Surgical outcome in monocular elevation deficit: A retrospective interventional study

Rakhi Bandyopadhyay, MS; Shashikant Shetty, MS; P Vijayalakshmi, MS

Background and Aim: Monocular elevation deficiency (MED) is characterized by a unilateral defect in elevation, caused by paretic, restrictive or combined etiology. Treatment of this multifactorial entity is therefore varied. In this study, we performed different surgical procedures in patients of MED and evaluated their outcome, based on ocular alignment, improvement in elevation and binocular functions.

Study Design: Retrospective interventional study.

Materials and Methods: Twenty-eight patients were included in this study, from June 2003 to August 2006. Five patients underwent Knapp procedure, with or without horizontal squint surgery, 17 patients had inferior rectus recession, with or without horizontal squint surgery, three patients had combined inferior rectus recession and Knapp procedure and three patients had inferior rectus recession combined with contralateral superior rectus or inferior oblique surgery. The choice of procedure was based on the results of forced duction test (FDT).

Results: Forced duction test was positive in 23 cases (82%). Twenty-four of 28 patients (86%) were aligned to within 10 prism diopters. Elevation improved in 10 patients (36%) from no elevation above primary position (–4) to only slight limitation of elevation (–1). Five patients had preoperative binocular vision and none gained it postoperatively. No significant postoperative complications or duction abnormalities were observed during the follow-up period.

Conclusion: Management of MED depends upon selection of the correct surgical technique based on employing the results of FDT, for a satisfactory outcome.

Key words: Inferior rectus recession, Knapp surgery, monocular elevation deficiency

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Introduction

Monocular elevation deficiency (MED) is characterized by defective elevation, as well as adducted or abducted positions in primary gaze, sometimes associated with hypotropia and ptosis or pseudoptosis.1 Though attributed to paralysis of both the elevators in some cases, superior rectus palsy alone can account for MED.1 In addition, MED can be caused by inferior rectus restriction and supranuclear etiologies.2 Differentiation on the basis of paretic or restrictive etiology, is important for appropriate surgical planning.3,4 Extensive Medline search did not reveal any major Indian study on MED. This encouraged us to evaluate the outcome of different surgical procedures in this condition, in a tertiary eye care hospital.

Materials and Methods

After obtaining institutional review board approval, a computer database retrieval system at the medical records section was used to search for all patients who underwent surgery for MED, from June 2003 to August 2006. Twenty-eight consecutive patients, comprising 12 males and 16 females, formed the cohort in this study.

Patients with restrictive strabismus due to thyroid eye disease, orbital fractures, orbital inflammation, orbital tumors, myasthenia gravis, ocular fibrosis and those with prior ocular and extraocular muscle surgery were excluded from this study.

All patients underwent a detailed workup, including full ophthalmic and orthoptic evaluation prior to surgery. This included assessment of visual acuity using Snellen chart, Cambridge single and crowding cards, Sheriden-Gardner charts and the “hundreds and thousands” test, as appropriate for the age of the patient, full cycloplegic refraction in children and dynamic refraction in adults, anterior segment slit-lamp biomicroscopy and fundus examination. Deviation was measured by alternate prism cover test for both near (33 cm) and distance (6 m) using fixation targets and with full optical correction. Neutralizing prisms were placed on the eye with MED to measure the primary deviation, which formed the target angle for surgery. Fusion was assessed for near and distance, using Worth four dot test, with room lights on, to make the test, as much less dissociative as possible and stereopsis was measured using TNO test, in both primary and chin up
position. Ocular movements were tested, including ductions, versions and vertical saccades. Ductions and versions were quantified on a four-point scale of –1 to –4, as follows: mild limitation = –1, moderate limitation = –2, severe limitation = –3, no elevation above primary position = –4. True ptosis, when present, was thoroughly evaluated. A forced duction test (FDT) was performed preoperatively for both elevation and depression in cooperative patients and was done intraoperatively for non-cooperative patients. In suspected cases, myasthenia gravis was ruled out by the Tensilon test.

All surgeries were performed by any one of the two authors (PV, SS).

The postoperative ocular deviation was measured at the end of one month. The follow-up period ranged from six months to three years. A satisfactory outcome was defined as an ocular deviation aligned to within 10 prism diopters (pd), in the primary position.

Based on the surgical procedure undertaken, the patients were divided into six subgroups,

- **Group-1**: Knapp procedure alone; was done in three patients, who had negative FDT for elevation. The surgical procedure consisted of a 180° superior limbal peritomy, isolation of the medial rectus (MR) and lateral rectus (LR) muscles and transpositioning them adjacent to the superior rectus (SR) muscle, preserving the contour of the spiral of Tillaux.

- **Group-2**: Knapp procedure combined with horizontal muscle (MR and LR) recession and resection for the associated horizontal strabismus in two patients.

- **Group-3**: Recession of the inferior rectus (IR) alone; was done in 12 patients who had positive FDT for elevation, due to IR restriction. The operative procedure was inferior conjunctival peritomy, isolation of IR muscle, thorough separation of the muscle from the Lockwood’s ligament and recession up to a maximum of 5 mm.

- **Group-4**: Inferior rectus recession followed by Knapp procedure in two sittings with a gap of four months in three patients.

- **Group-5**: Inferior rectus recession, followed by horizontal muscles’ recession and resection for coexisting horizontal squint in two sittings with a gap of four months in five patients.

- **Group-6**: Inferior rectus recession combined with contralateral vertical rectus or oblique muscle surgery in three patients wherein elevators were overacting.

In this study, grouping has been based on the surgical procedure performed. Monocular elevation deficiency can present as hypotropia alone or hypotropia associated with esotropia or exotropia. Hypotropia alone will require only Knapp surgery (Group-1) or IR surgery (Group-3), based on FDT. However, associated horizontal strabismus, when present, needs a different approach in which Knapp needs to be combined with recession and resection of MR and LR (Group-2) or IR recession needs to be combined with horizontal muscle surgery (Group-5). Sometimes when residual hypotropia persists after IR surgery, a Knapp surgery is required in addition (Group-4). Lastly, associated overaction of contralateral vertical rectus or oblique muscles can have a bearing on the surgical procedure chosen (Group-6). In two cases, weakening of the overacting contralateral SR was done in addition to IR recession. One of them habitually fixed with the MED eye, as the other one was amblyopic and had hypertropia with SR overaction. In another case, recession of overacting inferior oblique (IO) was done with IR recession, with gratifying results. This is the basis of division into six groups, as each group is different from the other in their presentation and management.

**Results**

The mean age at surgery in this study was 14.03 years with a range of two to 31 years.

The male patients were 12 (43%) and the female patients were 16 (57%). Right eye (OD) was involved in 18 cases (64%) and left eye (OS) in 10 (35%) cases. The best-corrected visual acuity ranged from 20/30 to 3/200 in the affected eye [Tables 1 and 2].

True ptosis was present in eight cases (29%) and Marcus Gunn jaw winking phenomenon was present in two cases (7%). The preoperative ocular deviation varied from 20 to 40 pd of hypotropia in primary position, with a mean deviation of 27.6 pd. Five patients (18%) had evidence of binocular single vision (BSV) at near with chin up position when tested with Worth four dot test. All others had suppression at near and distance. No patient had any stereopsis on TNO test. Preoperative ductions measured –3 or –4 in elevation, in all patients. The FDT was positive in 23 cases (82%); 27 patients preferred fixation with the non-paretic eye and one patient preferentially fixed with the paretic eye.

Elevation improved from –4 to –1 in 10 patients (36%), five patients had undergone Knapp procedure and five patients had IR recession. In seven patients elevation improved to –2. The rest of the patients had significant elevation deficiency which was no better than –3. Postoperatively, no patient in any group gained BSV. Only those patients who had BSV preoperatively, maintained it after surgery, with improvement in the chin up position. The BCVA also did not improve beyond the preoperative level in any of the patient. Postoperatively 24 of 28 patients (86%) had correction of deviation to within 10 pd [Table 3].

**Discussion**

The treatment of MED is surgical. The etiopathogenesis of this condition is heterogeneous, which makes it difficult to treat it with a single surgical formula. Successful alignment of MED has been described following different surgical modalities. The procedure of choice is determined by the FDT, which ascertains whether the cause is paretic due to SR palsy and/or IO palsy or restrictive due to IR restriction.

In presence of SR palsy, the procedure employed is a Knapp transposition. In his original work, Knapp reported 15 patients, in whom correction of hypotropia ranged from 21 to 55 pd with a mean of 38 pd. Good results were obtained in 14 out of 15 patients (93%). Other authors, have found similar amounts of correction. Barsoum-Homsy performed Knapp surgery in four cases of MED and observed an average correction of 31.7 pd. Watson, in his series, observed a mean correction of 30.5 pd. Cooper and Greenspan, reported an incidence of 26.6 pd of correction of hypotropia. Scott performed Knapp procedure in 19 patients and found a
correction of 21.1 pd in patients who had no prior surgery. Caldeira, noted in his series of 10 patients, in whom Knapp surgery was performed, a mean correction of 36.4 pd for distance and 29.5 pd for near. Kamlesh and Dadeya noted a correction of 20 pd of horizontal and 25 pd of vertical correction in their series of MED with associated horizontal deviation. In this series, Þ ve patients who underwent Knapp surgery, had a mean correction of deviation of 29.4 pd, which correlates well with the results of most studies [Figs. 1 and 2].

In our study, IR restriction was present in 23 out of 28 patients (82%). This high percentage has been reported by other authors. Wright has stated that the incidence of inferior restriction in MED is 70%. Scott and Jackson reported IR restriction in 11 out of 15 patients (73.3%). Metz reported 12 out of 15 patients of MED having restriction in elevation on FDT (80%). Some authors have advised, in such cases, IR recession ranging from 5 to 8 mm, while others have reported increased complications with recessions exceeding 5 mm. We have restricted IR recession to a maximum of 5 mm, to lower the complications of hypertropia in downgaze and lower lid retraction. The average correction was 16 pd from an average preoperative deviation of 25.8 pd.

Inferior rectus recession needs to be followed by Knapp procedure in the presence of residual SR palsy, due to persistent hypertropia. In our series, three such patients underwent both surgeries, with an average correction of 28.6 pd of deviation, at the end of two surgeries [Figs. 3 and 4]. Kocak-Altimtas et al., reported a series of six MED patients with positive FDT, who underwent IR recession, followed by Knapp, achieving a mean correction of 25.8 ± 5.6 pd. Scott reports a higher average correction of 38 pd following two surgeries.

Anterior segment ischemia (ASI) has been reported to occur after such procedures, due to disruption of ciliary circulation. One of our patients, a healthy young man aged 26 years, who

### Table 1: Demographic parameters in children with monocular elevation deficiency (2-15 years)

| Age/sex | Etiology       | Preop VA | Preop fusion | Postop VA | Postop fusion |
|---------|----------------|----------|--------------|-----------|--------------|
| 6 yrs/F | SR palsy       | 20/120   | NoBSV        | 20/120    | NoBSV        |
| 2 yrs/F | SR palsy       | Picks candy beads | BSV could not be tested | Picks candy beads | BSV could not be tested |
| 14 yrs/M | IR restriction   | 20/60   | NoBSV        | 20/60     | NoBSV        |
| 9 yrs/F | IR restriction   | 20/120  | NoBSV        | 20/120    | NoBSV        |
| 15 yrs/F | IR restriction   | 20/80   | NoBSV        | 20/80     | NoBSV        |
| 10 yrs/F | IR restriction   | 20/30   | BSV present  | 20/30     | BSV present  |
| 13 yrs/M | IR restriction   | 20/60   | NoBSV        | 20/60     | NoBSV        |
| 10 yrs/M | IR restriction   | 20/80   | NoBSV        | 20/80     | NoBSV        |
| 11 yrs/F | IR restriction   | 20/30   | BSV present  | 20/30     | BSV present  |
| 12 yrs/M | IR restriction   | 20/30   | BSV present  | 20/30     | BSV present  |
| 10 yrs/F | IR restriction with XT | 20/120  | NoBSV        | 20/120    | NoBSV        |
| 8 yrs/F | IR restriction with XT | 20/80   | NoBSV        | 20/80     | NoBSV        |
| 12 yrs/F | IR restriction with XT | 20/200  | NoBSV        | 20/200    | NoBSV        |
| 14 yrs/F | IR restriction with XT | 20/240  | NoBSV        | 20/240    | NoBSV        |
| 6 yrs/F | IR restriction with ET | 20/1200 | NoBSV        | 20/1200   | NoBSV        |
| 8 yrs/F | IR restriction    | 20/1200 | NoBSV        | 20/1200   | NoBSV        |
| 15 yrs/M | IR restriction    | 20/120  | NoBSV        | 20/120    | NoBSV        |
| 4 yrs/F | IR restriction    | 20/80   | NoBSV        | 20/80     | NoBSV        |

MED - Monoocular elevation deficiency, VA - Visual acuity, SR - Superior rectus, IR - Inferior rectus, BSV - Binocular single vision, ET - Esotropia, XT - Exotropia

### Table 2: Demographic parameters in adults with monocular elevation deficiency (16-31 years)

| Age/sex | Etiology       | Preop VA | Preop fusion | Postop VA | Postop fusion |
|---------|----------------|----------|--------------|-----------|--------------|
| 22 yrs/M | SR palsy       | 20/600   | NoBSV        | 20/600    | NoBSV        |
| 21 yrs/M | SR palsy       | 20/120   | NoBSV        | 20/120    | NoBSV        |
| 18 yrs/F | SR palsy       | 20/400   | NoBSV        | 20/400    | NoBSV        |
| 16 yrs/F | IR restriction | 20/1200  | NoBSV        | 20/1200   | NoBSV        |
| 23 yrs/F | IR restriction | 20/30    | BSV present  | 20/30     | BSV present  |
| 31 yrs/M | IR restriction | 20/200   | NoBSV        | 20/200    | NoBSV        |
| 20 yrs/M | IR restriction | 20/40    | BSV present  | 20/40     | BSV present  |
| 18 yrs/F | SR palsy with IR restriction | 20/200  | NoBSV        | 20/200    | NoBSV        |
| 19 yrs/F | SR palsy with IR restriction | 20/120  | NoBSV        | 20/120    | NoBSV        |
| 26 yrs/F | SR palsy with IR restriction | 20/200  | NoBSV        | 20/200    | NoBSV        |

MED - Monoocular elevation deficiency, VA - Visual acuity, SR - Superior rectus, IR - Inferior rectus, BSV - Binocular single vision
| Groups   | Age/Sex | FDT                  | Preop angle | BSV | Elevation | Surgery                                                                 | Residual deviation | Post op BSV | Elevation | Amount of correction achieved |
|----------|---------|----------------------|-------------|-----|-----------|--------------------------------------------------------------------------|-------------------|------------|-----------|-------------------------------|
| Group-1  | 18 yrs/F | Neg                  | 30 pd HoT (OS) | –   | –4        | Knapp                                                                    | 6 pd HoT          | –          | –2        | 24 pd HoT                      |
|          | 6 yrs/F  | Neg                  | 35 pd HoT (OD) | –   | –4        |                                                                      | 4 pd HoT          | –          | –1        | 31 pd HoT                      |
|          | 2 yrs/F  | Neg                  | 40 pd HoT (OD) | Cd not be tested | –4 |                                      | 8 pd HoT          | Cd not be tested | –2         | 32 pd HoT                      |
| Group-2  | 22 yrs/M | Neg                  | 35 pd XT with 40 pd HoT (OD) | –   | –4        | Knapp procedure + horizontal squint surgery                              | 10 pd XT         | –          | –2        | 25 pd XT                      |
|          | 21 yrs/M | Neg                  | 25 pd XT with 30 pd HoT (OD) | –   | –4        |                                                                      | 6 pd HoT          | –          | –1        | 25 pd XT                      |
| Group-3  | 14 yrs/M | Pos                  | 25 pd HoT (OS) | –   | –3        | IR recession 4.5 mm                                                     | 14 pd HoT         | –          | –3        | 21 pd HoT                      |
|          | 9 yrs/F  | Pos                  | 35 pd HoT (OS) | –   | –4        | IR recession 5 mm                                                       | 18 pd HoT         | –          | –3        | 17 pd HoT                      |
|          | 16 yrs/F | Pos                  | 35 pd HoT (OD) | –   | –4        |                                                                      | 16 pd HoT         | –          | –3        | 19 pd HoT                      |
|          | 15 yrs/F | Pos                  | 25 pd HoT (OD) | –   | –4        | IR recession 4.5 mm                                                     | 10 pd HoT         | –          | –3        | 15 pd HoT                      |
|          | 10 yrs/F | Pos                  | 20 pd HoT (OD) | +   | –3        |                                                                      | 2 pd HoT          | +          | –1        | 18 pd HoT                      |
| Group-4  | 23 yrs/F | Pos                  | 20 pd HoT (OS) | +   | –3        |                                                                      | 4 pd HoT          | +          | –1        | 16 pd HoT                      |
|          | 31 yrs/M | Pos                  | 35 pd HoT (OS) | –   | –4        | IR recession 5 mm                                                       | 14 pd HoT         | –          | –3        | 21 pd HoT                      |
|          | 13 yrs/M | Pos                  | 25 pd HoT (OD) | –   | –4        | IR recession 4.5 mm                                                     | 10 pd HoT         | –          | –2        | 15 pd HoT                      |
|          | 10 yrs/F | Pos                  | 30 pd HoT (OS) | –   | –4        | IR recession 5 mm                                                       | 12 pd HoT         | –          | –3        | 18 pd HoT                      |
|          | 11 yrs/M | Pos                  | 20 pd HoT (OD) | +   | –3        | IR recession 4.5 mm                                                     | 6 pd HoT          | +          | –1        | 14 pd HoT                      |
|          | 12 yrs/F | Pos                  | 20 pd HoT (OS) | +   | –3        |                                                                      | 8 pd HoT          | +          | –1        | 12 pd HoT                      |
|          | 20 yrs/M | Pos                  | 20 pd HoT (OD) | +   | –3        |                                                                      | 8 pd HoT          | +          | –1        | 12 pd HoT                      |
| Group-5  | 18 yrs/F | Pos                  | 35 pd HoT (OS) | –   | –4        | IR recession 5 mm + Knapp                                                | 6 pd HoT          | –          | –1        | 29 pd HoT                      |
|          | 19 yrs/F | Pos                  | 30 pd HoT (OD) | –   | –4        |                                                                      | 2 pd HoT          | –          | –1        | 28 pd HoT                      |
|          | 26 yrs/M | Pos                  | 30 pd HoT (OD) | –   | –4        |                                                                      | 8 pd HoT          | –          | –1        | 22 pd HoT                      |
|          | 10 yrs/M | Pos                  | 18 pd XT (OD) with 20 pd HoT | –   | –3        | IR recession 4.5 mm + 8 mm LR recession                                   | 4 pd XT           | –          | –2        | 14 pd HoT                      |
|          | 8 yrs/F  | Pos                  | 30 pd XT (OD) with 25 pd HoT | –   | –4        | IR recession 4.5 mm + 6/4 R and R                                       | 4 pd XT           | –          | –3        | 12 pd HoT                      |
|          | 12 yrs/F | Pos                  | 25 pd XT (OD) with 25 pd HoT | –   | –4        | IR recession 4.5 mm + 4/4 R and R                                       | 3 pd XT           | –          | –3        | 26 pd XT                      |
|          | 14 yrs/F | Pos                  | 25 pd XT (OD) with 20 pd HoT | –   | –3        | IR recession 4.5 mm + 4/4 RandR                                        | 5 pd XT           | –          | –2        | 22 pd XT                      |
|          | 6 yrs/F  | Pos                  | 30 pd ET (OS) with 25 pd HoT | –   | –4        | IR recession 4.5 mm + 4/6 RandR                                        | 2 pd ET           | –          | –3        | 28 pd ET                      |
| Group-6  | 8 yrs/M  | Pos                  | Fixing with MED eye (OD) 30 pd HT SR OA (OS) | –   | –4        | IR recession 4 mm OS with SR recession 4 mm OS                          | 6 pd HT (OS)      | –          | –3        | 24 pd HT                      |
|          | 15 yrs/M | Pos                  | 25 pd HoT (OS) 8 pd HoT (OS) | –   | –4        | IR recession 4 mm OS with SR recession 4 mm OD                          | 8 pd HoT (OS)     | –          | –3        | 17 pd HoT                      |
|          | 4 yrs/F  | Pos                  | 25 pd HoT (OS) with IO OA (OD) | –   | –4        | IR recession 4 mm OS with IO parks recession (OD)                       | 8 pd HoT (OS)     | –          | –3        | 17 pd HoT                      |

SR - Superior rectus, IR - Inferior rectus, IO - Inferior oblique, OA - Overaction, BSV - Binocular single vision, OD - Oculus dextrous, OS - Oculus sinister, HoT - Hypotropia, HT - Hypertropia, pd - prism dipters, RandR - Recession and resection, XT - Exotropia, Et - Esotropia, FDT - Forced duction test
Figure 1: Preoperative photograph showing hypotropia with ptosis in primary position and movements in nine gazes showing monocular elevation deficit in left eye (Group 1, Table 3)

Figure 2: Postoperative photograph of patient of fig 3 showing residual small hypotropia and improvement in elevation after Knapp procedure in left eye
Figure 3: Preoperative photograph showing hypotropia in primary position and movements in nine gazes showing monocular deficit in right eye (Group 4, Table 3)

Figure 4: Postoperative photograph of patient of fig. 1 showing marked improvement in hypotropia and elevation after Knapp procedure with IR recession and levator resection surgery in right eye
underwent Knapp with IR recession surgery, was noted to have cells and flare in the anterior chamber, 24 h after the second surgery. The two surgeries were spaced by a gap of four months and there was no evidence of any cardiovascular disease to account for this. The ASI in this patient, was well controlled with topical steroids and cycloplegics. His recovery within a span of two weeks could be attributed to the young age of the patient.

In two cases, where contralateral SR recession was done and in one patient where contralateral IO recession was done, good alignment results within 10 pd of orthotropia of primary position were achieved. Similar reports were achieved by Xiao, Shun and Li in their series of 11 patients, where they performed SR recession in the non-paretic eye in two cases, six months after IR recession with satisfactory results.16

Improvement in elevation occurring after Knapp transposition, is attributed to alteration in the point of tangency of the muscle with the globe, thereby changing the point of mechanical action. In addition, transposition results in a new muscle plane with a new axis of rotation. Improvement of elevation following IR recession occurs due to weakening of the restricted muscle, in the presence of normal SR function. Failure of improvement in elevation after IR recession is likely to be due to residual paresis of SR muscle.

Incidence of binocular vision was 18% in this study. The low incidence could be attributed to the congenital onset of MED that leads to early development of suppression and amblyopia. A large angle of hypotropia, often compounded with ptosis, was an important factor for disruption of binocularity. A smaller hypotropia may be overcome by a chin up position to achieve binocularity. Since most patients had large hypotropias of congenital onset, the incidence of binocularity was low.

In conclusion, we feel MED, though etiologically multifactorial, can be satisfactorily managed by judicious selection of the surgical technique.

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