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Surgical Results and Visual Outcomes of Vitreous Surgery for Advanced Stages of Retinopathy of Prematurity

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Purpose: We evaluated the effectiveness of vitreous surgery for advanced stages of retinopathy of prematurity (ROP) with traction retinal detachment.

Methods: Vitreous surgery was performed in 34 children (51 eyes) with total traction retinal detachment associated with stage 5 ROP between January 1989 and December 1991 at the Fukuoka University Hospital. The first phase of the procedure was composed of pars plicata lensectomy, followed by vitrectomy, membrane delamination, and hyaluronic acid injection. For unsuccessful cases, the second phase of the procedure, comprising scleral encircling, vitrectomy, membrane delamination, retinotomy fluid-air exchange, and SF6 or temporary silicone injection with endophotocoagulation, was performed. In cases with surgical success, visual acuity was measured using the Landolt ring test.

Results: Of the 33 eyes with unsuccessful phase 1 surgery, 15 underwent the second phase procedure. Retinal reattachment was achieved in 7 of these 15 eyes (46.7%). Our composite rate of successful retinal reattachment for advanced stages of ROP was 47% (24 of 51 eyes). In 15 of the 24 eyes with surgical success, visual acuity was more than 20/600 in 3 eyes and no light perception in 1 eye.

Conclusion: In vitreous surgery for advanced stages of ROP, retinal breaks and vitreous hemorrhage are important factors leading to surgical failure. In this series, we could achieve visual acuity of more than light perception for several cases. **Jpn J Ophthalmol 2000;44:661–667**

Key Words: Retinopathy of prematurity, visual acuity, vitrectomy.

Introduction

Stages 4 and 5 retinopathy of prematurity (ROP) are severe disorders leading to blindness. In the case of stage 5 ROP, vitreous surgery is effective therapy. There have been several reports that vitreous surgery was performed in severe cases of ROP in the United States, Europe, and Japan.[1–6] Some authors reported that it was not necessary to perform vitrectomy on cases of ROP with retinal detachment because there could be no useful visual outcome after the surgery.[7,8] Recently, Trese and his associate reported that timely surgical intervention and appropriate postoperative care could result in useful vision in stages 4 and 5 ROP.[9]

Since 1978, we have performed vitreous surgery for traction retinal detachment associated with stage 5 ROP.[3,10] At first, we performed vitreous surgery consisting of pars plicata lensectomy, followed by vitrectomy, membrane delamination, and hyaluronic acid injection. In quite a few cases, the retina has been reattached after this procedure. We have already reported the surgical results and visual acuity after the vitreous surgery we performed for advanced stages of ROP from 1978 to 1988.[11] In that report, several cases attained useful visual acuity.

However, in cases with retinal breaks, dialysis of the ora serrata, and/or significant amounts of vitreous hemorrhage, we could not reattach the retina with this surgery alone. Moreover, we have had many cases with retinal breaks found only during surgery. When previous surgery is unsuccessful, we

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have been trying, since 1989, to perform phase 2 of the procedure; that is, vitreous surgery with scleral encircling. To reattach the retina during surgery, we performed fluid-air exchange and SF6 or temporary silicone injection with endophotocoagulation. In this report, we examine the results of our new surgical procedure and recent visual outcomes.

Surgical Indication and Procedures

Our indication for vitreous surgery was stage 5 ROP with light perception and clear cornea. The candidates for our surgery were patients with no history of medical problems that would preclude general anesthesia.

First phase of the procedure. A 20-gauge vitrectomy instrument (Ocutome 10,000®; Alcon, Fort Worth, TX, USA) was used for all surgery. After circumferential opening of the bulbar conjunctiva at the corneal limbus, bridle sutures were placed under the four rectus muscles.

The scleral wound on the nasal side was made 1 mm behind the corneal limbus using a sclerotome, which was inserted toward the center of the clear lens. The second sclerotomy was performed on the temporal side. On the nasal side, a 22-gauge needle combined with a bottle of balanced salt solution at a height of 50 cm was inserted into the lens. On the temporal side, a vitreous cutter was inserted into the lens. A lensectomy was done bimanually.

After lensectomy, an infusion plug of 6 mm in length was inserted carefully into the space where the lens was removed, on the infero-temporal side 1 mm behind the corneal limbus. A three-port system for vitrectomy was then established. This infusion plug was not sutured onto the sclera.

The retrolental membrane was slit by a lancet-tipped blade. After that, the retrolental and epiretinal membranes, mixed with vitreous fibers, were delaminated from the retinal surface using a bimanual technique, with one hand holding a membrane peeler cutter and the other holding vitreous forceps. To obtain a good view of the vitreous base, a part of the anterior sclera was depressed by an assistant using a scleral depressor. An endo-illuminator and a small contact lens were sometimes used for careful observation of the posterior region.

After almost all the proliferative membranes in the anterior region were removed, a vitreous cutter was used to remove residual vitreous as close to the retina as possible, from the anterior region to the posterior region, until the optic disc was observed. Removal of vitreous in the peripheral retinal trough was essential in order to release the tight folding of the anterior retinal surface.

When as much as possible of the proliferative membranes and vitreous were removed, the retina became freely movable. Then the scleral wounds for vitrectomy were closed. Using a 27-gauge needle, hyaluronic acid was injected into the vitreous cavity through the sclera, 1 mm behind the corneal limbus. The conjunctiva was then closed.

We performed phase 2 surgery for cases with unsuccessful retinal reattachment after phase 1.

Second phase of the procedure. After circumferential opening of the conjunctiva at the corneal limbus at 360°, bridle sutures were placed under the four rectus muscles. Four presutures of nonabsorbable thread were placed on the sclera 8 mm behind the corneal limbus between each rectus muscle as an encircling procedure with a silicone band 2 mm wide.

After the encircling procedure was completed, we made a three-port system for vitreous surgery using the same method as in the phase 1. Next, an infusion plug 6 mm in length was inserted very carefully so as not to break the detached retina. After the placement of a three-port system, we removed as much as possible of the residual vitreous on the retina and the newly formed epiretinal membranes using the same membrane delamination technique and vitreous cutter as in phase 1. We then performed a retinotomy along the ora serrata using a flute needle with a soft tip to move the entire retina to the posterior region. When a tight, retinochoroidal scar made by cryopexy was on the peripheral retina, we sometimes cut the retina on the posterior side of the scar using a membrane peeler cutter. A fluid-air exchange through an intentional retinal tear on the peripheral region was done then to reattach the retina. If we could not reattach the retina under air alone, an air-fluid exchange was done for further retinotomy. After the retina was reattached by a fluid-air exchange, endophotocoagulation was performed on the retina around the intentional retinal tear and along the area of the retinotomy.

After closing the scleral wounds, we injected SF6 gas into the vitreous cavity through the sclera using a 27-gauge needle. Silicone oil can be used temporarily instead of SF6. When either SF6 injection or silicone oil is used, it is necessary to advise placing the patient's head in the facedown position on the shoulder of a parent for 3 or 4 hours a day. When silicone oil is used, the oil is removed between 2 and 4 weeks after surgery (Figure 1).

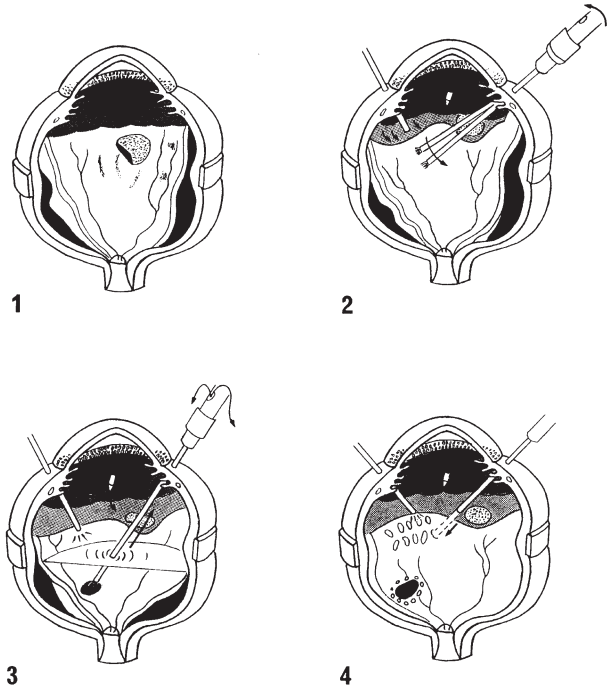

Figure 1. Schematic drawing of second phase of procedure. (**1**) Scleral encircling is done on sclera 8 mm behind corneal limbus. Retina is totally detached. (**2**) Retinotomy is performed around ora serrata using flute needle with soft tip. (**3**) Fluid-air exchange. (**4**) Endophotocoagulation is performed on retina around intentional retinal tear and along area of retinotomy during fluid-air exchange.

Materials and Methods

Retrospectively, we examined the ophthalmological and the surgical results of 34 patients (51 eyes) who had undergone vitreous surgery for stage 5 ROP for the first time at the Fukuoka University Hospital between January 1989 and December 1991.

All cases had been referred from other hospitals because they had reached stage 5 ROP, and all, except 2 eyes, had already received photocoagulation and/or cryopexy therapy after they had reached stage 3 ROP with plus disease. The initial therapy for the patients before surgery is summarized in Table 1.

We did not perform vitreous surgery in 11 patients (11 eyes) with stage 5 ROP because the parents did not consent to the surgery for their children. However, these 11 patients underwent vitreous surgery for the fellow eye. Two patients (2 eyes) with bulbar phthisis and falciform retinal detachment confirmed by preoperative examination did not undergo vitreous surgery. These 13 eyes were excluded from this study.

Table 1. Patient's Initial Therapy

Initial Therapy	No. of Eyes
Photocoagulation	15
Cryopexy	22
Photocoagulation and cryopexy	12
Not done	2

Preoperatively, patients were examined by slit-lamp biomicroscopy, indirect ophthalmoscopy, and B-scan ultrasonography. All eyes scheduled to undergo vitreous surgery had total retinal detachment with shallow or flat anterior chamber. Before surgery, they were judged as stage 5 without active neovascularization because they had been treated by photocoagulation and/or cryopexy.

Successful attachment was defined as at least total attachment of the posterior retina between the temporal vascular arcades at 6 months after the last surgery. For cases with unsuccessful retinal attachment in phase 1, phase 2 surgery was performed between 21 and 206 days (mean = 66.9 days) after phase 1. All cases had been followed up for more than 6 months (range, 25–109 months; mean = 64.4 months) at our hospital.

Statistical analysis was done using Student *t*-test for differences in surgical success and failure by birthweight, gestational age at birth, and age at phase 1 surgery. Chi-square test was used for differences in surgical success by each retinal funnel configuration. Student *t*-test was used to compare visual acuity of cases with retinal reattachment at phase 1 and phase 2 surgery.

Results

There were 19 boys and 15 girls with an average birthweight of 847 g (range, 536–1920 g), and an average gestation period of 25.6 weeks (range, 22–27 weeks). There were 24 right eyes and 27 left eyes. The average age at surgery was 11 months (range, 3–48 months). In 14 patients (20 eyes), the first phase of vitreous surgery was performed within 6 months after birth.

In ocular findings during surgery, there were retinal breaks, including a dialysis of the ora serrata, in 18 eyes. In 4 of the 18 eyes with retinal breaks, there were large posterior retinal breaks along the edge of the large retinochoroidal adhesion made by cryopexy. In the 4 eyes with dialysis of the ora serrata, 2 eyes had other retinal breaks. The remaining 10 eyes had retinal breaks in the equatorial or the peripheral regions. The number of retinal breaks and dialysis of ora serrata in each retinal funnel configuration according to the international classification of ROP are shown in Table 2.

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Table 2. Retinal Breaks and Dialysis of Ora Serrata in Retinal Funnel Configurations Found in Phase 1 Surgery

Ocular Findings	Eyes	Retinal Breaks	Dialysis of Ora Serrata
Open/open	16	4	0
Open/narrow	14	4	2
Narrow/open	9	1	0
Narrow/narrow	12	5	2
Total	51	14	4

Vitreous bleeding from epiretinal fibrovascular membrane occurred during surgery in 11 eyes. Six of the 11 eyes with vitreous hemorrhage underwent surgery within 6 months of birth. Three of the 11 eyes with vitreous hemorrhage had surgery more than 2 years after birth. Falciform retinal detachment was found in one eye during surgery (Table 3).

Of the 51 eyes operated on, 18 retinas were successfully attached in one operation (Figure 2). The success rate of phase 1 surgery was 35.3%.

Of the 33 eyes without retinal reattachment, 15 underwent phase 2 surgery. In some cases, we found anterior proliferative vitreoretinopathy during phase 2 surgery. In these cases, the detached retina adhered tightly behind the iris. This reoperation was not performed on the remaining 18 eyes for a variety of reasons; some had large posterior retinal breaks associated with large retinochoroidal adhesion. Others had a significant amount of vitreous hemorrhage. For other patients, we did not have parental consent. Four eyes of 9 with retinal breaks and/or dialysis of the ora serrata, and 2 eyes of 3 with vitreous hemorrhage had the retina reattached after phase 2 surgery (Figure 3). However, we could not reattach the retina in cases with simultaneous retinal breaks and vitreous hemorrhage. In all, 7 retinas (46.7%) were attached after phase 2 surgery (Table 4). Two of these 7 eyes with reattached retinas were operated on three times to remove the silicone oil. Our composite rate of successful retinal reattachment with either the first, or a combination of the first and second phases of our procedure, was 49% (25 of 51 eyes).

Table 3. Ocular Findings and Surgical Outcome of Phase 1 Surgery

Ocular Findings During Surgery	Successful	Unsuccessful
No tear and no bleeding	16	7
Retinal tear only	1	11
Posterior retinal tear	0	4
Vitreous bleeding only	1	8
Tear and bleeding	0	2
Falciform retinal detachment	0	1
Total	18	33

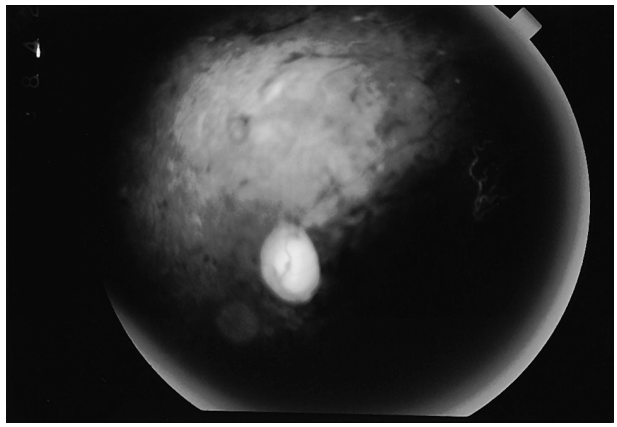

Figure 2. Fundus photograph after phase 1. Optic disc is almost normal. Retina has scattered pigment granules.

More than 6 months following the last operation, 2 eyes regressed to total retinal detachment, while 1 eye with shallow retinal detachment after the operation had a reattached retina. At this time, 24 in 51 eyes (47%) had the retina reattached.

Differences in surgical success and failure by birthweight, gestational age at birth, and age at phase 1 are shown in Table 5. There are no statistically significant differences between successful cases and unsuccessful ones. Gestational age, birthweight, and age at surgery were not predictive of the surgical outcome. We evaluated the connection between the surgical success rate and the configuration of the detached retina (Table 6). However, there were no statistically significant differences in surgical success between any two configurations of the detached retina.

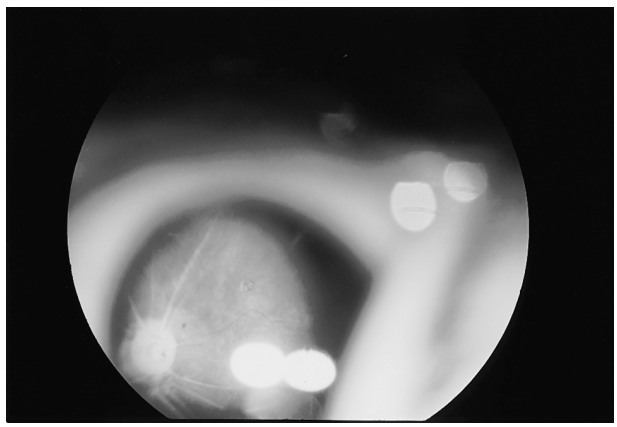

Figure 3. Fundus photograph after phase 2. Retinal vessels have whitened, although retina is attached.

Table 4. Surgical Outcome of Phase 2 Surgery by Ocular Findings in Phase 1

Ocular Findings at Phase 1	Successful	Unsuccessful
No tear and no bleeding	1	0
Retinal tear only	4	5
Vitreous bleeding only	2	1
Tear and bleeding	0	2

In the 24 eyes with surgical success, 1 eye was lost during follow-up. In 5 patients (8 eyes), visual acuity could not be measured because of their severe cerebral palsy. In the remaining 15 eyes, visual acuity corrected with glasses of about +25 D was measured using the Landolt ring test. In eyes with surgical success after phase 1 surgery, visual acuity was 20/600 to 20/4000 in 3 eyes, hand movement in 1 eye, and light perception in 6 eyes. In eyes with surgical success after phase 2 surgery, visual acuity was 20/250 in 1 eye, hand movement in 1 eye, light perception in 2 eyes, and no light perception in 1 eye. This difference between surgery performed in phase 1 and in phase 2 did not reach statistical significance.

During follow-up, in 26 eyes with unsuccessful retinal reattachment, 22 eyes developed bulbar phthisis.

Discussion

Historically, vitreous surgery has been an effective therapy for traction retinal detachment associated with ROP (stage 5).[1–6] Several investigators outside Japan suggested that it was possible to reattach the retina in about 40% of vitreous surgery cases using sophisticated vitreoretinal techniques.[1,6] However, they did not describe the initial treatment, such as photocoagulation and/or cryopexy, conducted prior to vitreous surgery.

In Japan, photocoagulation and/or cryopexy therapy has been performed for cases that had reached stage 3 and plus disease.[12,13] Nagata and colleagues reported that the rate of grades 3, 4, and 5 by cicatricial Reese classification, retrolental fibroplasia (RLF), was 1%, and the rate of bilateral blindness was 0.7% in the treated eyes using photocoagulation and/or cryopexy.[13] In the United States, it was reported that an unfavorable outcome after progression to stages 4 and 5 ROP was significantly less frequent in eyes undergoing cryopexy (21.8%) compared to the untreated eyes (43%).[14] These treatments were very effective in stopping retinal neovascularization.[15] At almost all the hospitals in Japan, treatment using photocoagulation and/or cryopexy has been performed for stage 3. Because of that, there might have been only a small number of cases progressing to RLF in Japan. However, it is known that there were more severe cases progressing to stages 4 and 5 ROP despite treatment by photocoagulation and/or cryopexy.[12,14]

All our cases except one had progressed to stage 4 and had total retinal detachment (stage 5), although they had undergone photocoagulation and/or cryopexy. It is possible that our cases were more severe than those in other reports.

We had several cases with vitreous hemorrhage during or after surgery. Blood clots adhered tightly to the retinal surface, and also to each other. We speculated that a significant amount of vitreous hemorrhage led the retina to a closed funnel configuration, preventing the attachment of the retina.

Sokol reported that there is rapid maturation of retino-cortical sensory elements of the human visual system during the first 6 months of life.[16] Fuchino and colleagues suggested that better visual acuity was achieved by having only a short interval between birth and surgery.[11] We have been trying, therefore, to perform vitreous surgery earlier, if possible within the first 4 months after birth, for development of macular function. When treatment for avascular areas and a ridge of the retina using photocoagulation and/or cryopexy was repeated consistently, fibrovascular proliferative membranes would change to cicatricial membranes.[12,15] In this case, vitreous surgery could be done without hemorrhage, even within 6 months of birth.[11] Actually, 14 of 20 eyes had undergone vitreous surgery within 6 months of birth and there was no vitreous hemorrhage either during or after surgery.

It has been suggested that retinal breaks or vitreous hemorrhage lead to the lack of success in vitreous surgery.[1,2,5] Phase 1 of our surgery did not result

Table 5. Difference in Surgical Success and Failure by Birth weight, Gestational Age at Birth, and Age at Phase 1

	Successful (n = 18)	Unsuccessful (n = 33)
Gestational age at birth (wk)	22–27 (median 25)	22–32 (median 26)
Weight at birth (g)	536–1120 (median 733)	590–1920 (median 848)
Age at surgery (mo)	3–34 (median 11.5)	3–48 (median 7)

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Table 6. Difference in Surgical Success and Failure by Retinal Funnel Configuration for Phase 1

Ocular Findings	Successful	Unsuccessful	Total
Open/open	5	11	16
Open/narrow	4	10	14
Narrow/open	6	3	9
Narrow/narrow	3	9	12
Total	18	33	51

in reattached retinas in eyes with retinal breaks or vitreous hemorrhage. Twenty-seven of 51 eyes (52.9%) had retinal breaks and/or vitreous hemorrhage. This may be the reason that our success rate (38.5%) for phase 1 was lower than the success rate in other reports. However, our rate of successful retinal reattachment for the cases without retinal breaks and/or vitreous hemorrhage was 69.5% (16 in 23 eyes). In cases without retinal breaks or vitreous hemorrhage, we were more effective in reattaching the retina in phase 1.

Gestational age, birthweight, age at surgery, and type of funnel configuration of the detached retina were not predictive of our surgical results.

In several cases, however, without retinal breaks or vitreous hemorrhage, the retina could not be reattached. We speculate that incomplete relaxation of the retina, because of tight adhesion between the retina and the vitreous led to surgical failure.

An increasing number of cases with retinal breaks or vitreous hemorrhage required another surgical procedure after phase 1. However, there have been no reports in the literature describing methods of reoperation for cases with unsuccessful retinal reattachment in initial surgery. We performed vitreous surgery with scleral encircling only in unsuccessful cases of phase 1. In cases of ROP having retinal stiffness associated with tight adhesion between the retina and the vitreous, we could not obtain complete relaxation of the retina even though we removed as much vitreous and proliferative tissues as possible. If complete relaxation of the detached retina was not achieved, we could not reattach the retina using a fluid-air exchange technique during the operation. Therefore, we performed retinotomy along the ora serrata in order to move the retina entirely to the posterior region. We then performed a fluid-air exchange in phase 2 to have the retina reattached during the operation. Phase 2 was useful for the treatment of eyes with retinal breaks, including a dialysis of the ora serrata, except for large posterior retinal breaks. We have no idea, however, about the effect of a scleral encircling band on a growing child's eye. This is a subject on which we can report only after evaluation of the patient's long-term, follow-up care.

We had some cases that did not undergo phase 2 surgery because of large posterior retinal breaks or a closed-funnel retinal detachment after significant amounts of vitreous hemorrhage. This scar formation between the sensory retina and the retinal pigment epithelium prevented retinal movement to the posterior region. A large posterior retinal break was usually observed along the edge of tight retinochoroidal adhesion. In these cases, therefore, we could not move the retina entirely to the posterior region. On the other hand, in cases with a closed-funnel retinal detachment due to a large amount of vitreous hemorrhage, the retinal surfaces adhered tightly to each other. We could not separate them. These were our reasons for not performing phase 2 surgery. To avoid formation of large posterior retinal breaks before surgery and to avoid vitreous hemorrhage during surgery, the selection of a method to treat threshold ROP and the decision on the location of treatment for dealing with scar formation in retinal neovascularization are very important.[12,13,15]

In this report, we had only a few cases who attained useful visual acuity compared with our previous report.[11] We had only 2 cases in which we performed vitrectomy within 4 months after birth. That may be the reason why few cases reached useful visual acuity. Quinn and his colleagues reported on visual acuity of eyes at 5 1/2 years after vitreous surgery.[17] They had few cases with useful visual acuity, however, they have not concluded that vitreous surgery for eyes with severe ROP and total retinal detachment fails to provide any functional benefit. Moreover, it was reported that even though visual acuity after vitrectomy was low, vision was useful to these patients.[18] Surgical failure of phase 1 leads to bulbar phthisis and no light perception. To prevent bulbar phthisis, it is worth performing phase 2 surgery.

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