



Recovery of stereoacuity after Yokoyama procedure in patients with highly myopic strabismus with good vision

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ARTICLE INFO

Keywords:

Highly myopic strabismus
Yokoyama procedure
Esotropia
MRI
Stereopsis
Heavy eye syndrome

ABSTRACT

Purpose: To report stereopsis after bilateral Yokoyama procedure in patients with highly myopic strabismus and good visual acuity.

Observations: Five patients aged between 34 and 81 years with best-corrected visual acuity of 20/25 or better were operated on. The preoperative strabismus angle ranged from esotropia of 35–113 prism diopters (PD) at distance and esotropia of 40–113 PD at near. One patient had left hypotropia of 4 PD and excyclotorsion of 15°, and the other had left hypotropia of 10 PD. Their axial lengths were 27.65–33.07 mm, and the posterior globe dislocation angles were between 123 and 148° on coronal magnetic resonance imaging (MRI). Limitations of abduction were between –1 and –2. All patients complained of diplopia, and none of them showed stereopsis. The Yokoyama procedure was performed on both eyes. Postoperative alternate cover testing showed from esotropia of 2 PD to exophoria of 8 PD at distance and from exotropia of 12 PD to esophoria of 10 PD at near. Three patients recovered stereopsis of 100, 50, and 140 sec, respectively. Two cases required unilateral inferior rectus muscle recessions, and their postoperative stereopsis was 25 and 50 sec.

Conclusions and Importance: The Yokoyama procedure is effective not only in cases of heavy eye syndrome but also in cases of myopic esotropia associated with a globe dislocation angle of 120° or with little abduction restriction. If visual acuity is good, stereopsis may be restored with improvement in eye deviation.

1. Introduction

Esotropia associated with high myopia is caused by dislocation of the posterior part of the globe between the superior rectus (SR) and lateral rectus (LR) muscles.^{1,2} The muscle union procedure, developed by Yokoyama in 2001³, has been widely accepted as a primary procedure for correcting severe esotropia with high myopia called “heavy eye syndrome.” In most cases, patients may not complain of double vision because of poor vision in at least one eye but may complain of cosmetic issues or difficulties in seeing straight ahead. The Yokoyama procedure is highly effective in correcting heavy eye syndrome. However, there is a concern that this method may result in overcorrection when performed on patients with myopic strabismus who have little abduction limitation and a small strabismus angle.

There are several reports on favorable outcomes after the Yokoyama procedure in selected patients with a lower displacement of the LR muscle and nasal displacement of the SR muscle in non-myopic eyes

observed on coronal magnetic resonance imaging (MRI).⁴ However, a search of PubMed, Google Scholar, and Ichushi-web (Japanese) showed only one case report⁵ in Japanese that reported on stereopsis.

Here, we report on the postoperative stereopsis of five patients with esotropia treated with the Yokoyama procedure for both eyes. The best-corrected visual acuities (BCVAs) of the patients, which were measured in decimal and converted to Snellen acuity, were 20/25 or better. Their axial lengths were greater than 27 mm, and herniation of the posterior globe between the SR and LR muscles was observed on coronal MRI.

In this case series, the globe dislocation angle was measured using MRI. A 1.0- or 3.0-T system (Signa Infinity Twin Speed with Excite, version 12, GE Healthcare, WI, USA) was used to obtain axial and coronal T2-weighted spin-echo images with a slice thickness of 3 mm. The slice, which was approximately 9 mm anterior to the optic nerve-globe junction, was used to analyze the positional relationships between the globe and the SR and LR muscles. MR images were obtained as 112 × 112-pixel bitmap images and analyzed using Image J 1.53k software

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<https://doi.org/10.1016/j.ajoc.2023.101892>

Received 1 April 2023; Received in revised form 18 June 2023; Accepted 4 July 2023

Available online 7 July 2023

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(Wayne Rasband, National Institutes of Health, MD, USA). The coordinates of the mathematical centers of the globe and the SR and LR muscles were determined. Reference lines between the centers of the globe and each extraocular muscle were drawn. The angle between the two lines was measured and defined as the globe dislocation angle.

The Yokoyama procedure was performed under general anesthesia for all patients. The surgical procedure was as follows. A radial conjunctival incision was created between the SR and LR muscles, and they were identified. After these muscles were separated from the connective tissue and oblique muscles, 5-0 polyester sutures were placed along the superior border of the LR muscle and lateral border of the SR muscle at 15 mm posterior from the insertions. The two sutures were tied firmly, and the two muscles were joined without a scleral pass.

2. Findings

Patients' characteristics are shown in the [Table 1](#).

Cases from 1 to 3 obtained satisfactory results with a simultaneous bilateral Yokoyama procedure, and cases 4 and 5 underwent additional single rectus muscle surgery as a 2nd procedure and regained stereopsis. None of the patients showed stereopsis preoperatively.

We will describe cases 4 and 5 cases briefly.

Case 4 is an 81-year-old woman had had horizontal and vertical diplopia for 9 years.

One month after bilateral Yokoyama procedure, APCT showed right exophoria of 4 PD and left hypotropia of 18 PD at distance and right exotropia of 12 PD and left hypotropia of 12 PD at near. A Fresnel prism was prescribed for the residual diplopia. Five years later, she underwent a 5-mm left inferior rectus muscle recession. After 13 months postoperatively, the Randot stereo test showed 25 sec of stereopsis.

Case 5 is a 60-year-old man had had horizontal, vertical, and torsional diplopia for 5 years. A cyclophorometer (Nanoh Optics Inc.) showed 15° of excyclotorsion. His eye position ([Fig. 1](#)) and MRI image showing globe dislocation with 142° for the right eye and 140° for the left eye ([Fig. 2](#)). The Yokoyama procedure was performed for both eyes, and one month postoperatively ([Figs. 1 and 3](#)), APCT showed right esophoria of 4 PD and left hypophoria of 2 PD at distance and left esophoria of 6 PD and left hypophoria of 10 PD at near. The excyclotorsion improved by 5°, and the stereo fly test result improved to 60 sec. However, 7 months postoperatively, the left hypotropia recurred and he lost stereopsis. A 2 mm left inferior rectus muscle recession was performed. One month postoperatively, APCT showed orthophoria at distance and at near. The stereo fly test showed 50 sec of stereopsis.

3. Discussion

The cases of esotropia reported here had different angles of deviation, but they were corrected with the same surgical procedure. Stereopsis improved in all cases.

The recurrence of esotropia is common after the conventional recession for horizontal muscles.⁶ Yokoyama et al.⁷ developed a new surgical procedure, regardless of the strabismus angle whenever the posterior globe herniation from the extraocular muscle cone was observed on coronal orbital MRI.

Serafino performed the bilateral Yokoyama procedures on patients with axial lengths less than 27 mm, and none was overcorrected.⁴ Wabbels performed the bilateral Yokoyama procedure on patients with small angles of esotropia, and 5 out of 6 did not develop overcorrection.⁸ Thus, the Yokoyama procedure may be safe and effective for cases with small-angle esotropia with SR and LR muscle dislocations; the recovery of stereopsis was, however, not reported.

The angle of dislocation was reported as 105.2 ± 8.4° for non-strabismic participants.⁹ When the angle exceeds 120° for both eyes, the bilateral Yokoyama procedure is recommended as the first choice.

We found only one case report of two patients showing the recovery of measurable stereopsis after the bilateral Yokoyama procedure.⁵ They

Table 1
Patient characteristics.

Cases	Age (years)	Sex	Eye	BCVA	Axial Length (mm)	Dislocation Angle (°)	Abduction Limitation	Eye Position (Far)		Eye Position (Near)		Stereopsis	
								Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
1	65	M	R	20/16	29.17	137	-2	45Δ ET	2Δ XP, 2Δ L/R	45Δ ET	6Δ XP	Fly 100 sec (-) *1	
2	47	F	L	20/25	29.86	136	-1	113Δ ET	8Δ ET	113Δ ET	6Δ EP	Fly 50 sec (-) *2	
			R	20/16	27.96	136	-2	63Δ ET	8Δ EP	45Δ ET	10Δ EP	Fly 140 sec (-) *1,2	
3	34	M	R	20/20	32.41	130	-1	59Δ ET, 10Δ R/L	Post-op 5Y: 1.2Δ XT, 18Δ R/L	LJR recess after: ortho	Post-op 5Y: 20Δ XT, 18Δ R/L	Fly LJR recess after: 25 sec *1	
4	81	F	R	20/20	33.07	130	-1			53Δ ET, 10Δ R/L	LJR recess after: 12Δ XT, 5Δ R/L	(-)	Fly LJR recess after: 25 sec *1
5	60	M	L	20/25	30.11	148	-2	35Δ ET, 4Δ R/L	Post-op 7 M: small EP, 2Δ R/L	40Δ ET, 15° ex	Post-op 7 M: small EP, 12Δ R/L	Fly LJR recess after: ortho	
			R	20/20	28.29	142	-1	L	LJR recess after: ortho				(-)

M: Male, F: Female, BCVA: Best-corrected visual acuity *1 Randot stereo test, *2 stereo fly test.



Fig. 1. Case 5: Eye movement
Upper row: Both eyes showed a limitation of abduction of -1 preoperatively.
Lower row: The limitation was reduced postoperatively.

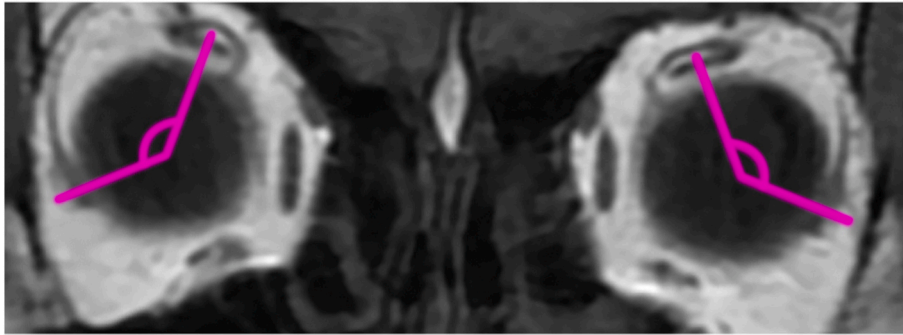


Fig. 2. Case 5: Orbital MRI
The nasal shift of both superior rectus muscles (SRs); downshift of the lateral rectus muscles (LRs); dislocation of the posterior half of the globe outside the muscle cone (right: 142° , left: 140°); and angle (dislocation angle) of the line connecting the centers of the cross-section of the SR muscle, globe, and LR muscle from the orbital wall on the auricular side were measured.

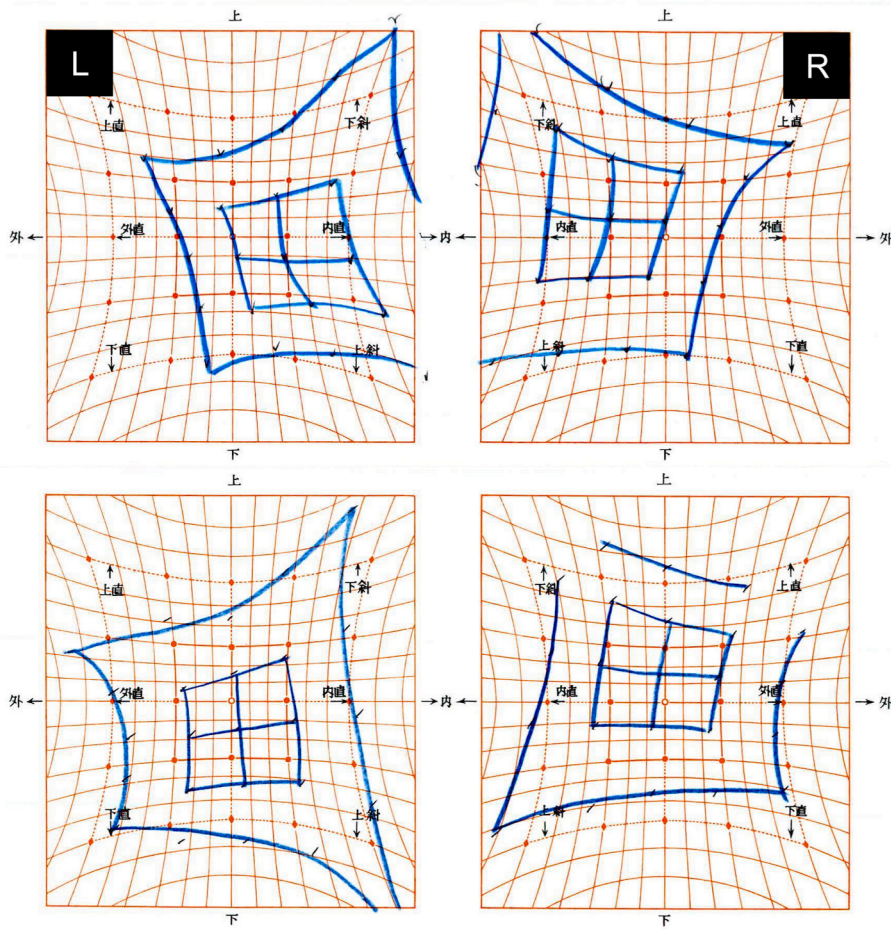


Fig. 3. Case 5: Hess chart
The esotropia and limitation of abduction were reduced (upper row: preoperative Hess chart; lower row: postoperative Hess chart).

also had good visual acuity, minimal limitation of abduction, and posterior globe herniation from the extraocular muscle cone.

Notably, the cyclophorometer showed extorsional diplopia of 15° for case 5, which decreased to 5° after the bilateral Yokoyama procedure. The incidence and mechanism of cyclotorsion for cases of esotropia associated with high myopia have not been established in the literature, but the Yokoyama procedure may help in correcting excyclotorsion.

The limitation of this case report is the small number of patients and the short period of follow-up after the surgery for some cases. Patients with highly myopic esotropia who have good visual acuity and a small strabismus angle may have been treated with recess-resect procedure in the past, and comparisons with their long-term results are needed. However, the postoperative outcome of performing the Yokoyama procedure on the lateral rectus muscle that has been resected on in the past is problematic. For patients who are likely to develop heavy eye syndrome in the future, the Yokoyama procedure may be an effective choice as the initial surgery. Since highly myopic esotropia develops in adulthood, the likelihood of regaining stereopsis after strabismus surgery seems high. Preoperative binocular function testing such as synoptophore or prism simulation would be useful for patient selection. Sagging eye syndrome produces small-angle strabismus in the elderly and may be difficult to distinguish from the initial manifestation of highly myopic esotropia. Coronal MRI imaging is most useful in differentiating the two.

However, it is relevant for reporting the recovery of stereopsis in patients with good visual acuities.

4. Conclusions

The Yokoyama procedure may be useful for the recovery of stereopsis in patients with good visual acuity, high myopia with axial lengths of >27 mm, herniation angles greater than 120°, and relatively small magnitudes of esotropia.

Patient consent

This study protocol was reviewed and approved by the institutional review board of the Hamamatsu University School of Medicine (No. 16–24). The patients consented to the publication of the cases in writing.

Funding

No funding or grant support was provided.

Authorship

All authors attest that they meet the current ICMJE Criteria for Authorship.

Author contributions

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Hiroko Suzuki: Writing - Investigation, Review & Editing, Visualization.

Yoshihiro Hotta: Writing - Review & Editing, Supervision.

Miho Sato: Conceptualization, Methodology, Resources, Validation, Writing - Review & Editing, Visualization.

Data statement: All the data in this article is available to access through the corresponding author.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to thank Editage (www.editage.jp) for English language editing.

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