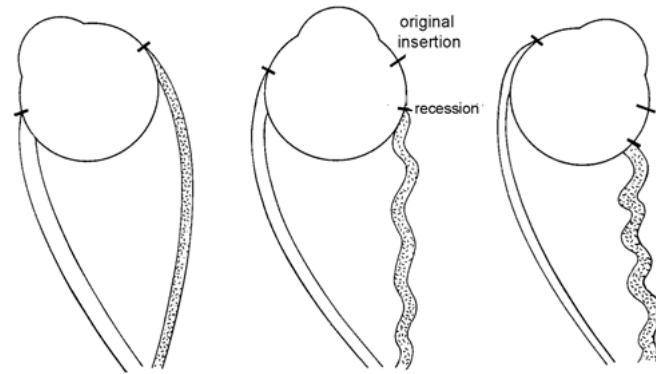
Where  $m$  =moment arm

$F$  = muscle force



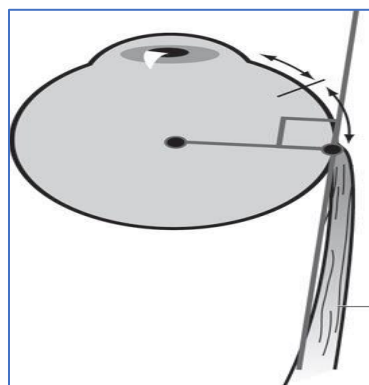
**FIGURE 1 (A)** Diagram of the horizontal rectus muscles shows the relationship of the moment arm ( $m$ ) to the muscle axis and center of rotation. The moment arm intersects the center of rotation and is perpendicular to the muscle axis. The longer the moment arm, the greater the rotational force. **(B)** Starling's length–tension curve. The relationship of a muscle's force is proportional to the tension on the muscle. More tension on a muscle increases muscle force and slackening a muscle reduces its force. Note that the relationship is exponential, not linear: toward the end of the curve, a small amount of slackening produces a disproportionately large amount of muscle weakening.(10)

A muscle recession transports the muscle insertion nearer to the muscle's origin (*Figure 2*), creating muscle loose(slack).



**FIGURE 2** Drawing of rectus muscle recession (*shaded muscle*). The effect of the recession is greatest when the eye rotates toward the recessed muscle. **(A)** The eye rotates away from the recessed muscle, causing the recessed muscle to tighten, therefore reducing muscle slack. **(B)** A rectus muscle recession resulting in muscle slack. **(C)** The eye rotates toward the recessed muscle, and the muscle and the muscle slack increase.(10)

This muscle loose (slack) reduces muscle strength per Starling's length–tension curve, but the moment arm does not significantly change when the eye is in primary position (*Figure 3*). The arc of contact of the MR muscle allows for large recessions of the rectus muscles without significantly changing the moment arm. *Figure 3* shows a 7.0-mm recession of the MR muscle. There is no change in the moment arm with these large recessions. So, the amount of muscle slack produced can regulate the effect of a recession on eye position (10)



**FIGURE 3** Medial rectus muscle recession. Diagram shows normal insertion at 5.5 mm posterior to the limbus and a 7.0-mm medial rectus recession. In primary position, the moment arm ( $m$ ) has not changed, so the effect of the recession is to create muscle slack rather than to change the moment arm.(10)

We can note at the end of the curve in the length–tension curve there is a quick loss of muscle force when muscle slack is increased (see *Figure 15 B*); this is why even small, accidental inaccuracies of large recessions (6-7mm) can cause dramatic changes in muscle force and result in an adverse outcome.

### Augmented medial rectus muscle recession

Augmentation of MR recession can be operated by bilateral MR recession according to the distance deviation with adding 1mm or 1.5 mm to the amount of recession. Adding 1 mm if the difference between the far and near deviation is equal to or less than 20 PD. Adding 1.5 mm if the difference is more than 20 PD. (31)

Another method of augmentation; is bilateral MR recession with augmented formula where the target angle is an average between near deviation without correction and distance deviation with hypermetropic correction. (41)

the Faden operation (POSTERIOR FIXATION SUTURE) with recession.

Cu"ppers in 1974, was the first who described Faden-operation. In this operation, suturing the muscle to the sclera behind the equator and thus creating a new insertion, posterior to the anatomical insertion the action of a rectus muscle is selectively weakened in its primary field of action without upsetting the balance between agonist and antagonist in other positions of gaze. the expression Faden operation is somewhat nonspecific. Faden is a German word meaning suture, it is derived from suturing the muscle to the sclera. But sutures are used for most types of muscle surgery. It was also used to describe traction sutures. Therefore, It is better to be elected posterior fixation suture, retropey of an extraocular muscle or retro-equatorial myopexy.

### *The mechanism of action of faden procedure*

The Faden does not change the moment arm when the eye is in primary position nor when the eye is rotated away from the muscle with the Faden.

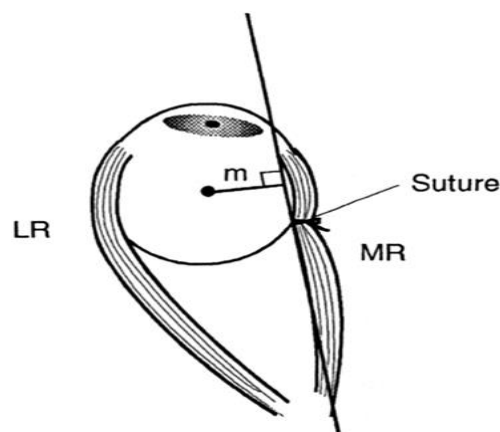
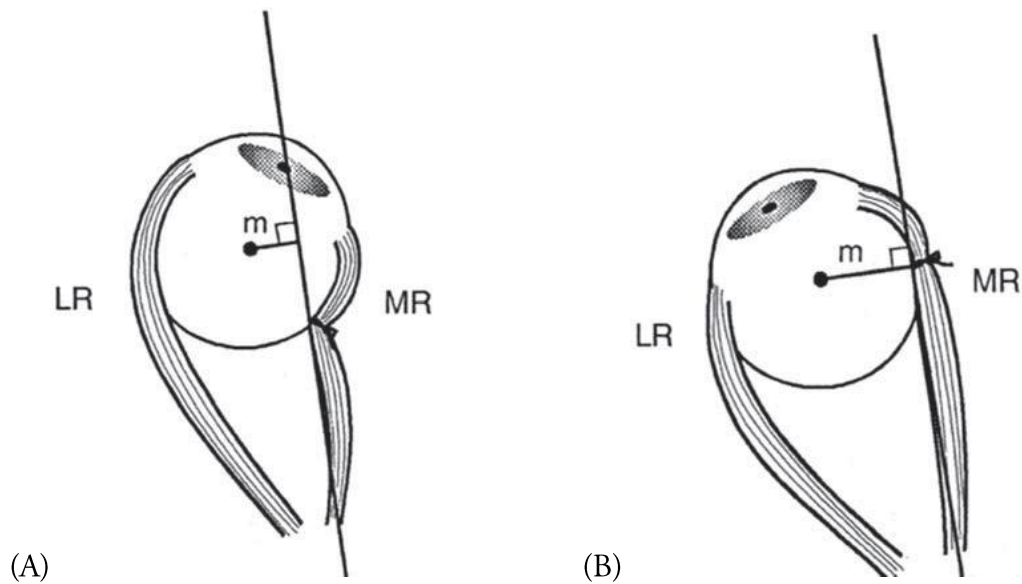


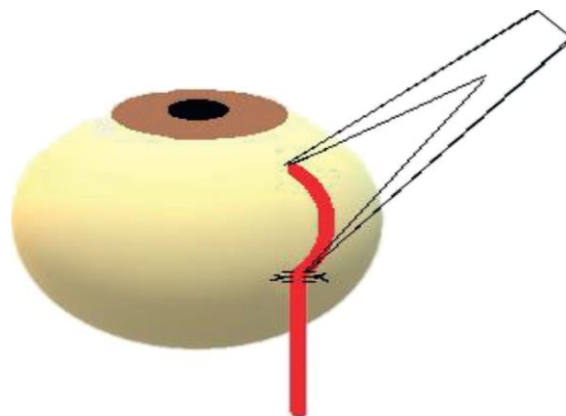
FIGURE 4 Faden of rectus muscle. In primary position, the Faden does not significantly change the moment arm ( $m$ ). (10)

But when the eye rotates toward the fadened muscle, the moment arm shortens, thus reducing the rotational force and so faden procedure can correct incomitant esotropia and enhance the effect of a medial rectus recession as in the case of high AC/A esotropia. (10)



**Figure 5** (A) Ocular rotation toward the Faden results in shortening of the moment arm ( $m$ ) as the muscle is pinned to sclera. (B) On rotation away from the Faden, the moment arm ( $m$ ) is normal and the faden has no significant effect. Thus, the Faden weakens the muscle on rotation toward the fadened muscle.(10)

Also, the operation increases innervation to the yoke muscle of the fellow eye (Hering's law). Furthermore, the contractile elements of the muscle are shortened and the effectiveness of a muscle contraction is decreased. A mechanical restriction also occurs from an opposite leash effect. Meanwhile, the sector of the muscle between its anatomical and new insertions is functionally inactivated, the contractile components of the muscle are reduced and the efficacy of a muscle contraction is decreased. The operation is most effective when performed on the medial rectus, less effective on the vertical rectus, and least effective on the lateral rectus muscle. (14)



**Figure 6:** A sketch of de Decker's Faden technique, side view(42)

#### *Disadvantage of faden procedure*

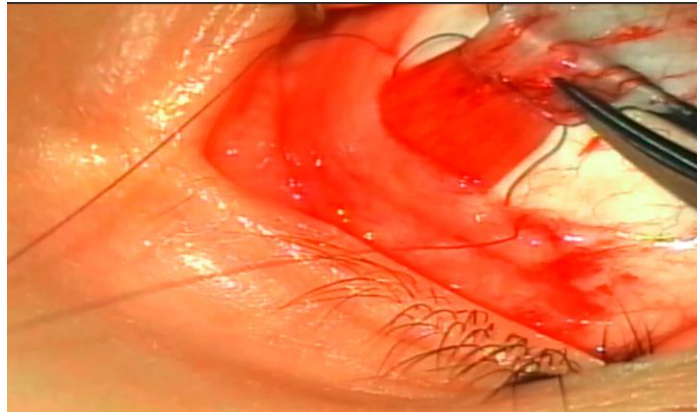
The surgery can be technically challenging because the exposure is usually insignificant, and the posterior sclera is relatively thin and liable to perforation and so retinal detachment. (43)

bilateral Combined resection recession (CRR) of medial rectus muscle

Scott was the first who suggested a large resection of a rectus muscle and recession of the same muscle while the recession amount was more than the resection amount. Scott reported good results and follow-up. In 1999 Bock and colleagues adjusted Scott's technique by reducing the amount of resection. In 1995 Thacker and colleagues suggested recessing by amount double that of resection. (43)

If the amount of resection exceeds the amount of recession this may lead to immediate postoperative exotropia; because the restrictive component and the stretching of the connective tissue pulley are too much displaced. Thus, the priority is given to recession over resection.(33)

Combined resection recession (CRR) is a combination between MR muscle resection and recession of the same muscle. A muscle resection is performed by eliminating the anterior part (2.5 mm) of the muscle then recession of the same muscle with addition of 1 ml to compensate for the effect of resection. (*Figure 7*)



**Figure 7:** combined recession and resection

### ***Mechanism of action***

The mechanism of action of CRR surgery is still in a point of theory. Related to MR, a first explanation is like the Faden operation. Muscle recession reduce the arc of contact and the resection tightens the pulley forward and retains its initial position, preventing it from following the movement of the recessed muscle. (33) (10)

Additional explanation of the effect of combined recession-resection would be in the phenomena of proprioceptive impulse of palisade endings nerve terminals at the tendinous insertions of recti muscles. The palisade endings may be sensory (proprioceptive) and motor but their role hasn't been completely explained. By resecting these tendinous junctions, some surgeons supposed that oculomotor influx would be repressed to the brain causing a rearrangement of tonic impulse. There were acceptable outcomes in infantile nystagmus and esotropia with convergence excess.

### **Bilateral Y-splitting and recession (YSR)**

In 1991, Bagolini et al. suggested recession and splitting of the medial rectus as an alternative to posterior fixation suture. Subsequently, other authors have highlighted the applicability of the Y-splitting procedure in the treatment of near far disparity esotropia.(44)

### *Mechanism of action*

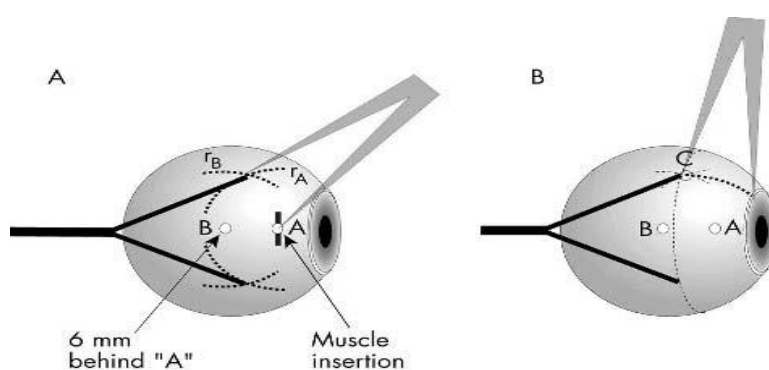
A Y-split recession characteristically combines two effects; reduction of the lever arm, and the torque exerted by the muscle for all eye positions, thereby reducing the variability of the strabismus angle. This torque reduction in y splitting is analogous to the torque reduction by a Faden procedure, via a suture 15 mm behind the insertion. Y splitting prevents incomitance through a fairly constant torque reduction. The muscle recession controls the minimum strabismus angle: by changing the muscle recession, so the primary position of the eye can be controlled.(45)

Intraoperative risk of perforation of the sclera and retinal detachment of faden procedure is reduced in the Y-splitting procedure because the insertion of the medial rectus muscle remains anterior of the equator. Y-splitting surgery has also been reported to result in less incomitance than posterior fixation surgery(44)

### *Surgical procedure*

At First, the muscle is split bluntly as posterior as possible (along a length of 15 mm). To measure the accurate new insertion positions for the two muscle halves, we can take up the procedure: a first alignment point, considered "A", is located in the middle of the normal insertion of the MR muscle. A second point, considered "B," is straight behind A according to the amount of recession intended. The distance "rA" and the distance "rB" are marked on the globe with methylene blue with the pair of compasses,. The connection point of the two methylene blue lines results the new insertion point of the first muscle half. The same procedure is performed on the second muscle half.

We can measure the control distance which is the distance between the limbus and the new insertion for simple evaluation of the correct new insertions of the two muscle halves. We can notice that a splitting of 15 mm, does not affect the pulley structure, as the pulleys are placed posterior the muscle split.



**Figure 8:** Y-split recession, side view. (A) The first orientation point ("A") is given by the middle of the normal muscle insertion. The second orientation point ("B") is located 6 mm straight behind A. With a compass, the distance rA is marked with color on the globe. The same procedure is repeated from B, with the distance rB. The connection of the two marked lines shows the new insertion points for the split muscle halves. (B) The "control distance" confirms correct placement of the new insertion positions.(45)

### Slanted recession

Slanted muscle surgery has been used for A- and V-pattern esotropia, exotropia with convergence weakness, and esotropia with convergence excess. In 1971; it was effectively used by Boyd et al. in correcting A- and V-patterns. in 1993; Nemet et al. stated respectable results with slanted muscle recession in esotropia with convergence excess. Although acceptable results have been described, there are restricted researches studying the effect of slanted medial rectus muscle recession on convergence excess esotropia. Also, there is restricted information about this type of surgery in texts. (39)

The higher end of the medial rectus muscle is recessed for distance deviation, and the lower end of the same rectus muscle is recessed for near deviation. The amount of recession is based on the conventional surgical squint tables. The amount of slant was defined as the difference of superior and inferior recession of the medial rectus muscles(31)

### No Conflict of interest.

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