Outcome of inferior oblique disinsertion versus myectomy in the surgical treatment of unilateral congenital superior oblique palsy

Mohammad Reza Akbari, MD, Arash Mirmohammad Sadeghi, MD, Hadi Ghadimi, MD, and Mojgan Nikdel, MD

PURPOSE To compare the outcome of inferior oblique disinsertion and myectomy in patients with unilateral congenital superior oblique palsy.

METHODS In this prospective study, consecutive patients with superior oblique palsy underwent either myectomy or disinsertion of the inferior oblique muscle. Success was defined as postoperative hypertropia of $\leq 5^{\Delta}$ in primary position and no hypotropia. In cases with preoperative hypertropia of $\leq 5^{\Delta}$, success was defined as improved hypertropia and resolution of abnormal head position (AHP).

RESULTS A total of 62 patients were included: 34 underwent myectomy; 28, disinsertion. Preoperative primary position hypertropia was $15.8^{\Delta} \pm 7.4^{\Delta}$ in the myectomy group and $14.5^{\Delta} \pm 7.3^{\Delta}$ in the disinsertion ($P = 0.756$). AHP was present in 85.3% and 85.7% of patients, respectively ($P = 1$). Mean follow-up was in the myectomy group 7.5 ± 6.7 months and 6.9 ± 3.0 months in the disinsertion group ($P = 0.637$). Correction of hypertropia in primary position was more pronounced in the myectomy group ($14.3^{\Delta} \pm 7.4^{\Delta}$ vs $10.0^{\Delta} \pm 5.4^{\Delta}$; $P = 0.013$). Success was achieved in 91.2% of myectomy and 60.7% of disinsertion patients ($P = 0.006$). Persistence of AHP did not differ between groups (8.8% in the myectomy group vs 7.1% in the disinsertion group [$P = 1$]). Comparison of patients with preoperative hypertropia of $\leq 15^{\Delta}$ revealed nonsignificant differences between groups in rate of success (100% vs 81.3% [$P = 0.226$]) and correction of primary position hypertropia ($8.8^{\Delta} \pm 3.2^{\Delta}$ vs $7.6^{\Delta} \pm 4.0^{\Delta}$ [$P = 0.336$]).

CONCLUSIONS In our study cohort, inferior oblique myectomy had a greater effect in reduction of primary position hypertropia; however, disinsertion proved as effective as myectomy if preoperative vertical deviation was $\leq 15^{\Delta}$. Both procedures effectively corrected AHP and demonstrated self-adjustment. (J AAPOS 2019;23:77.e1-6)

Superior oblique palsy is the most common cause of vertical ocular misalignment, with congenital etiology accounting for most cases.[1] The eye on the side of the paretic muscle becomes hypertropic, and the condition is aggravated in gaze to the unaffected side and on head tilt to the same side as the palsy. Symptomatic superior oblique palsy is generally treated surgically, and the most common procedure is ipsilateral inferior oblique weakening. Regarding the different surgical options for inferior oblique weakening,[2,3] some surgeons prefer disinsertion,[4,5] whereas others advocate anterior transposition,[6,7] myectomy,[8,9] or recession of the inferior oblique.[10,11] The choice of surgical procedure greatly depends on surgeon experience and preference.[12] We are unaware of prior publications that have directly compared the outcomes of inferior oblique myectomy and disinsertion.

Also open to discussion is the "self-grading," or "self-adjusting," effect of inferior oblique disinsertion, which has not been studied as widely as for myectomy.[9,12,13] Self-adjusting refers to the larger correction of vertical deviation in patients who have larger preoperative hypertropia. While this phenomenon is well-known for inferior oblique myectomy,[9,12,13] no prior studies have quantified the effect or even documented its existence for disinsertion surgery. Considering the minimal bleeding associated with the procedure and preservation of inferior oblique muscle, disinsertion could be a potential, safe alternative to inferior oblique myectomy. The present study was aimed

Author affiliations: Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran

The authors have no financial or proprietary interest in the materials presented herein. No grants or funds were received for this study.

Submitted May 2, 2018.

Revision accepted November 14, 2018.

Published online March 15, 2019.

Correspondence: Mojgan Nikdel, MD, Farabi Eye Hospital, Ghazvin square, Tehran, Iran (email: mojgan_nik@yahoo.com).

1091-8531/$36.00

https://doi.org/10.1016/j.jaapos.2018.11.009

to compare inferior oblique disinsertion with myectomy and to demonstrate the self-adjusting effect of disinsertion.

Subjects and Methods

The study was approved by the Ethics Committee and Institutional Review Board of Farabi Eye Hospital and adhered to the tenets of the Declaration of Helsinki. Patients (or legal guardians of minors) were informed about possible therapeutic options, and those who consented to the research and probable publication of their data and photographs were enrolled.

Between 2011 and 2015, patients with superior oblique palsy were treated at Farabi Eye Hospital with inferior oblique myectomy[14]; in 2016 and 2017, inferior oblique disinsertion was performed. Superior oblique palsy was diagnosed on the basis of three-step Parks-Bielschowsky test,[15] with hypertropia in primary position that increased on contralateral gaze and on ipsilateral head tilt. A congenital etiology for superior oblique palsy was diagnosed based on previous family photographs of the patient, history of strabismus for several years, and absence of diplopia. Consecutive patients with unilateral congenital superior oblique palsy who had visual acuity of at least 20/25 and were sufficiently cooperative for deviation measurement tests were considered for inclusion. Those with acquired or bilateral superior oblique palsy or poor visual acuity or poor cooperation were excluded, as were those who did not adhere to the follow-up schedule for at least 3 months postoperatively. Patients who required simultaneous strabismus surgery on horizontal rectus muscles were also excluded. All included patients had inferior oblique overaction (IOOA); none had significant superior oblique underaction.

Deviation was measured by alternate prism cover test preoperatively and compared to final postoperative values. Vertical and horizontal deviations in primary position (both in far and near fixation) and lateral gazes as well as in head tilt to both sides were recorded. Abnormal head position (AHP), defined as presence of either head turn or head tilt to the unaffected side, were evaluated pre- and postoperatively. Pre- and postoperative measurements were first obtained by an orthoptist then confirmed by a strabismus surgeon (MRA). Neither the surgeon nor the orthoptist was masked to the procedure performed.

All operations were performed under general anesthesia by a single surgeon (MRA), using a technique resembling that previously described by Parks.[2] Briefly, a 4-0 silk traction suture to the perilimbal conjunctiva was used to keep the eye in adduction and elevation and provide exposure of inferotemporal quadrant, where a fornix inferotemporal peritomy was performed. The inferior oblique muscle was exposed after dissection of Tenon's capsule and the intermuscular septum and engaged with muscle hooks. For disinsertion, the muscle was simply cut flush to its scleral insertion, without cautery, and allowed to retract spontaneously. For myectomy, a hemostat clamp was placed approximately 8 mm from the insertion for a few seconds, followed by separation of the muscle from scleral insertion and excision of the segment of the muscle between the clamp and the insertion. Thermal cauterization was used for hemostasis, and the cut end of the muscle was allowed to freely retract. Conjunctival incision was repaired.

Based on severity of preoperative hypertropia in primary position, patients were further categorized into subgroups, with preoperative deviation of $\leq 15^{\Delta}$ and $>15^{\Delta}$. Success was defined as postoperative hypertropia in primary position $\leq 5^{\Delta}$ and no hypotropia at distance and near fixation at final follow-up. In cases with preoperative hypertropia of $\leq 5^{\Delta}$, the indication for surgery was presence of AHP. Success in this subgroup was defined as improvement in hypertropia and resolution of AHP.

Statistical Analysis

Statistical analysis was performed using IBM SPSS software version 20.0 (SPSS Inc, Chicago, IL). A P value of <0.05 was considered statistically significant. Self-adjustment of each surgical procedure (larger correction of vertical deviation by surgery type in patients with larger preoperative hypertropia) was studied by creating scatterplots of correlation of preoperative hypertropia with the amount of correction of vertical deviation. Pearson's correlation coefficient (r) was calculated for analysis of correlation between the two continuous variables, after the normality of their distribution was confirmed by the Kolmogorov-Smirnov test. For comparison of the categorical and continuous variables between the two procedures, the Fisher exact test and t test were applied, respectively.

Results

During the study period, 67 unilateral superior oblique palsy patients underwent inferior oblique weakening, 39 by means of inferior oblique myectomy and 28 by inferior oblique disinsertion. Of the patients in the myectomy group, 5 had acquired (traumatic) superior oblique palsy and were excluded from analysis. All patients in the disinsertion group had congenital superior oblique palsy. Mean duration of follow-up was 7.5 ± 6.7 months in the myectomy group and 6.9 ± 3.0 months in the disinsertion group ($P = 0.637$). Patient characteristics of both groups are summarized in Table 1. Patients in each group were matched with regard to preoperative parameters such as age, sex, presence of AHP, and amount of vertical deviation in primary position (with nonsignificant differences). None of our patients complained of diplopia or subjective torsion.

Success in the entire cohort was achieved in a significantly greater percentage of myectomy patients than disinsertion patients (31/34 vs 17/28, or 91.2% vs 60.7% [$P = 0.006$]). Patients in the myectomy group experienced greater reduction of hypertropia in primary position postoperatively compared with the disinsertion group (decrease of $14.32^{\Delta} \pm 7.35^{\Delta}$ vs $10.04^{\Delta} \pm 5.40^{\Delta}$ decrease [$P = 0.013$]). Hypotropia was observed in none of the patients postoperatively. No major complications or adverse events were observed intraoperatively or during the follow-up in either group.

Of note, there were 3 patients with preoperative hypertropia of 20^{Δ} who became orthotropic after inferior oblique disinsertion. However, when the patients were subcategorized based on preoperative deviation, the

Table 1. Comparison of patients in inferior oblique myectomy and disinsertion groups

Variable[a]	Myectomy (n = 34)	Disinsertion (n = 28)	*P* value
Male sex	19 (55.9)	17 (60.7)	0.798
Age, years	18.74 ± 13.41 (4 to 58)	24.04 ± 11.07 (5 to 42)	0.099
Duration of follow-up, mos	7.5 ± 6.7 (4 to 34)	6.9 ± 3.0 (3 to 13)	0.637
Before surgery			
AHP	29 (85.3)	24 (85.7)	1
HT, PD			
PP	15.79 ± 7.41 (3 to 30)	14.50 ± 7.34 (2 to 25)	0.495
IpsG	6.65 ± 5.05 (0 to 20)	5.54 ± 4.37 (0 to 15)	0.363
ConG	21.97 ± 8.83 (8 to 45)	21.25 ± 6.70 (7 to 37)	0.723
IpsT	22.18 ± 8.46 (8 to 40)	20.04 ± 8.03 (6 to 37)	0.315
ConT	8.09 ± 6.08 (0 to 28)	6.68 ± 5.32 (0 to 18)	0.341
After surgery			
AHP	3 (8.8)	2 (7.1)	1
Change in HT, PD[b]			
PP	14.32 ± 7.35 (3 to 30)	10.04 ± 5.40 (2 to 20)	0.013
IpsG	6.00 ± 4.65 (0 to 18)	3.68 ± 3.57 (−4 to 12)	0.036
ConG	18.82 ± 9.21 (4 to 45)	14.54 ± 6.53 (3 to 27)	0.043
IpsT	17.53 ± 9.09 (2 to 40)	12.82 ± 7.60 (0 to 30)	0.033
ConT	7.21 ± 5.34 (0 to 18)	4.50 ± 3.90 (−1 to 14)	0.030
Success	31 (91.2)	17 (60.7)	0.006

AHP, abnormal head position; *ConG*, contralateral gaze; *ConT*, contralateral tilt; *HT*, hypertropia; *IpsG*, ipsilateral gaze; *IpsT*, ipsilateral tilt; *PD*, prism diopter; *PP*, primary position.
[a]Continuous variables are presented as mean ± SD (range); categorical variables, as number (%).
[b]Difference in pre- and postoperative values.

Table 2. Comparison of patients in inferior oblique myectomy and disinsertion groups with primary position preoperative deviation ≤15$^{\Delta}$

Variable[a]	Myectomy (n = 16)	Disinsertion (n = 16)	*P* value
Male sex	9 (56.3)	10 (62.5)	1
Age, years	14.63 ± 9.24 (4 to 34)	22.19 ± 12.28 (5 to 42)	0.058
Before surgery			
AHP	12 (75)	13 (81.3)	1
HT, PD			
PP	9.50 ± 3.33 (3 to 14)	9.06 ± 4.48 (2 to 14)	0.756
IpsG	4.63 ± 2.75 (0 to 12)	2.94 ± 2.62 (0 to 9)	0.086
ConG	17.75 ± 5.83 (8 to 30)	17.50 ± 5.68 (7 to 27)	0.903
IpsT	18.31 ± 7.09 (8 to 30)	16.13 ± 7.43 (6 to 30)	0.401
ConT	5.94 ± 4.01 (0 to 14)	3.38 ± 3.01 (0 to 11)	0.050
After surgery			
AHP	1 (6.3)	1 (6.3)	1
Change in HT, PD[b]			
PP	8.81 ± 3.15 (3-14)	7.56 ± 4.03 (2 to 14)	0.336
IpsG	4.57 ± 2.93 (0 to 12)	2.56 ± 2.66 (0 to 9)	0.059
ConG	16.19 ± 5.80 (6 to 30)	13.69 ± 6.34 (3 to 27)	0.254
IpsT	14.44 ± 6.29 (4 to 30)	13.06 ± 7.90 (0 to 30)	0.590
ConT	5.20 ± 4.02 (0 to 14)	3.00 ± 2.83 (0 to 11)	0.087
Success	16 (100)	13 (81.3)	0.226

AHP, abnormal head position; *ConG*, contralateral gaze; *ConT*, contralateral tilt; *HT*, hypertropia; *IpsG*, ipsilateral gaze; *IpsT*, ipsilateral tilt; *PD*, prism diopter; *PP*, primary position.
[a]Continuous variables are presented as mean ± SD (range); categorical variables, as number (%).
[b]Difference in pre- and postoperative values.

differences between myectomy and disinsertion were not significant in those with preoperative hypertropia of ≤15$^{\Delta}$ (Table 2) and were only significant in patients with preoperative deviations of >15$^{\Delta}$. In patients with preoperative hypertropia of ≤15$^{\Delta}$, mean reduction of primary position hypertropia did not differ significantly for those in the myectomy group compared with those in the disinsertion group (8.81$^{\Delta}$ ± 3.15$^{\Delta}$ vs 7.56$^{\Delta}$ ± 4.03$^{\Delta}$ [$P = 0.336$]). Rate of success was 100% for the myectomy group 81.3% for the disinsertion groups; the difference was not statistically significant ($P = 0.226$). There were 3 patients (8.8%) with preoperative hypertropia of ≤5$^{\Delta}$ in the myectomy group and 6 (21.4%) in the disinsertion group ($P = 0.277$). All patients with preoperative hypertropia of ≤5$^{\Delta}$ had successful outcome.

Preoperatively, AHP was present in 29 patients (85.3%) in the myectomy group and 24 (85.7%) in the disinsertion group ($P = 1$). Postoperative AHP was observed in 3

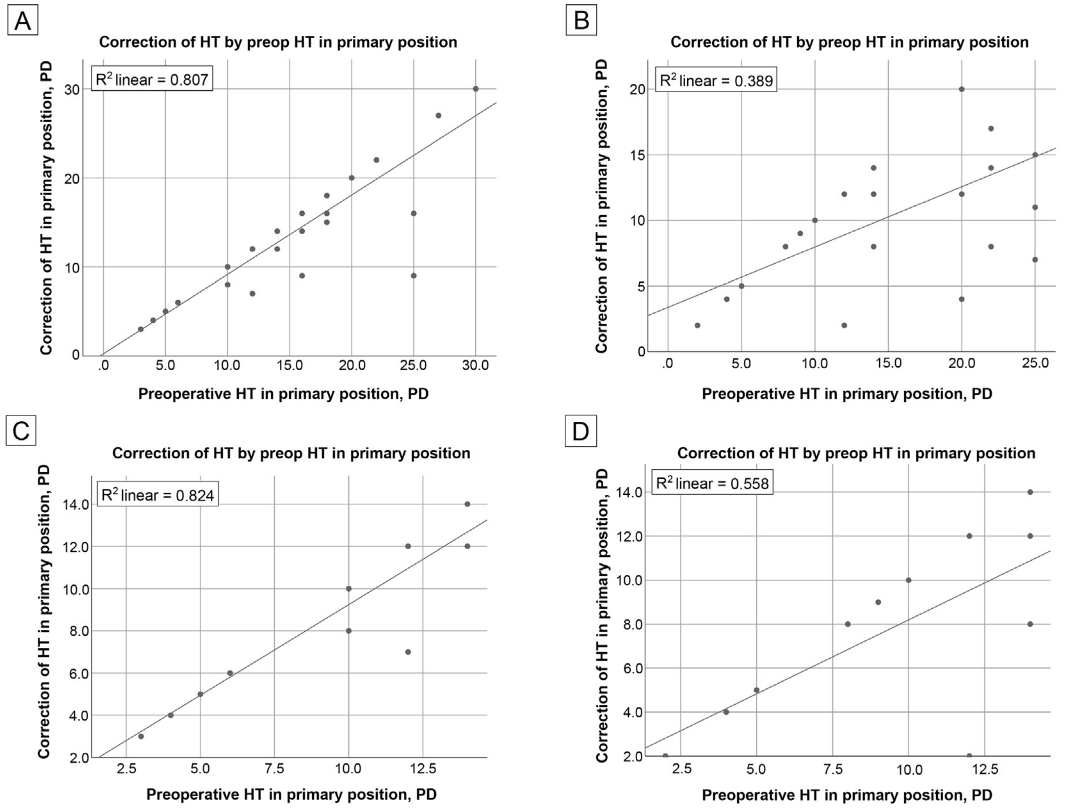

FIG 1. Scatterplot with trend line of self-adjusting effect of inferior oblique–weakening procedures. A, Inferior oblique myectomy patients ($R^2 = 0.807$; $r = 0.898$; $P < 0.001$). B, Inferior oblique disinsertion patients ($R^2 = 0.389$; $r = 0.624$; $P < 0.001$). C, Inferior oblique myectomy patients with preoperative primary position hypertropia $\leq 15^{\Delta}$ ($R^2 = 0.824$; $r = 0.908$; $P < 0.001$). D, Inferior oblique disinsertion patients with preoperative primary position hypertropia of $\leq 15^{\Delta}$ ($R^2 = 0.558$; $r = 0.747$; $P = 0.001$).

patients (8.8%) in the myectomy group and in 2 (7.1%) in the disinsertion group ($P = 1$).

Self-adjusting effects of inferior oblique myectomy and disinsertion (the larger the preoperative hypertropia, the greater the amount of correction of vertical deviation) are illustrated in scatterplots of Figure 1A-B. The correlation was stronger for myectomy patients ($r = 0.898$; $P < 0.001$) than for disinsertion patients ($r = 0.624$; $P < 0.001$). Figure 1C-D illustrates similar scatterplots for patients who had preoperative primary position hypertropia of $\leq 15^{\Delta}$ in the myectomy ($r = 0.908$; $P < 0.001$) and disinsertion ($r = 0.747$; $P = 0.001$) groups.

Discussion

The present study showed that, in our study cohort, inferior oblique disinsertion was as effective in correcting primary position vertical deviation of unilateral congenital superior oblique palsy patients as inferior oblique myectomy, when preoperative vertical deviation was $\leq 15^{\Delta}$. However, when preoperative hypertropia was $>15^{\Delta}$, inferior oblique myectomy had a more prominent effect in reduction of primary position vertical deviation. Both procedures were highly effective, with no significant difference, in correcting AHP, which is one of the main indications for surgical intervention in superior oblique palsy. Finally, disinsertion was shown to have self-adjusting effect similar to those reported with myectomy, although the correlation was stronger for myectomy.

Although Costenbader and Kertesz[16] compared inferior oblique disinsertion with myectomy, they performed most myectomy procedures using a transdermal approach, with transection of inferior oblique muscle near the origin.[16] Currently inferior oblique myectomy is commonly performed through conjunctival incision and at the site of scleral insertion,[2] as in the present study.

Inferior oblique muscle, whether resected or disinserted, retracts into its Tenon's sheath along its normal course and reattaches to the sclera.[17] An experimental study on rhesus monkeys has shown that following both inferior oblique disinsertion and myectomy, the length of remaining inferior oblique muscle decreases to approximately two-thirds of its original length and is almost equal in both operations.[18] This finding may partially account for the comparable effect of each procedure for patients with preoperative hypertropia of $\leq 15^{\Delta}$ in our study.

Inferior oblique disinsertion has been studied as an inferior oblique weakening procedure, either in patients with superior oblique palsy or in those with primary IOOA. Dyer[19] was an advocate of inferior oblique disinsertion for inferior oblique weakening. In his study of 45 eyes of 43 patients who underwent inferior oblique disinsertion, postoperative hypertropia reduced to $<10^{\Delta}$ in 41 eyes (91%) and to $<5^{\Delta}$ in 32 eyes (71%), with resolution of IOOA in all instances and no need to reoperate. Of the 38 patients with preoperative hypertropia $>10^{\Delta}$, the effect of disinsertion in reduction of primary position was $12.7^{\Delta} \pm 5.4^{\Delta}$. Self-adjustment could be inferred from a scatterplot he presented, although no correlation coefficient was provided.[19] The outcome of their patients was more favorable than the entire disinsertion group of our study, with moderately higher success (71% vs 61%).

Jones and colleagues[4] reviewed the results of inferior oblique disinsertion as their preferred method for inferior oblique weakening between 1960 and 1981. Of 337 patients with either unilateral or bilateral IOOA, inferior oblique disinsertion was successful in correction of diplopia and hyperdeviation in the field of action of the inferior oblique muscle in 88% and 72% of patients with primary and secondary IOOA, respectively. In the subgroup of patients similar to our study subjects (36 patients with unilateral secondary IOOA), mean vertical deviation decreased from $17.6^{\Delta} \pm 12.7^{\Delta}$ preoperatively to $3.5^{\Delta} \pm 4.7^{\Delta}$ postoperatively.[4] The mean reduction of hypertropia (approximately 14^{Δ}) is more prominent than our disinsertion results (with 10^{Δ} reduction); however, their average preoperative hypertropia was approximately 3^{Δ} higher[4] than ours. Regarding self-adjustment following inferior oblique disinsertion, more correction is expected in patients with higher preoperative vertical deviation. Therefore, the more remarkable effect of inferior oblique disinsertion in the study by Jones and colleagues[4] could be accounted for by the higher preoperative hypertropia in their patients.

Mulvihill and colleagues,[5] in their study of inferior oblique disinsertion, reported the outcome of 52 unilateral superior oblique palsy cases. Mean vertical deviation of their patients was reduced from 12.9^{Δ} to 4^{Δ}, which is comparable to our results, with 10^{Δ} effect of inferior oblique disinsertion, but 13.6% of their patients required further surgery because of significant undercorrection of deviation.[5]

Costenbader and Kertesz[16] compared three inferior oblique weakening procedures: recession (50 eyes of 34 patients), disinsertion (41 eyes of 27 cases) and myectomy (78 eyes of 54 patients). However, their myectomies, as noted above, were not performed in the manner that is currently routine. Therefore, their results cannot be directly compared to ours.

Cooper and Sandall[20] compared inferior oblique disinsertion in 102 eyes and inferior oblique recession in 54 eyes with mean preoperative primary position hypertropia of 7.43^{Δ} and 8.65^{Δ}, respectively. The average amount of correction of hypertropia in primary position was 5.27^{Δ} for inferior oblique disinsertion and 6.88^{Δ} for recession.[20] The effect of disinsertion on correcting hypertropia in their study was lower than ours (5.27^{Δ} vs 10.04^{Δ}), which could be due to self-adjustment phenomenon, considering the lower preoperative hypertropia in their series (7.43^{Δ} vs 14.50^{Δ}).

Yanyali and colleagues[6] reported that 11 patients who underwent inferior oblique disinsertion for unilateral superior oblique palsy had a mean reduction of primary position hypertropia of $13.3^{\Delta} \pm 1.9^{\Delta}$, compared to a corresponding value of $18.5^{\Delta} \pm 3.9^{\Delta}$ with anterior transposition of inferior oblique (ATIO) muscle ($P = 0.001$). Thus, ATIO was found to be more effective compared to inferior oblique disinsertion.[6] However, the longer surgical time and the need to suture are mentioned as disadvantages of ATIO compared to inferior oblique disinsertion. Mean preoperative hypertropia of the patients who underwent inferior oblique disinsertion in that study was larger compared to ours ($22.2^{\Delta} \pm 6.2^{\Delta}$ vs $14.5^{\Delta} \pm 7.3^{\Delta}$). Therefore, greater reduction of hypertropia in their series (13.3^{Δ} vs 10^{Δ}) is not surprising, considering self-adjustment phenomenon.

The present study had certain limitations, including its nonrandomized design, deviation measurement by unmasked examiners, and relatively short duration of follow-up. In addition, AHP was not measured quantitatively. Nevertheless, this study showed similar effectiveness of disinsertion and myectomy in correcting primary position vertical deviation of unilateral congenital superior oblique palsy patients if preoperative hypertropia is $\leq 15^{\Delta}$. Finally, inferior oblique disinsertion is simpler than inferior oblique myectomy and is associated with less bleeding and no need for cauterization; moreover, it preserves the entire inferior oblique muscle for potential future operations on this muscle.

Literature Search

PubMed was searched on March 3, 2018, for English-language results using the following terms: (*oculomotor nerve* OR *trochlear nerve* OR *superior oblique* OR *fourth nerve* OR *fourth cranial*) AND (*insertion* OR *disinsertion* OR *resection* OR *recession* OR *transposition* OR *myotomy* OR *myectomy* OR *plication* OR *tuck* OR *advancement*).

References

1. Mollan SP, Edwards JH, Price A, Abbott J, Burdon MA. Aetiology and outcomes of adult superior oblique palsies: a modern series. Eye (Lond) 2009;23:640-44.
2. Parks MM. Inferior oblique weakening procedures. Int Ophthalmol Clin 1985;25:107-17.
3. Chang MY, Coleman AL, Tseng VL, Demer JL. Surgical interventions for vertical strabismus in superior oblique palsy. Cochrane Database Syst Rev 2017;11:CD012447.
4. Jones TW Jr, Lee DA, Dyer JA. Inferior oblique surgery: experience at the Mayo Clinic from 1960 to 1981. Arch Ophthalmol 1984;102:714-16.
5. Mulvihill A, Murphy M, Lee JP. Disinsertion of the inferior oblique muscle for treatment of superior oblique paresis. J Pediatr Ophthalmol Strabismus 2000;37:279-82.
6. Yanyali A, Elibol O, Talu H, Karabas L, Alp B, Caglar Y. A comparative study of the effectiveness of disinsertion and anterior transposition of the inferior oblique in the treatment of unilateral superior oblique palsy. Strabismus 2001;9:83-90.

7. Clifford L, Roos J, Dahlmann-Noor A, Vivian AJ. Surgical management of superior oblique paresis using inferior oblique anterior transposition. J AAPOS 2015;19:406-9.
8. Ghazawy S, Reddy AR, Kipioti A, McShane P, Arora S, Bradbury JA. Myectomy versus anterior transposition for inferior oblique overaction. J AAPOS 2007;11:601-5.
9. Toosi SH, von Noorden GK. Effect of isolated inferior oblique muscle myectomy in the management of superior oblique muscle palsy. Am J Ophthalmol 1979;88(3 Pt 2):602-8.
10. Mataftsi A, Strickler J, Klainguti G. Vertical and torsional correction in congenital superior oblique palsy by inferior oblique recession. Eur J Ophthalmol 2006;16:3-9.
11. Singh V, Agrawal S, Agrawal S. Outcome of unilateral inferior oblique recession. J Pediatr Ophthalmol Strabismus 2009;46:350-57.
12. Yoo JH, Kim SH, Seo JW, Paik HJ, Cho YA. Self-grading effect of inferior oblique recession. J Pediatr Ophthalmol Strabismus 2013; 50:102-5.
13. Shipman T, Burke J. Unilateral inferior oblique muscle myectomy and recession in the treatment of inferior oblique muscle overaction: a longitudinal study. Eye (Lond) 2003;17:1013-18.
14. Akbari M, Sadrkhanlou S, Mirmohammadsadeghi A. Surgical outcome of single inferior oblique myectomy in small and large hypertropia of unilateral superior oblique palsy. J Pediatr Ophthalmol Strabismus 2019;56:23-7.
15. Bielschowsky A. Lectures on motor anomalies of the eyes: Ii. paralysis of individual eye muscles. Arch Ophthalmol 1935;13:33-59.
16. Costenbader FD, Kertesz E. Relaxing procedures of the inferior oblique: a comparative study. Am J Ophthalmol 1964;57:276-80.
17. Parks MM. A study of the weakening surgical procedures for eliminating overaction of the inferior oblique. Trans Am Ophthalmol Soc 1971;69:163-87.
18. Wertz RD, Romano PE, Wright P. Inferior oblique myectomy, disinsertion, and recession in rhesus monkeys. Arch Ophthalmol 1977; 95:857-60.
19. Dyer JA. Tenotomy of the inferior oblique muscle at its scleral insertion: an easy and effective procedure. Arch Ophthalmol 1962;68:176-81.
20. Cooper EL, Sandall GS. Recession versus free myotomy at the insertion of the inferior oblique muscle: comparative analysis of the surgical correction of overaction of the inferior oblique muscle. J Pediatr Ophthalmol 1969;6:6-10.