Efficacy analysis of inferior oblique muscle belly transposition for small-angle asymmetric superior oblique palsy

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Asymmetric superior oblique palsy (SOP) is a complicated, non-comitant type of strabismus. Patients usually present with small-angle hypertropia in the affected eyes, accompanied by inferior oblique muscle overaction (IOOA).\[1\] Compensatory head posture and asymmetric development of the face are typically observed in congenital SOP, while diplopia is more common in an acquired SOP.\[2\] Prism glasses can improve diplopia and vertical deviation in the primary position, but they are not so successful at correcting non-comitant paralytic strabismus. In addition, vertical strabismus and compensatory head posture will return after the prism glasses are removed, wearing prism glasses will lower the vision of children prominently. Surgery like an inferior oblique muscle (IO) weakening procedure is often required eventually in those patients. However, conventional procedures for IO weakening may cause overcorrection and/or secondary A pattern in patients who have mild to moderate IOOA together with small-angle asymmetric SOP, posing a risk to its safety.\[3\]

In the study by Caldeira,\[4\] 21% of the patients with mild to moderate IOOA developed A pattern following the surgery. Therefore, it remains a clinical challenge to select the most appropriate type of surgery for the treatment of small-angle asymmetric SOP. Inferior oblique muscle belly transposition (IOMBT),\[5\] a new IO weakening procedure introduced to our practice lately, has shown positive results in treating small-angle asymmetric SOP as well as a lower risk of complications such as overcorrection and secondary A pattern. In this study, we evaluated the efficacy and safety of the IOMBT procedure for the treatment of small-angle asymmetric SOP.

A total of 30 pediatric patients (42 affected eyes) with small-angle asymmetric SOP who underwent IOMBT procedure at Anhui Province Children’s Hospital from June 2018 to August 2020 met the inclusion criteria: (1) a diagnosis of asymmetric SOP; (2) concurrent mild to moderate unilateral or bilateral IOOA, graded “+” to “++” according to the scale by Kenneth;\[6\] (3) severity of vertical deviation in primary position < 5 prism diopters (PD); and (4) complete follow-up information. This study received approval from the Clinical Ethics Committee of Anhui Province Children’s Hospital (No.APC20089A), and informed consent was obtained from all the study patients and their guardians.

Comprehensive eye exams were performed in all patients pre-operatively to assess their visual acuity, anterior segment, fundus, refraction, and eye movements. Angles of deviation (including horizontal and vertical deviations) were measured by alternate prism cover testing at distance (5 m) and near (33 cm) in the primary gaze position. The fundus photographs were taken with a retinal camera (Canon, Japan). The fovea and the optic disc center were located manually on the photo using CorelDRAW X4 graphics (Corel Corporation, Canada); the fovea-disc angle (FDA), defined as the angle between the disc-fovea line and the horizontal line through the fovea, was determined automatically by the software. All the eye examinations were repeated at follow-up visits 1- and 6-month post-operatively.

IOMBT was performed as follows: for patients under 12 years of age, the surgical field was disinfected following successful general anesthesia; the operative eye was fully exposed after proper prepping and draping. Patients above 12 years of age received topical and subconjunctival anesthesia after disinfection and draping. A fornix incision was made in the inferotemporal quadrant. The IO was isolated and hooked 10 to 11 mm from the temporal...
insertion, then secured with a double-armed 6-0 absorbable suture using loop suture technique [Figure 1A] 5 mm posterior to the temporal insertion of the inferior rectus muscle [Figure 1B and 1C]. The fornix incision was then sutured to complete the operation. Patients with concurrent horizontal strabismus underwent simultaneous surgical correction. The surgical procedure is shown in Supplementary Video [Video of the Surgery, http://links.lww.com/CM9/A638].

Repeated eye exams were performed to assess gaze positions and eye movements, as well as the improvements in their double vision and compensatory head posture. At 6-month follow-up, the surgery was considered successful if: the vertical deviation in primary position disappeared; eye movement testing did not show any signs of IOOA; compensatory head posture disappeared in patients with congenital SOP; diplopia disappeared in patients with acquired SOP; the difference in post-operative angles of deviation was <10 PD between upgaze (25°) and downgaze (25°) positions in patients with V pattern; and no complications such as overcorrection, secondary A pattern, or insufficiency of IO was observed at 6-month follow-up. Statistical analysis was performed using SPSS software v23.0. t-test was used for categorical variables. Paired t-test was used for continuous variables. A P value of <0.050 was considered statistically significant.

This study included 42 affected eyes of 30 pediatric patients (12 bilateral and 18 unilateral cases). Baseline characteristics were summarized in Supplementary Table 1, http://links.lww.com/CM9/A631. Mean vertical deviations in primary position at 1- (0.2 ± 0.1 PD) and 6-month (0.3 ± 0.1 PD) post-operatively were significantly reduced compared with 4.5 ± 0.6 PD pre-operatively, p < 0.001. The mean reduction from baseline in vertical deviation in primary position was 4.2 ± 0.4 PD at 6-month post-operatively. The FDA at 1- (4.0° ± 2.5°) and 6-month (4.2° ± 2.2°) post-operatively was significantly smaller than that of before surgery (10.5° ± 4.1°), p < 0.001. The mean reduction from baseline in FDA was 6.5° ± 2.3°. The eight patients with concurrent V pattern had their condition significantly improved as well: at 6-month post-operatively, the mean degree of V pattern decreased from 18.0 ± 3.5 PD pre-operatively to 1.6 ± 0.9 PD (P < 0.001), which has a mean decrease of 16.4 ± 2.5 PD. Supplementary Figure 1, http://links.lww.com/CM9/A636 shows the gaze positions of a patient before and day 1 after the procedure. Before the procedure, the patient had bilateral IOOA (+) with mild V pattern exotropia and fundus extorsion; the difference in angles of deviation between upgaze (25°) and downgaze (25°) positions was 16 PD. On post-operative day 1, IOOA disappeared in this patient; the difference in angles of deviation was 3 PD between upgaze (25°) and downgaze (25°) positions, and fundus extorsion was not observed. Of the 30 patients in the study, six had IOOA (+), 24 had IOOA (+), pre-operatively; after surgery, IOOA disappeared in 26 patients and four patients were improved to IOOA (+), yielding a success rate of 86.7%. Compensatory head posture was present in 13 patients pre-operatively but disappeared in 11 patients and was improved in one patient after surgery, with a success rate of 84.62% (11/13). Diplopia disappeared post-operatively in five of the six patients with diplopia, with a success rate of 5/6. In terms of safety, none of the 30 patients in this study experienced overcorrection, secondary A pattern, or any other complications post-operatively.

IO myectomy and IO recession are commonly performed IO weakening procedures. In patients with small-angle hypertropia (≤5 PD), both procedures have a high risk of potential complications like overcorrection and secondary A pattern, as the two procedures usually correct vertical strabismus by 7 to 15 PD on average. Overcorrection is a common complication of other IO weakening procedures as well, including denervation-extirpation, pure anteropositioning, and anteronasal transposition. Whereas in the IOMBT procedure, instead of excising the distal tendon, the IO is sutured at the belly 10 to 11 mm from its insertion and is fixed to the sclera 5 mm posterior to the temporal insertion of the inferior rectus muscle. This location is along the normal course of the IO, and fixation at this location moves the point of attachment of IO muscle to the eyeball posterior to its original place, considerably decreasing the operating length of the IO. Consequently, the action strength of the IO is reduced, resulting in a reduction of IOOA and a mild correction of vertical deviation in the primary position. For the reasons above, the IOMBT procedure can effectively...
diminish IO function similar to those conventional procedures, that is, myectomy, recession, and anterior transposition, but with a lower risk of overcorrection.\textsuperscript{1,3,7}

The IOMBT procedure was first implemented by Dr. Yang in treating IOOA with small-angle hypertropia (\(\leq 5\) PD).\textsuperscript{5}

Despite the successful outcomes, potential bias may be a concern of this retrospective study, and more clinical data are necessary to support their conclusion due to its small sample size (ten cases).

The 30 pediatric patients with small-angle asymmetric SOP in our study also suffered from small-angle hypertropia of \(\leq 5\) PD and mild to moderate IOOA. At 6-month post-IOMBT procedure, the mean vertical deviation in primary position decreased from \(4.7 \pm 0.8\) to \(0.3 \pm 0.1\) PD with a mean reduction of \(4.4 \pm 0.6\) PD; overcorrection was not observed. The mean FDA was reduced from \(10.5^\circ \pm 4.1^\circ\) to \(4.2^\circ \pm 2.2^\circ\) post-operatively. The success rate for IOOA was high at 86.70\% (26/30). Compensatory head posture and diplopia were also successfully corrected in 84.62\% (11/13) and 83.30\% (5/6) of the respective patient subpopulations. These success rates suggested that IOMBT could be a competitive candidate over other treatment procedures for IOOA with small-angle hypertropia in the primary position.

Full correction of V pattern strabismus combined with mild to moderate IOOA (+ or ++) is hard to achieve by horizontal rectus transposition, and IO myectomy carries a high risk of overcorrection.\textsuperscript{10} In this study, none of the 30 patients experienced any post-operative complications including overcorrection and secondary A pattern, indicating a good safety profile of the IOMBT procedure.

The eight patients who had concurrent V pattern achieved full correction by IOMBT, with a decrease in the mean amount of V pattern from \(18.0 \pm 3.5\) to \(1.6 \pm 2.3\) PD post-operatively and a success rate of 100\%. These results showed the efficacy of the IOMBT procedure in treating V pattern strabismus with mild to moderate IOOA (+ or ++).

This study demonstrated the treatment success in small-angle asymmetric SOP and a lower risk of overcorrection and secondary A pattern by IOMBT. This procedure also showed efficacy in treating V pattern strabismus with mild to moderate IOOA, making it an ideal surgery option. This study could have some data bias given the observational study design, so future studies including high quality, randomized controlled trials are needed to further evaluate the efficacy of IOMBT in the treatment of small-angle asymmetric SOP.

**Conflicts of interest**

None.

**References**

1. Maher S, El-Fayoumi D, Awadein A, Khazbak L. Torsional changes after vertical transposition of horizontal recti in V-pattern exotropia without oblique dysfunction. J Pediatr Ophthalmol Strabismus 2019;56:107–115. doi: 10.3928/01913913-20190205-03.

2. Wang X, Zhang W, Liu L. Effect of isolated oblique muscle weakening procedures on horizontal deviation in A- and V-pattern exotropia. Curr Eye Res 2020;45:211–214. doi: 10.1080/02713683.2019.1660795.

3. Lee YB, Rhiu S, Lee JY, Choi MY, Paik HJ, Lim KH, et al. Effect of horizontal rectus surgery for the correction of intermittent exotropia on sub-A or sub-V pattern. PLoS One 2017;12:e0179626. doi: 10.1371/journal.pone.0179626.

4. Caldeira JAF. V-pattern exotropia: a review; and a study of the outcome after bilateral recession of the inferior oblique muscle: a retrospective study of 78 consecutive patients. Binocul Vis Strabismus Q 2003;18:35–48.

5. Yang S, Guo X, Tien DR. Inferior oblique belly transposition for small angle hypertropia with inferior oblique overaction: a pilot study. J Pediatr Ophthalmol Strabismus 2018;55:43–46. doi: 10.3928/01913913-20170801-04.

6. Ekenen MR, Polar S, Can CU, Altıntaş AGK. Evaluation of inferior oblique muscle overaction existence time and surgical outcomes in infantile exotropia. Turk Oftalmoloji Gazetesi 2013;43:419–423. doi: 10.4274/tog.38237.

7. Si M, Yang S, Tien DR, Yue Y, Shao X, Guo X. Inferior oblique belly transposition for V pattern strabismus. Strabismus 2020;28:29–33. doi: 10.1080/09273972.2019.1701502.

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