Surgical strategy for third nerve palsy with aberrant regeneration: Harnessing the aberrant power

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Purpose: Our study aimed to evaluate the outcome of contralateral eye (CE) fixation duress squint surgery (FDSS) in third nerve palsy (³⁄₄ NP) with aberrant regeneration and compare the postoperative ptosis correction with preoperative ptosis improvement on adduction. Methods: Patients of ³⁄₄ NP with aberrant regeneration who underwent CE FDSS between December 2012-July 2015 in a tertiary-care eye hospital with a follow-up period of 1-year were retrospectively studied to analyze preoperative and postoperative details. Surgical success was defined as the correction of ptosis within 1 mm of preoperative ptosis improvement during maximal adduction of the affected eye, postoperative alignment ≤10Δ, and resolution of subjective diplopia in primary position. Results: A total of 14 eyes in 14 patients (mean age 23.6 ± 13.6 years) were included. Mean preoperative exotropia and ptosis in primary position in 14 patients was 53.4 ± 20pd and 4.89 ± 2.9 mm, respectively, and mean hypotropia in 6 patients was 23.67 ± 5.89pd. The mean improvement of ptosis on adduction and supraduction in all patients was 4.07 ± 2.64 mm and 2.89 ± 2.22 mm, respectively (P < 0.01). All patients underwent large recession of CE lateral rectus (mean 12.4 ± 2.7 mm), 9 patients underwent CE medial rectus resection/plication (mean 6.0 ± 0.9 mm) and 6 patients underwent CE superior rectus recession (mean 6.6 ± 0.67 mm). Postoperatively, mean ptosis and exotropia correction was 3.7 ± 2.4 mm (P = 0.000) and 15 ± 9.6pd (P = 0.000), respectively, and mean hypotropia was 2.17 ± 4.02pd (P = 0.000). Surgical success was achieved in 6 patients. Postoperative ptosis correction showed strong positive correlation with preoperative improvement of ptosis on adduction (r = 0.87; P = 0.00). Conclusion: Preoperative lid excursion on adduction in ³⁄₄ NP can be regarded as a prognostic sign of the success of CE FDSS which can simultaneously correct both ptosis and squint.

Key words: Aberrant regeneration, fixation duress, inverse-duane’s sign, pseudo-graefe’s sign, third nerve palsy

Surgery for correction of oculomotor paralysis is challenging because all extra-ocular muscles including levator-palpebrae-superioris (LPS) are paralyzed except superior oblique and lateral rectus (LR). But third nerve palsies (³⁄₄ NP) are known to regenerate partially with aberrant innervation known as acquired oculomotor misdirection or synkinesis. It was first described by Gowers in 1879.¹ This is most often seen in acquired cases of trauma, compressive lesions, and sometimes in congenital cases. The prevailing pathomechanism of acquired oculomotor synkinesis is the regeneration of sprouting axons within broken axonal cylinders of ³⁄₄ N (destined for medial/inferior rectus) which become misdirected and innervate LPS muscle.²⁻⁴ Sometimes misdirected axons may also innervate sphincter pupillae muscle (Pseudo-Argyll Robertson pupil) resulting in gaze-evoked pupillary constriction and greater constriction of the pupil to convergence than to light. In a classical case of aberrant regeneration of the ³⁄₄ N, the upper eyelid is elevated when the eyeball is adducted (Inverse-Duane’s sign) or infra-ducted (Pseudo-Graefe’s sign). In such cases, contralateral eye (CE) fixation duress squint (FDSS) surgery has been described by a few authors decades ago.⁵⁻⁶ The purpose of our study is to investigate the role of preoperative lid excursion on attempted adduction in prognosticating the outcome of fixation duress surgery in ³⁄₄ NP with aberrant regeneration. In this study, we would also study the relationship between preoperative parameters and surgical doses of squint surgery based on principles of fixation duress with postoperative results.

Methods

This retrospective cohort study was approved by the Institutional Review Board of our institute and followed the tenets of the Declaration of Helsinki. The medical records of all patients with ³⁄₄ NP with aberrant regeneration treated at our tertiary institute from December 2012-July 2015 were analyzed.

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reviewed. Patients of 3rd NP with ptosis and squint in the primary position and signs of aberrant regeneration who underwent fixation-duress squint surgery for the combined correction of ptosis and squint were included. Both congenital and acquired cases (non-recovery or partial recovery after at least 6 months of observation) were included. Signs of aberrant regeneration included ptosis improvement on adduction (Inverse-Duane’s sign) with or without improvement of ptosis on downgaze (pseudo-Graefe’s sign) and/or on supraduction. Exclusion criteria were patients with hypotropia and pseudo-ptosis (ptosis getting fully corrected when hypo-tropic eye takes central fixation in primary-position) without signs of aberrant regeneration and <12 months follow-up. Informed consent was obtained for all patients. Age, sex, any relevant systemic findings, visual-acuity, anterior/posterior segment examination findings were recorded. Complete orthoptic work-up including pre and postoperative measurements of squint, ductions, any face turn, force duction test, and type of synkinesis were recorded. Exotropia was measured by an alternate prism-bar cover test (PBCT), Krimsky, and Hirschberg corneal reflection tests. Ductions were recorded on a scale from 0 to −4, with 0 indicating full rotation up to canthus, −1 for slight limitation, −2 for half the range from the midline to canthus, −3 for slight movement from midline but not up to halfway, and −4 for not crossing the midline.

Marginal Reflex distance1 (MRD1), the distance between pupillary light reflex and lid margin was measured in both eyes and their difference was used to calculate the amount of preoperative true ptosis in the affected eye in primary position. In patients with hypotropia, true MRD1 was calculated by doing an algebraic sum of MRD1 with the plus value of hypotropia in mm (1 mm for every 7 degree hypotropia). Also, VPFH (vertical palpebral fissure height), the distance between the upper and lower lid margin was measured in both normal and affected eyes, while the normal eye fixated in the straight-ahead gaze. And their difference between the two eyes confirmed the value of ptosis in primary position. A note was made of the nature of aberrant innervation in all patients. Improvement in ptosis in adduction (pseudo-Duane’s sign), supra-duaction, and infra-duaction (pseudo-Graefe’s sign) in the affected eye was measured by calculating the difference between VPFH of the affected eye in the primary position and its value in the adducted, supra-duacted and infra-duacted position, respectively.

Fixation duress for simultaneous correction of both exotropia and ptosis was utilized by contralateral/nomral eye horizontal muscle surgery (large/supramaximal LR recession with or without MR resection). In affected eye, supramaximal recession of lateral rectus with medial rectus resection was performed only when it was required to address large exotropia (≥60pd). Periosteal fixation in affected eye was done in cases with large exotropia and tight LR. Fixation duress was also used to correct ptosis along with primary position hypotropia in affected eye by performing large SR recession in good eye. MR plication/cinching was added in good eye if recession of two muscles was already performed to prevent ASI. Posterior fixation suture on IR was added in patients with significant lid retraction on downgaze. IR recession was performed in normal eye only when affected eye exhibited ptosis with pseudo-Graefe’s sign and total limitation of infra-duaction but without primary position hypotropia thereby, creating fixation duress in normal eye to elevate the lid in affected eye without inducing vertical deviation. A note was made for the number of muscles operated, their surgical doses, and the number of sittings of surgery, any re-surgery/complications.

Based on the type of surgeries performed, data were grouped into 3 groups:

- **Group 1**: horizontal surgery alone
- **Group 2**: horizontal surgery combined with SR recession
- **Group 3**: horizontal surgery combined with IR recession

Surgical success was defined as the correction of ptosis equal to or within 1 mm of preoperative ptosis improvement during maximal adduction of the affected eye; postoperative alignment ≤10 prism dipters (pd) and omission of subjective diplopia in primary position. Details of the postoperative outcome in terms of exotropia and hypotropia correction along with ptosis improvement in primary position, any sign of anterior segment ischemia (ASI), and resolution/persistence of subjective diplopia and were recorded and compared with preoperative findings.

### Statistical analysis

Statistical analysis was performed using IBM SPSS version 22. A correlation was calculated using the Spearman-rho correlation. An Independent t-test was applied to compare the means of quantitative variables between two groups. A comparison between the preoperative and postoperative values was carried out using a paired t-test. All P values less than 0.05 were considered to indicate statistical significance with a 95% confidence interval.

### Results

We reviewed 14 patients undergoing surgery for 3rd NP with aberrant regeneration. All patients were acquired (post-traumatic) cases with partially recovered MR, large exotropia, and true ptosis in primary position. MRI Brain was done in all patients and none of the patients underwent any neurosurgical intervention. There were 10 males and 4 females. The right eye was involved in 8 patients. The mean age was 23.61 ± 3.6 years. All 14 patients had exotropia along with true ptosis in the primary position. Mean exotropia in primary position was 53.4 ± 20 pd. 6 patients had an additional finding of hypotropia in the involved eye in primary position (mean 23.67 ± 5.89pd). The parietic eyes of these 6 patients were not able to supra-duct beyond midline from their hypo-tropic position on maximal attempted supraduction of the contralateral eye.

Mean preoperative MRD1, VPFH, and ptosis in primary position in affected eye in 14 patients was −0.64 ± 3 mm, 4.36 ± 3 mm and 4.89 ± 2.9 mm, respectively. Mean preoperative improvement in ptosis from primary position to maximal adduction (Inverse-Duane’s sign) in 14 patients was 4.07 ± 2.64 mm. Mean improvement of ptosis in supraduction was 2.89 ± 2.22 mm in 14 patients (P = 0.213). 4 patients had improvement of ptosis on downgaze (pseudo-Graefe’s sign) with mean value 3.38 ± 2.56 mm in affected eye. None of the patients had residual hypotropia along with pseudo-ptosis as the only finding without inverse-Duane’s or pseudo-Graefe’s sign as they were excluded from the study. None of the patients were able to fix with the involved eye in supra-duaction/infra-duaction. Bells was poor in all patients. Mean preoperative duction was SR -3.71, IR -3.5, IO -3.7, MR -2.1. Pupillary involvement (pseudo-Argyll Robertson pupil) was present in 3 patients with constriction on adduction or infra-duaction.

Large-supra maximal recession of normal eye/CE LR was done in all 14 patients with a mean recession of 12.4 ± 2.7 mm (minimum 8 mm; maximum 18 mm). 9 patients underwent MR resection/plication (mean 6.0 ± 0.9 mm) in the CE in addition to LR recession. Because of large exotropia, large combined recession and resection in the affected eye
was done in 4 patients, including 1 patient who underwent periosteal fixation [Table 1]. Limbal conjunctival incision was used when large/supramaximal recession was performed. Rest cases underwent fornix incision. 6 patients with hypotropia underwent CE SR recession (mean 6.6 ± 0.67 mm) [Table 1 and Fig. 1]. MR plication (entire width of muscle tendon) in CE was done in 3 patients [Table 1, patient 3, 6 & 8; Fig. 2] when it was necessary to operate third recti (after operating one horizontal and one vertical recti in good eye). It was staged for minimal 3-6 months to avoid ASI. Only 1 patient (patient 4) with large ptosis and minimal pseudo-Duane’s sign but significant lid retraction on downgaze (pseudo-Graefe’s sign) and total infraduction limitation in affected eye underwent normal eye IR recession. 3 patients underwent PFS on CE/normal eye IR was done in 4 patients in which large lid retraction in downgaze was present [Table 1]. 5 children (patient 2, 3, 6, 12 and 13) underwent surgery under general anesthesia and local anesthesia was administered in rest of the adult patients. 9 patients underwent a single setting of surgery, 3 required 2 settings, and 2 patients required 3 settings of surgery. None of the patients underwent re-surgery on the same operated muscle. 3 willing patients underwent adjustable suture but none required postoperative adjustment. Patients were followed postoperatively on Day 1, Day 5, 3 weeks, and 6 months. No signs of ASI were found. None of the patients developed corneal exposure after surgery.

Postoperatively mean exotropia in 14 patients was 15 ± 9.6pd with mean correction of 39.86 ± 15.6pd (P = 0.000). Postoperative mean MRD1 and VPFH of affected eye, whereas CE fixated in primary position in 14 patients was 2.75 ± 2.3 mm and 7.75 ± 2, respectively. There was an improvement of 3.7 ± 2.4 mm of ptosis in primary position at 12-months follow-up in 14 patients (P = 0.000). Postoperative ptosis correction showed strong positive correlation with preoperative ptosis improvement value on adduction (r = 0.88; P = 0.000). An X–Y scatter plot has been drawn to understand the behavior of data: preoperative ptosis improvement on adduction versus postoperative ptosis correction [Fig. 3]. The graph shows the best fit straight line which has been represented by the following equation y = 0.8036x + 0.4067 (R² = 0.7646).

Surgical success was achieved only in 6 patients. [Table 1]. 8 patients remained under-corrected, out of which 3 adult patients had residual subjective diplopia in primary position for which prismatic glasses were prescribed. 2 children (patient no 12 and 13) with residual squint were advised for further surgery but it could not be performed as parents were not willing.

Figure 1: Misdirected regeneration of right eye (RE) third nerve (patient no 1) following trauma with signs of aberrant regeneration. Preoperative pictures in 9-gaze (a-i); Note elevation of the right eye (RE) upper lid on attempted adduction (l), elevation of RE upper-lid on attempted downgaze of (f), Postoperative picture (j-r) after left eye (LE) lateral rectus recession 12 mm & superior rectus recession 5 mm showing alignment in primary position without ptosis in RE with mild lid-retraction in LE (n) with an improvement of incomitance in upgaze (k) compared to preoperative image (b)
Group 1
Mean preoperative ptosis, improvement of preoperative ptosis on adduction and postoperative value of ptosis correction in 7 patients in which horizontal muscle recession was done alone (without vertical muscle recession) was 3.57 mm, 3.71 mm, and 3 mm, respectively.

Group 2
Mean preoperative ptosis, ptosis correction on adduction and postoperative value of ptosis correction in 6 patients in which SR recession was done along with horizontal muscle recession was 5.75 mm, 5.08 mm, and 4.83 mm, respectively. Postoperative mean hypotropia after SR recession in 6 patients was 2.17 ± 4.02pd with a mean correction of 21.5pd (P = 0.000). Mean lid retraction of 1.67 ± 0.61 mm was seen in these 6 patients in which SR recession was done.

The mean difference of postoperative ptosis correction between the two groups (group 1 and 2) was not significant (P = 0.181).

Group 3
There was only 1 patient (patient 4) in which IR recession was done along with horizontal muscle surgery. His preoperative ptosis correction value in adduction, supraduction, and infra-duction was 0.5 mm, 0 mm, and 2 mm, respectively. But postoperatively he achieved only 1.5 mm ptosis correction compared to 9 mm preoperative ptosis value (only patient with an unsatisfactory postoperative outcome).

LR recession in CE in all 14 patients showed no correlation with ptosis correction achieved postoperatively (r = 0.46; P = 0.098). Preoperative residual MRduction deficit (after regeneration) in 14 patients showed no significant correlation with exotropia correction (r = -0.163; P = 0.578) and postoperative ptosis correction (r = -0.112; P = 0.704). Also, postoperative ptosis correction showed no correlation with preoperative hypotropia in 6 patients (r = 0.334; P = 0.518). Postoperative lid-retraction in 6 patients did not show significant correlation both with postoperative ptosis correction (r = 0.265; P = 0.612) and amount of SR recession in CE (r = 0.574; P = 0.233).

Discussion
Several surgeries have been described in the affected eye to improve exotropia in 3rd NP cases. But if ptosis is present, its correction is generally deferred because of the paralysis of both elevators and poor Bells. Remarkable results of
correcting ptosis and squint together by simple recess-resect procedure primarily or exclusively on the contralateral fixing eye have been described.[5,6] Our study aimed to evaluate if preoperative lid excursion on adduction can predict the success of postoperative ptosis correction using principles of FDSS.

Parulekar and Elston[9] performed LR recession (7-8 mm) and small MR resection on the non-paretic eye of 4 cases to correct the horizontal misalignment based on the ocular deviation measured with the dominant eye fixing. But when there is large exotropia, hypotropia along with true ptosis (which improves on adduction); combined recess-resect procedure of horizontal recti in normal eye/CE may leave residual hypotropia and combining recession of one horizontal rectus (within safe limits) with one vertical rectus in the normal eye might leave residual exotropia. Also combining recess-resect of horizontal recti with vertical recti recession may bear the risk of ASI. Hence, in our study, large/supramaximal LR recession in the normal eye was done in selected cases when it was required to combine SR recession in the same eye as part of fixation duress surgery to simultaneously correct large exotropia (secondary-deviation), hypotropia and to match with adduction deficit of affected eye. Resection of the involved eye medial rectus was typically avoided in patients with inverse Duane’s sign to maximize the effect of fixation duress, but large lateral rectus recession and medial rectus resection in the affected eye was performed only when it was required to address large residual exotropia. Plication of MR was done in normal eye in the subsequent stage for residual exotropia in patients who already underwent SR and LR recession to avoid ASI.

Surgery in normal eye created fixation duress which by Hering’s law transmitted extra innervation to the yoke muscle (partially regenerated medial rectus) of the affected eye which got transmitted to LPS which thereby elevated the lid in primary position. Postoperative ptosis correction showed strong significant positive correlation \( r = 0.87, \ P = 0.000 \) with preoperative ptosis correction value on adduction. So, by examining the amount of lid excursion in the affected eye on attempted full adduction, one can prognosticate the amount of ptosis correction which can be achieved by FDSS and patients can be counseled accordingly. Postoperatively there was an average abduction deficit of -1 in the normal eye which partially matched with the adduction deficit of paralytic eye (mean -2.1) hence creating greater comitance in the horizontal gaze.

Noonan and O’Connor[13] described large SR recession and/or LR recession to decrease elevation and create fixation-duress in CE to correct hypotropia and pseudoptosis in the affected eye. The cases they described all had complete pseudo-p toesis such that when involved eye took fixation there was no residual ptosis in the involved eye and also ductions were normal. Also, there was no evidence of aberrant regeneration except pseudo-Argyll Robertson pupil. We performed SR recession in CE in 6 patients. But in our 6 cases, all patients had -4 supraduction (except one with -2.5). All affected eyes were at-least able to reach midline from hypo-tropic position when made to fixate but still, there was residual true ptosis in all our cases unlike described by Noonan and O’Connor.[13]

We measured improvement of ptosis in maximum supraduction of the affected eye (mean 2.89 ± 2.22 mm) in 14 patients and compared to the improvement of ptosis in adduction (mean 4.07 ± 2.64 mm). It is prudent to think that improvement of ptosis on attempted supraduction could have been contributed by SR recession in the normal eye in improving lid position postoperatively. Probabilities could be two-fold. First, it could be that by performing large SR recession we might have used pseudo-ptosis component but this is less likely unless it was missed clinically, as we excluded patients with hypotropia occurring in conjunction with clinically evident pseudo-ptosis from our study. Secondly, use of fixation duress in the improvement of ptosis could be due to aberrant supply to LPS from affected SR and maximal supraduction attempt in affected eye after SR recession in the normal eye might have added to the component of ptosis correction (by Hering’s law). This has a greater possibility because there was an improvement of ptosis on the maximal attempt of supraduction even in patients without hypotropia and with supraduction-4 [Table 1]. And the difference between improvement in adduction and supraduction was not statistically significant \( (P = 0.213) \) thereby, suggesting the role of aberrant regeneration.

The amount of correction achieved by SR recession alone could not be measured separately from horizontal muscle fixation-duress surgery. Hence, we segregated the data
| Patient no/age/sex | Involved eye | Primary Position deviation | Pre-operative ptosis (mm) | Involved eye Duction MR/SR/IR/O | Type of synkinesis/Aberrant | Surgery -contralateral eye |
|-------------------|--------------|----------------------------|---------------------------|--------------------------------|-----------------------------|---------------------------|
|                   |              |                            |                           |                                | Ptosis improvement in adduction (mm) | Ptosis improvement on supraduction (mm) | Ptosis improvement on downgaze (mm) |
| 1 26/F            | R            | 45                         | 8                         | -1/-4/-3/-4                    | P                           | P (4)                     | A                         | 12                        | -                        |
| 2 9/M             | R            | 50 L/R20                   | 4                         | -1/-2.5/-2/-2                 | P                           | P (3.5)                   | A                         | 15                        | -                        |
| 3 15/F            | O            | 60 L/R22                   | 8                         | -3.5/-4/-4/-4                 | P                           | P (3.5)                   | A                         | 15                        | 5.5                      |
| 4 28/M            | L            | 90                         | 9                         | -3/-4/-3/-4                   | P                           | A                         | P                         | 10                        | 6                        |
| 5 50/F            | R            | 50                         | 4                         | -3.5/-4/-4/-4                 | P                           | P                         | A                         | 12                        | 5                        |
| 6 12/M            | L            | 60 R/L20                   | 7                         | -3/-4/-4/-4                   | P                           | P                         | A                         | 14                        | 8                        |
| 7 30/M            | L            | 50 L/R20                   | 6.5                       | -2/-4/-4/-4                   | P                           | P                         | A                         | 10                        | 6                        |
| 8 35/M            | R            | 50 L/R20                   | 5.5                       | -3/-4/-4/-4                   | P                           | P                         | A                         | 18                        | 6                        |
| 9 25/M            | L            | 55                         | 1                         | -2.5/-4/-4/-4                 | P                           | P                         | A                         | 9                         | 6                        |
| 10 27/F           | R            | 25                         | 1                         | -1/-3/-3/-3                   | P                           | P                         | P                         | 8                         | -                        |
| 11 28/M           | R            | 20                         | 2.5                       | -1/-3/-3/-3                   | P                           | P                         | P                         | 12                        | -                        |
| 12 8/M            | L            | 90                         | 8                         | -1/-4/-3/-4                   | P                           | P                         | A                         | 12                        | 6                        |
| 13 2/M            | R            | 40 L/R25                   | 2                         | -3.5/-4/-4/-4                 | P                           | P                         | A                         | 15                        | -                        |
| 14 45/M           | L            | 60                         | 2                         | -1/-4/-4/-4                   | P                           | P                         | A                         | 12                        | 5.5                      |

Contd...
| Patient no/age/sex | Surgery -contralateral eye | Surgery-Ipsilateral | Postoperative |
|-------------------|-----------------------------|---------------------|--------------|
|                   | Surgery                       |                      |              |
|                   | SR recession | IR recession | Fixation | LR recession | MR resection |                       | Primary position deviation | Ptosis correction primary position | MR duction | Lid Retraction (mm) |
| 1 26/F             | 7                        | -                    | -        | -            | -            | 8 BI**                  | 7.5                     | -1                   | 2               |
| 2 9/M              | 7                        | -                    | SR       | -            | -            | 6 BI**                  | 3.5                     | -1                   | 1               |
| 3 15/F             | 5.5                      | -                    | SR IR    | 18           | 7            | 4BI**                  | 7                      | -2.5                 | 1               |
| 4 28/M             | -                        | 6                    | IR       | PF 22        | 8.5          | 35                     | 1.5                     | -2.5                 | -               |
| 5 50/F             | -                        | -                    | -        | -            | -            | 10**                   | 5                      | -2.5                 | -               |
| 6 12/M             | 7                        | -                    | -        | 18           | 9            | 20                     | 5                      | -2                   | 2.5             |
| 7 30/M             | -                        | -                    | -        | -            | -            | 16                     | 4                      | -1.5                 | -               |
| 8 35/M             | 7                        | -                    | SR       | -            | -            | 12                     | 4.5                    | -2                   | 2               |
| 9 25/M             | -                        | -                    | -        | -            | -            | 18                     | 0.5                    | -2.5                 | -               |
| 10 27/F            | -                        | -                    | IR       | -            | -            | 8**                    | 0.5                    | -0.5                 | -               |
| 11 28/M            | -                        | -                    | IR       | -            | -            | 8**                    | 2.5                    | -0.5                 | -               |
| 12 8/M             | -                        | -                    | -        | 18           | 9            | 35                     | 7                      | -3                   | -               |
| 13 2/M             | 6                        | -                    | -        | -            | -            | 15                     | 1.5                    | -2.5                 | 1.5             |
| 14 45/M            | -                        | -                    | -        | -            | -            | 15                     | 1.5                    | -0.5                 | -               |

M=male; F=female; R=right eye; L=left eye; P=present; A=absent; Dip=diplopia; I Dip=Intermittent diplopia; R=resolved; LR=lateral rectus; SR=superior rectus; IR=inferior rectus; MR=medial rectus; PF-periosteal fixation. ** denotes patients in which surgical success was achieved. *Post operative Diplopia was absent due to large residual ptosis in primary position.
separately in 3 groups: cases in which horizontal muscle surgery was done alone or when combined with SR/IR recession. 6 patients (patient 1, 2, 3, 6, 8, 13) underwent SR recession along with horizontal muscle surgery [Table 1 and Figs 1 and 2] and 7 patients underwent horizontal muscle surgery in contralateral eye alone [Table 1]. When we compared the postoperative correction of ptosis between the two groups we didn’t find any statistically significant difference thereby implying that the addition of vertical muscle does not necessarily achieve greater correction of ptosis than horizontal muscle alone. Indeed large SR recession does contribute a part of ptosis correction, but it may not be a superior alternative to horizontal muscle surgery if there is evidence of useful improvement of pre-operative ptosis on addition. Hence, such patients of 3rd NP with aberrant regeneration presenting with significant hypotropia in the primary position and some amount of supraduction (eye reaching at least up-to midline), SR recession can be combined with horizontal muscle surgery in the normal eye. Also, large SR recession additionally decreased the ability of normal eye to elevate and brought comitance in upgaze [Fig. s 1 and 2]. Postoperative ptosis correction showed no correlation with preoperative hypotropia (r = -0.35; P = 0.220). Slight lid retraction in normal eye (mean 1.7 mm) was the most common complication which was encountered after SR recession even when all surgical precautions (detaching LPS attachments from SR) were taken for its prevention [Fig. 1].

Pseudo-Graefe’s sign (aberrant supply from IR to LPS) may be used to correct ptosis by operating on good eye IR only when VPFFH in downgaze is more than that of primary position or addition with total infra-duction limitation and absence of hypotropia in affected eye in primary position. In such cases large IR recession in normal eye can create fixation duress to elevate lid in affected eye. Fixation-duress created in the normal eye to infra-duct and fixate in primary position after IR recession gets transmitted to affected eye IR and hence aberrant supply to LPS thereby correcting ptosis. IR recession in normal eye was done only in 1 patient (case 4). But there was poor postoperative outcome in terms of ptosis correction as preoperatively the patient had severe ptosis with only minimal improvement on addition (0.5 mm) and probably patient needed larger IR recession to achieve the advantage. Separate studies are required to test the role of fixation duress IR recession in such cases. Rest all 13 patients showed good correction of ptosis postoperatively as all had a good preoperative correction of ptosis on addition and this aberrant supply was harnessed to correct ptosis in primary position.

Elston[14] mentioned contralateral eye posterior fixation suture (PFS) on vertical recti as surgical techniques to increase the innervational drive to the yoke muscle to omit diplopia and increase the existing area of a single vision. PFS on vertical recti at 14 mm was done in 6 patients. PFS alone (without recession) on normal eye IR was done in 4 patients in which pseudo-Graefe’s sign was present. This created comitance, omitted diplopia, and matched lid retraction in downgaze. And PFS on normal eye SR was done (along with recession) in 3 patients with hypotropia which decreased the ability of the normal eye to elevate and brought comitance in upgaze [Fig. 3].

The amount of normal eye LR recession doesn’t determine the amount of ptosis correction in the affected eye. Similarly, postoperative exotropia or ptosis correction is not determined by preoperative residual MRduction deficit. The limitation of the study was a small sample size.

Conclusion

In 3rd NP with aberrant regeneration, individualization of the case and surgical selection are the key parameters. The amount of ptosis correction on adduction can be used as a useful preoperative predictor of success for the postoperative surgical outcome in terms of ptosis correction. Aberrant supply to LPS during addition can be used and further reinforced by maximally weakening the normal eye LR thereby correcting both ptosis and squint. In patients with hypotropia, one should check the improvement of ptosis on addition in supra-version and can decide the addition of SR recession in addition to horizontal muscle surgery in the normal eye. SR recession with or without PFS can not only correct hypotropia and brings comitance in upgaze but can also contribute to ptosis correction either by using aberrant innervation on supraduction or clinical/subclinical pseudoptosis. PFS on IR in the normal eye can be reserved for cases with pseudo-Graefe’s to increase innervation in yoke muscles to bring comitance in downgaze, correct diplopia, and match lid retraction in downgaze.

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Conflicts of interest

There are no conflicts of interest.

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