The management of large-angle esotropia in Graves ophthalmopathy with combined medial rectus recession and lateral rectus resection

James A. Garrity, MD,[a] Daniel A. Greninger, MD,[b] Noha S. Ekdawi, MD,[a] and Eric A. Steele, MD[c]

PURPOSE To describe surgical management and outcomes for large-angle esotropia of ≥50$^{\Delta}$ secondary to Graves ophthalmopathy using combined initial nonadjustable medial rectus recessions and lateral rectus resections.

METHODS The medical records of consecutive patients undergoing strabismus surgery for large-angle esotropia secondary to Graves ophthalmopathy from 1995 to 2012 by a single surgeon at each of two institutions was performed. Patient characteristics, surgical technique, and pre- and postoperative measurements of ocular alignment were analyzed. A modified Gorman diplopia scale was used to assess outcome.

RESULTS Of 38 patients, 36 had bilateral nonadjustable medial rectus recessions and lateral rectus resections as initial treatment for esotropia, and 6 patients underwent simultaneous vertical muscle surgery. Mean preoperative horizontal deviation was 60$^{\Delta}$ and mean preoperative vertical deviation was 10$^{\Delta}$. Of the 38 patients, 19 (50%) reached the primary outcome, including 5 of 6 (85%) who had no preoperative vertical strabismus. The indications for reoperation were vertical strabismus in 13 of 21 patients (62%), residual esotropia in 7 of 21 (33%), and consecutive exotropia in 1 of 21 (5%). With a median follow-up of 13.2 months after first surgery, 32 of 38 patients (84%) reached the secondary outcome.

CONCLUSIONS Combining nonadjustable medial rectus recessions with lateral rectus resections can be a beneficial primary treatment for large-angle esotropia in patients with Graves ophthalmopathy, especially in those patients with small or no associated vertical strabismus.

There are a multitude of surgical approaches to strabismus in Graves ophthalmopathy, including adjustable sutures,[1,2] matching the restriction of ductions,[3] and intraoperative relaxed muscle positioning.[4] The underlying principle in managing restrictive strabismus is to recess the restricted muscle. The amount of recession must be balanced against potential loss of muscle function, especially with the larger recessions required for greater deviations. Large-angle esotropia, defined here as esotropia of ≥50$^{\Delta}$, makes up a small subset of patients with strabismus associated with Graves ophthalmopathy. There are no clear management guidelines for these patients. In our practice, medial rectus recession combined with lateral rectus resection has been the initial procedure of choice to correct horizontal deviations in all patients with large-angle esotropia secondary to Graves ophthalmopathy for 20 years. We describe our experience with, indications for, and outcomes following this procedure based on the thoughts and experience of JA Dyer.[5]

Subjects and Methods

This study complied with the US Health Insurance Portability and Accountability Act of 1996 and was approved by the Oregon Health and Science University Institutional Review Board. The medical records of consecutive Graves ophthalmopathy patients who underwent strabismus surgery by a single surgeon (JAG) from January 1995 to December 2012 at the Mayo Clinic and patients operated on by a single surgeon (EAS) from January 2008 to December 2012 at the Oregon Health Science University were reviewed retrospectively for the following information: age, sex, smoking history, treatment for thyroid dysfunction, indication for and method of orbital decompression, strabismus surgeries, and date of last follow-up. All patients had a firm diagnosis of Graves ophthalmopathy, which included a compatible clinical

Author affiliations: [a]*Department of Ophthalmology, Mayo Clinic, Rochester, Minnesota;* [b]*Department of Ophthalmology, Kaiser Permanente Diablo Service Area, Antioch, California;* [c]*Department of Ophthalmology, Casey Eye Institute, Oregon Health and Science University, Portland, Oregon*

Supported by grant P30 EY010572 from the National Institutes of Health (Bethesda, MD) and by unrestricted departmental funding from Research to Prevent Blindness, New York, NY.

Submitted November 9, 2017.
Revision accepted August 29, 2018.
Published online January 19, 2019.

Correspondence: Daniel A. Greninger, MD, Kaiser Permanente, Antioch Medical Center, 4501 Sand Creek Rd, Antioch, CA, 94531 (email: Daniel.A.Greninger@kp.org).

1091-8531/$36.00
https://doi.org/10.1016/j.jaapos.2018.08.013

examination with elevated thyroid stimulating antibodies or TSH-receptor antibodies and neuroimaging, if required.

The surgical technique employed a conventional limbal incision and nonadjustable sutures using 6-0 polyglactin 910. Techniques are detailed in *Atlas of Extraocular Muscle Surgery*.[6] Surgical planning for horizontal muscle surgery was based on the unpublished experience of JA Dyer. Our surgical algorithm began at 50^{Δ} distance esotropia, for which bilateral 5 mm medial rectus recessions and bilateral 5 mm lateral rectus resections were used. The amount of medial rectus recession and lateral rectus resection was increased by 1 mm for each additional 10^{Δ} of esotropia, with rare variations of 1 mm in cases of asymmetric deviation. The conjunctiva over the medial rectus was typically "tight" and by necessity recessed 1–2 mm. Intraoperative inspection of the muscles was noted, and forced ductions were recorded on a subjective 0-4 scale before beginning the operation.

The approach to associated vertical strabismus varied with each patient. In general, we made a decision whether or not to address the vertical based on the presence or absence of vertical diplopia after correcting the horizontal with prism on the preoperative visit, and we also considered the patient's age, smoking history, presence of diabetes, and other vascular disease risk factors. In patients who underwent combined horizontal and vertical rectus muscle surgery, an empiric subconjunctival injection of 20 mg methylprednisolone was given at the end of the case and the pupil was dilated with 1% atropine drop, a treatment based on the anecdotal experience of Dyer.

All patients had a complete pre- and postoperative orthoptic evaluation performed by a single orthoptist at each institution. A modified Gorman scale of 0-4 was used to assess subjective diplopia for distance in primary gaze and reading (0 = no diplopia, 1 = diplopia when tired or upon awakening, 2 = diplopia at extremes of gaze, 3 = constant diplopia able to be corrected with prism, and 4 = constant diplopia unable to be corrected with prism).[7] A satisfactory outcome was defined as absence of constant diplopia in primary or reading position within the central 30° (score, 0-2), and unsatisfactory outcome was defined as presence of constant diplopia in primary and/or reading position (score, 3-4).

Results

During the study period, 30 patients with large-angle esotropia ($\geq 50^{\Delta}$) of 806 Graves ophthalmopathy patients (4%) underwent strabismus surgery at the Mayo Clinic; 8 of 47 (17%), at Oregon Health Science University. Of the total of 38 patients included 28 (74%) were females. Combined vertical and horizontal deviations were seen in 19 patients (50%). Patient characteristics and individual outcomes are listed in Table 1 (see eSupplement 1, available at jaapos.org, for a slightly more detailed presentation of characteristics and outcomes). The mean age at time of strabismus surgery was 54.9 years (median, 55.2; range, 31.0-89.9). Of the 38 patients, 20 (53%) were current or recently stopped smokers. Thirty-four patients (89%) had previously undergone orbital decompression, of which the majority (26 [76%]) were performed via transantral approach, reflective of institutional bias. Strabismus surgery was performed a mean of 3.7 months (median, 1.9; range, 1.5-21.0) after decompression. The 4 patients with no decompression had stable orthoptic examinations for a mean of 14 months after the completion of oral steroids. Thirty-four patients (89%) were hyperthyroid and were treated with radioactive iodine in 26 cases, oral antithyroid medications in 13 cases, and surgical thyroidectomy in 2 cases.

Thirty-seven patients (97%) experienced continuous diplopia before surgical intervention, and 1 patient (23), who had a history of infantile esotropia and who had undergone childhood strabismus surgery, complained of intermittent diplopia and asthenopia. One other patient (17) had undergone vertical rectus muscle surgery 9 months prior to development of an optic neuropathy, which was treated with bilateral transantral orbital decompression. This patient subsequently developed a large-angle esotropia. With the exception of the 2 above-mentioned patients, no patients in this series had undergone strabismus surgery before the horizontal rectus muscle surgery.

The mean preoperative horizontal deviation was 60^{Δ} esotropia (median, 60^{Δ}; range, 50^{Δ}-95^{Δ}). Of the 38 patients, 32 had concomitant vertical strabismus, with mean preoperative vertical deviation of 10^{Δ} (median, 7^{Δ}; range, 0^{Δ}-65^{Δ}). In 3 patients, performing horizontal rectus surgery with transpositions addressed the vertical strabismus, and additional vertical strabismus surgery was not required. Six patients received initial combined horizontal and vertical strabismus surgery; 9 others underwent a staged approach. The mean medial rectus recession in the entire series was 6.2 mm (median, 6.0 mm; range, 5–8 mm), and the mean lateral rectus resection was 6.1 mm (median, 6.0 mm, range, 4–9 mm). Forced ductions on all medial rectus muscles were grade 4 restricted with the exception of patient 11, who had virtually normal forced ductions and no evidence of myasthenia gravis. Forced ductions on lateral rectus muscles were minimally if at all restricted.

Of the 38 patients, 19 (50%) reached the primary outcome. This group had a final mean Gorman score of 1.2. Of these 19, the mean initial esotropia was identical to the overall group mean (60^{Δ}). However, the mean initial vertical deviation in this group was 5^{Δ} (median, 4^{Δ}; range, 0^{Δ}-12^{Δ}), whereas the mean initial vertical deviation in the 19 who did not reach the primary outcome was 15^{Δ} (median, 10^{Δ}; range, 0^{Δ}-65^{Δ}). Additionally, of the 6 patients with no detectable vertical deviation preop, 5 (83%) reached the primary outcome. A total of 21 patients (55%) underwent more than one strabismus surgery, with a final mean Gorman score of 1.7. In this group, the indications for reoperation were vertical strabismus in 13 patients (62%), residual esotropia in 7 (33%), and consecutive exotropia in 1 (5%).

With a mean follow-up of 23.5 months after first surgery (median, 13.2; range, 2.1-173.9), 32 of 38 patients (84%) reached the secondary outcome (10 patients with no

Table 1. Patient characteristics

			Decompression		Initial deviation, PD		Recession, mm		Resection, mm			Post-op week 6 exam			Final exam	
Case	Sex	Prior Tx[a]	Indication	Type	ET	HT	R-MR	L-MR	R-LR	L-LR	Vertical[b]	Distance alignment primary gaze, PD	Modified Gorman score	Total surgeries	Distance alignment primary gaze, PD	Modified Gorman score[c]
1	F	RAI	EP	TA	50	5	5	5	5	5	N	Ortho	2	1	2 L-H	2
2	F	RAI, ATD	ON	TA	50	0	5	5	5	5	N	4 X	0	1	4 X, 4 L-H	0
3	F	T, RAI	C	TA	50	2	5	5	5	5	N	4 E	1	1	4 E	1
4	F	RAI	C	TA	50	10	5	5	5	5	N	4 X, 6 R-HT	3	2	8 X, 5 L-H	1
5	F	T, ATD	EP	TA	50	10	5	5	5	5	Y	10 E, 16 L-HT	4	2	Ortho	2
6	M	RAI	C	Endo	50	2	5	5	5	5	N	10 E, 12 L-HT	3	3	5 E, 6 L-H	1
7	F	RAI	ON	TA	50	12	5	5	5	5	N	18 XT	1	1	10 X	1
8	F	RAI	N/A	N/A	50	3	5	5	5	5	N	5 X	0	1	Ortho	0
9	F	ATD	ON	TA	50	5	5	5	5	5	N	8 ET, 12 L-HT	4	3	4 ET, 2 R-HT	3
10	M	N/A	ON	TA	50	0	6	6	4	5	N	2 X	2	1	3 X, 2 L-H	2
11	F	N/A	N/A	N/A	50	5	6	6	0	0	N	35 ET	4	2	Ortho	0
12	M	RAI	C	3-wall	50	5	5	5	5	5	N	Ortho	0	1	Ortho	0
13	M	RAI	C	TA	55	16	5	6.5	5	6	N	8 XT, 18 L-HT	4	2	1 ET, 1 R-HT	3
14	F	RAI	EP	TA	55	0	5	6	5	5	N	3 ET	2	1	4 E	2
15	F	RAI	EP	Endo	55	65	6	7	6	7	Y	3 ET, 16 R-HT	4	4	4 E	0
16	F	RAI	N/A	N/A	55	8	6	6	6	6	Y	2 ET	1	1	9 E	1
17	F	RAI	ON	TA	55	3	6	6	6	6	N	12 ET, 20 RHT	4	2	Ortho	0
18	M	RAI	C	3-wall	55	3	5.5	5.5	5.5	5.5	N	Ortho	2	1	3 R-H	2
19	F	N/A	ON	TA	60	5	6.5	6	6	6	N	18 ET, 5 R-HT	2	2	6 E, 2 L-H	0
20	M	RAI	ON	TA	60	0	6	7	5	7	N	4 ET	0	1	Ortho	0
21	M	ATD	ON	TA	60	30	6	6	6	6	N	60 ET, 30 LHT	4	4	3 E	2
22	F	N/A	C	3-wall	60	2	6	6	6	6	N	Ortho	0	1	Ortho	0
23	F	RAI	ON	TA	70	5	4	5	8	8	N	4 XT, 6 R-HT	2	2	12 X, 5 L-H	2
24	F	RAI, ATD	ON	TA	70	10	6	7	6	6	N	25 XT, 5 R-HT	4	3	20 XT	4
25	F	RAI	ON	TA	70	10	7	7	7	7	N	5 XT, 10 L-HT	3	2	2 X, 2 L-H	1
26	F	RAI, ATD	EP	TA	70	0	6.5	6.5	7	7	N	3 ET, 12 excyclo	4	2	4 E	2
27	F	RAI	ON	TA	70	20	6	6	6	7	N	12 ET, 20 L-HT	4	3	5 ET, 6 L-HT	3
28	M	ATD	Disfigurement	TA	70	8	7	7	7	7	Y	Ortho	1	1	1 R-H	2
29	F	RAI, ATD	ON	3-wall	70	8	7	7	0	0	N	45 ET, 8 L-HT	4	3	8 E	2
30	F	RAI	EP	3-wall	72	0	7	7	7	7	N	Ortho	2	1	Ortho	2
31	F	ATD	ON	TA	75	30	7	8	6	8	Y	16 ET, 3 R-HT	3	4	25 X(T)	2
32	F	RAI	EP	TA	75	8	6	8	6	9	N	9 ET, 8 R-HT	3	2	8 E	1
33	F	RAI	ON	3-wall	80	6	8	7	8	7	N	8 ET	2	1	Ortho	2
34	F	ATD	C	3-wall	80	8	8	8	8	8	N	Ortho	2	1	Ortho	2
35	F	RAI	EP	TA	85	10	7	7	7	8	N	15 L-HT	4	2	5 L-HT	3
36	M	RAI, ATD	N/A	N/A	85	8	8	8	8	9	Y	16 XT, 20 R-HT	4	3	Ortho	0
37	M	ATD	ON	3-wall	90	10	8	8	8	8	N	Ortho	2	1	Ortho	2
38	F	ATD	ON	TA	95	50	Torn	8	0	8	N	16 ET, 8 R-HT	3	2	2 ET, 1 R-HT	3

ATD, anti-thyroid medications; *C,* congestion; *E,* esophoria; *Endo,* endoscopic; *EP,* excess proptosis; *Excyclo,* excyclotorsion; *ET,* esotropia; *H,* hyperphoria; *HT,* hypertropia; *LR,* lateral rectus muscle; *MR,* medial rectus muscle; *N/A,* not applicable; *ON,* optic neuropathy; *Ortho,* orthotropic; *RAI,* radioactive iodide; *TA,* transantral; *Tx,* therapy; *X,* exophoria; *XT,* exotropia; *(X)T,* intermittent exotropia.

[a]Previous treatment for hyperthyroidism; some patients had prior eye therapies as well (see eSupplement 1).

[b]Vertical muscle surgery at first intervention.

[c]Final modified Gorman scores: no diplopia, 0; diplopia only when tired, 1; diplopia only with deviant gaze, 2; constant diplopia resolved in primary gaze with prism, 3; constant diplopia uncontrolled with prism, 4.

diplopia in any field of gaze, 7 with diplopia only when tired, and 15 with diplopia only in extreme gaze positions), whereas 16% had unsatisfactory results (5 patients required prism correction for constant diplopia, including 1 with constant diplopia who was not amenable to prism correction). No patients who had surgery on both horizontal rectus muscles and an additional ipsilateral vertical rectus muscle experienced clinically detectable anterior segment ischemia (iritis or iris transillumination defects) with repeated postoperative slit-lamp examinations.

Figure 1 illustrates an example of the pre- and postsurgical alignment and motility in horizontal gaze of a patient with a large-angle esotropia (90^{Δ}) who underwent combined medial rectus recession and lateral rectus resection with excellent results.

FIG 1. Clinical photographs of patient 37, who had an esotropia of 90^{Δ} at presentation. A, preoperative photographs in primary, right, and left gazes. B, Postoperative day 1. C, Postoperative month 2.

Discussion

Large-angle esotropia secondary to Graves ophthalmopathy is a rare and difficult problem for the strabismus surgeon. The traditional approach, using initial large bilateral medial rectus recessions, often results in multiple surgeries because of persistent diplopia, either from undercorrections or convergence insufficiency.[8] Different techniques and approaches have been used for Graves ophthalmopathy strabismus in general that have then been applied to large-angle esotropia patients with variable success. Thomas and Cruz[9] found no difference in their series, which compared outcomes between surgical corrections of restricted duction and deviation, although there were no large-angle esotropia patients in their series. Del Monte,[10] in his retrospective series of 135 patients over 25 years, reported a decreasing success rate with increasing angle of esotropia; in his series, only 3 of 8 patients with esotropia of 55^{Δ}-65^{Δ} and 1 of 5 with esotropia of $>65^{\Delta}$ esotropia achieved successful alignment after adjustable-suture surgery. While intraoperative relaxed muscle positioning achieved good long-term results in 83% of patients, a post hoc analysis found that the increasing angle of horizontal strabismus was the greatest predictor of repeat surgery. As such, only 4 of 14 patients with angle of esotropia $>30^{\Delta}$ and no patients with esotropia $>45^{\Delta}$ achieved excellent or good outcomes with only one surgery.[4] Yan and Zhang[11] reported results on 27 patients with large-angle esotropia using a variety of techniques, including recession of the involved muscle plus resection of an antagonist. There were 4 overcorrections, and 24 patients underwent a single operation; the authors recommended consideration of rectus muscle recession with a traction suture, which corrected 20 patients (74%) in their series.

Three recent studies have specifically investigated combining resection and recession in Graves ophthalmopathy. Yoo and colleagues[12] reported on 8 patients who underwent rectus muscle resection as part of their surgical management for thyroid-related strabismus. In their study, different muscles were resected for both horizontal and vertical strabismus; our investigation, on the contrary, focused exclusively on resection of the lateral rectus combined with medial rectus recession. Additionally, our series focuses primarily on large-angle, restrictive esotropia, whereas Yoo and colleagues[12] included patients with both restrictive and nonrestrictive strabismus. Kim and colleagues[13] reported on 9 patients, in 7 of whom residual esotropia was successfully treated with sequential lateral rectus resection, with no significant overcorrections. Only 2 of their patients, however, had large-angle esotropia, and these were the 2 patients left undercorrected. Weldy and Kerr[14] also reported on 11 patients who underwent sequential lateral rectus resection after maximal or supramaximal medial rectus recession to treat residual esotropia using adjustable sutures, with a 91% success rate at the 2-month postoperative visit and no complications. The degree of esotropia on initial presentation and the percent of patients who were satisfied with medial rectus recession alone before reoperation was offered was unclear; hence their results cannot be directly compared to ours. Each of these studies used different definitions of success, but all reported no significant overcorrections or side effects.

It is commonly taught that smaller medial rectus recessions are sufficient to resolve larger deviations in restrictive strabismus than typically recommended for nonrestrictive strabismus. However, it has been our experience and that of others[8,15,16] in Graves ophthalmopathy that even large medial rectus recession alone resulted in undercorrection more frequently than overcorrection in patients with large-angle esotropia. Years ago, this observation led Dyer to experiment with combining recessions with resections in initial surgery to reduce the total number of operations, which is the approach we advocate here.

It is also traditionally taught that bilateral medial rectus recession is accompanied by a greater-than-average risk of sequential exotropia because of lateral rectus involvement in Graves ophthalmopathy.[17,18] Therefore, some surgeons may be reluctant to perform a resection of the lateral rectus muscle because of an even larger risk of sequential exotropia or convergence difficulties. We report only 3 cases of horizontal overcorrection after 38 initial surgeries in our series, of which 2 resolved over time. Only 1 case would have likely required surgical correction if the patient had not been lost to follow-up.

Therefore, we propose that adding lateral rectus resection to initial medial rectus recession does not lead to a greater-than-average risk of sequential or consecutive exotropia for large-angle esotropia. In fact, undercorrection of esotropia was more common than overcorrection with our technique. Undercorrections were all symptomatic and typically displayed a "divergence insufficiency" pattern. Undercorrections were addressed via different surgical techniques, including combined recession-resection procedures, additional lateral rectus resection alone, and additional medial rectus recession alone. In our experience, additional lateral rectus resection gave more predictable results in the case of initial undercorrection of esotropia.

One of the difficulties in comparing results of surgical outcomes is the use of different outcome measures. Jellema and colleagues[21] suggest a field of binocular single vision and quality-of-life measurement as the best measures. In this retrospective series, we used the subjective Gorman scale as our surrogate measure of quality of life. Our approach resulted in satisfactory results in 50% of large-angle esotropia patients after one surgery and in 84% of patients after all surgical interventions. Seventeen patients (45%) required only one surgery, and 10 patients (26%) reported no diplopia at any time in any field of gaze after all surgery.

Orbital decompression had been performed in 89% of the patients in our series. This large percentage could be due to the coexistence or occurrence of large-angle esotropia with advanced Graves ophthalmopathy after decompression. There was no difference in outcomes between the large subset who had undergone orbital decompression and the small subset who had not. We were also unable to identify any other association between the patient variables in Table 1 and surgical outcomes. As such, we generalize our surgical approach to all patients with large-angle esotropia secondary to Graves ophthalmopathy.

The only intraoperative complication in the series was a torn medial rectus muscle. Pulled-in-two-syndrome is a known risk of strabismus surgery in Graves ophthalmopathy patients, and the muscle tear occurred before any intervention on the ipsilateral lateral rectus muscle. No patients had atypical postoperative conjunctival inflammation after lateral rectus resection. There were no cases of anterior segment ischemia observed in the 16 patients (42%) who had surgeries on both horizontal rectus muscles in addition to one vertical rectus muscle. Anterior segment ischemia is a rare complication of surgery,[19,20] and this study suggests that surgeons should not be reluctant to perform lateral rectus resections in addition to medial rectus recessions to address large-angle esotropia for fear of the patient's developing anterior segment ischemia.

The advantages of this study include the large cohort of cases in two practices over many years. Additionally, the surgeons used the same surgical technique and algorithm for surgical planning. The median patient follow-up was also >1 year after initial surgery. Limitations of this study include its retrospective nature, the variable approach to vertical strabismus, variable timings of final Gorman score as an outcome measure, and the short follow-up period of <6 months in 9 patients (24%).

Acknowledgments

The authors would like to thank Pam Berg, CO, for her assistance in obtaining clinical measurements of extraocular motility and alignment.

References

1. Kraus DJ, Bullock JD. Treatment of thyroid ocular myopathy with adjustable and nonadjustable suture strabismus surgery. Trans Am Ophthalmol Soc 1993;91:67-79. discussion 79-84.
2. Lueder GT, Scott WE, Kutschke PJ, Keech RV. Long-term results of adjustable suture surgery for strabismus secondary to thyroid ophthalmopathy. Ophthalmology 1992;99:993-7.
3. Nguyen VT, Park DJ, Levin L, Feldon SE. Correction of restricted extraocular motility in surgical management of strabismus in Graves' ophthalmopathy. Ophthalmology 2002;109:384-8.
4. Dal Canto AJ, Crowe S, Perry JD, Traboulsi EI. Intraoperative relaxed muscle positioning technique for strabismus repair in thyroid eye disease. Ophthalmology 2006;113:2324-30.
5. Dyer JA. Ocular muscle surgery in Graves' disease. Trans Am Ophthalmol Soc 1978;76:125-39.
6. Dyer JA, Lee DA. Atlas of Extraocular Muscle Surgery. 2nd ed. Praeger Scientific; 1984.
7. Bahn RS, Gorman CA. Choice of therapy and criteria for assessing treatment outcome in thyroid-associated ophthalmopathy. Endocrinol Metab Clin North Am 1987;16:391-407.
8. Lyons CJ, Rootman J. Strabismus in Graves' orbitopathy. Pediatr Endocrinol Rev 2010;7(suppl 2):227-9.
9. Thomas SM, Cruz OA. Comparison of two different surgical techniques for the treatment of strabismus in dysthyroid ophthalmopathy. J AAPOS 2007;11:258-61.
10. Del Monte MA. 2001 an ocular odyssey: lessons learned from 25 years of surgical treatment for Graves' eye disease. Am Orthopt J 2002;52:40-57.
11. Yan J, Zhang H. The surgical management of strabismus with large angle in patients with Graves' ophthalmopathy. Int Ophthalmol 2008;28:75-82.
12. Yoo SH, Pineles SL, Goldberg RA, Velez FG. Rectus muscle resection in Graves' Ophthalmopathy. J AAPOS 2013;17:9-15.
13. Kim EY, Roper-Hall G, Cruz OA. Effectiveness of bilateral lateral rectus resection for residual esotropia in dysthyroid ophthalmopathy. Am J Ophthalmol 2016;171:84-7.
14. Weldy E, Kerr NC. Lateral rectus muscle resection following maximal recession of the medial rectus muscle in thyroid eye disease. J AAPOS 2017;21:291-4.
15. Mocan MC, Ament C, Azar NF. The characteristics and surgical outcomes of medial rectus recessions in Graves' ophthalmopathy. J Pediatr Ophthalmol Strabismus 2007;44:93-100.
16. Schotthoefer EO, Wallace DK. Strabismus associated with thyroid eye disease. Curr Opin Ophthalmol 2007;18:361-5.
17. Dagi LR, Elliott AT, Roper-Hall G, Cruz OA. Thyroid eye disease: honing your skills to improve outcomes. J AAPOS 2010;14:425-31.
18. Plager DA, Parks MM, von Noorden GK. Strabismus Surgery: Basic and Advanced Strategies. In: Ophthalmology Monographs 17, American Academy of Ophthalmology. New York, NY: Oxford University Press; 2004.
19. Wan MJ, Hunter DG. Complications of strabismus surgery: incidence and risk factors. Semin Ophthalmol 2014;29:421-8.
20. Saunders RA, Bluestein EC, Wilson ME, Berland JE. Anterior segment ischemia after strabismus surgery. Surv Ophthalmol 1994;38:456-66.
21. Jellema HM, Braaksma-Besselink Y, Limpins J, von Arx G, Wiersinga WM, Mourits MP. Proposal of success criteria for strabismus surgery in patients with Graves' orbitopathy based on a systematic literature review. Acta Ophthalmol 2015;93:601-9.