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Two-Year Follow-up Study Comparing Primary Vitrectomy with Scleral Buckling for Macula-off Rhegmatogenous Retinal Detachment

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Purpose: To compare the anatomic and visual outcomes achieved by scleral buckling and primary vitrectomy for the repair of macula-off rhegmatogenous retinal detachment.

Methods: The records were reviewed for a consecutive series of 167 patients (167 eyes) who were initially treated with scleral buckling or pars plana vitrectomy for primary macula-off retinal detachment. Patients were treated between January 1993 and December 1996. After adjustments for preoperative characteristics, data from 102 cases (55 scleral buckle cases and 47 primary vitrectomy cases) were used for the final comparison. There had been a minimum follow-up period of 24 months.

Results: No significant differences in single-procedure reattachment incidence (91%), final success incidence (100%) and incidence of postoperative proliferative vitreoretinopathy development (4%) were observed between the two treatment groups. Preoperative visual acuity, preoperative intraocular pressure, and duration of macular detachment were the three best predictors of postoperative visual recovery in both groups. Favorable overall visual recovery was obtained postoperatively, with no significant differences between the two groups throughout the follow-up period. However, in the eyes with poor preoperative visual acuity (<0.1), ocular hypotony (intraocular pressure <7 mm Hg), or prolonged macular detachment (more than 7 days), visual recovery in the primary vitrectomy group was significantly better ($P < .05$) than in the scleral buckle group from the first postoperative month.

Conclusion: Both procedures achieved favorable anatomic and visual outcomes in the majority of patients with primary macula-off retinal detachment. Primary vitrectomy may be more effective than scleral buckling for achieving early visual rehabilitation in cases complicated by poor preoperative vision, ocular hypotony, and prolonged macular detachment. **Jpn J Ophthalmol 2000;44:538–549** © 2000 Japanese Ophthalmological Society

Key Words: Macular detachment, pars plana vitrectomy, rhegmatogenous retinal detachment, scleral buckling, visual prognosis

Introduction

Several surgical techniques have been used successfully for two decades to repair rhegmatogenous retinal detachment.[1–3] The modern scleral buckling procedure is considered the treatment of choice for most cases, unless proliferative vitreoretinopathy is present.[1] However, as facilities for vitreous surgery have become more widely available and surgeons have become more experienced with this technique, the threshold for vitrectomy has fallen and the indication for primary vitrectomy for retinal detachment widely overlaps that for scleral buckling. Recently, the final anatomic success rate has been reported to be over 90% for both procedures.[1,4–8] Therefore, not only reattaching the retina but also obtaining an early visual recovery are important factors when determining which surgical technique to perform to treat primary retinal detachment.

Received: August 12, 1999

The authors have no proprietary interest in any of the materials or equipment discussed in this article.

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Jpn J Ophthalmol 44, 538–549 (2000)

Published by Elsevier Science Inc.
0021-5155/00/$–see front matter
PII S0021-5155(00)00205-7

Although a number of reports have been published about changes in visual recovery after scleral buckling and pneumatic retinopexy,[9–15] little is known about changes in visual acuity in patients who underwent primary vitrectomy. To date only one published study[4] has directly compared the surgical outcomes of scleral buckling and primary vitrectomy for retinal detachment with posterior retinal breaks. However, because of the short follow-up period, the small series of cases, and no assessment of preoperative factors that may possibly affect visual recovery, detailed differences between scleral buckling and primary vitrectomy are not well understood. Therefore, the best method for repairing "routine" retinal detachment with optimum recovery of visual acuity remains a matter of speculation and bias until more appropriate data are obtained. In addition, considerations must be made of other factors before the comparisons.[16] To provide the best information possible, statistical methods to adjust for the preoperative characteristics are important to facilitate comparison.[17,18] The necessity for these methods has come to be realized and emphasized in recent studies.[15,16]

In a previous study, we reported the preliminary results of visual recovery in patients who underwent pars plana vitrectomy or scleral buckling as the initial surgery for repairing retinal detachment.[19] The goals of the present study were to assess the anatomic and visual outcomes after retinal detachment surgery to treat primary retinal detachment with macular involvement and to compare the surgical impact on the visual recovery after primary vitrectomy with that after scleral buckling. All surgical interventions were conducted at two surgical institutions; the data obtained were combined using modified statistical methods to arrive at comparable groups for analysis.

Materials and Methods

Patients

This retrospective study reviewed the charts of 422 consecutive patients who underwent scleral buckling and 141 patients who underwent pars plana vitrectomy as the initial surgery for primary rhegmatogenous retinal detachment. All surgery was performed between January 1993 and December 1996 at either the Osaka Rosai Hospital or the Yodogawa Christian Hospital, both in Osaka.

To evaluate the impact of these two surgical techniques on visual recovery, only patients who met the following criteria were included in the analyses: the presence of retinal detachment with retinal breaks resulting from posterior vitreous detachment; the presence of retinal detachment involving the macula; and, the absence of macular pathology affecting pre- and postoperative visual function, such as age-related macular degeneration, myopic retinochoroidal atrophy, and diabetic retinopathy. In addition, the availability of at least 6 months of postoperative follow-up information was required. Patients with a retinal detachment resulting from macular breaks, giant retinal tears or ocular trauma, or with complications such as vitreous hemorrhage or severe proliferative vitreoretinopathy ($>$grade C1)[20] were excluded. Finally, a total of 167 cases (95 scleral buckle and 72 primary vitrectomy cases) met the criteria for data analysis.

Surgical Technique

Informed consent was obtained from all patients before surgery. When scleral buckling was performed, chorioretinal adhesions were created with cryopexy around the retinal breaks. An exoplant (segmental silicone sponges in combination with an encircling silicone band) was used to support the peripheral retinal breaks. External drainage of subretinal fluid was performed in most eyes and, if necessary, intravitreal gas (air or 20% sulfur hexafluoride, SF_6) was used to maintain intraocular pressure (IOP).

When pars plana vitrectomy was performed, a standard three-port system was used as previously described.[8] The surgical techniques consisted of a vitrectomy that released the vitreous traction around the breaks, internal drainage of subretinal fluid, a total gas-fluid exchange using air or 20% SF_6, and endo-laser photocoagulation to create chorioretinal adhesions. An encircling band was used only during the early study period (until December 1995). After that time, in addition to the basic vitrectomy technique, combined cataract surgery was also performed in elderly patients instead of using an encircling buckle.[8]

In both treatment groups, patients who were injected with gas were instructed to maintain a face-down position to encourage tamponade of the retinal breaks during the first 2 postoperative weeks.

Adjustment of Preoperative Characteristics and Data Analysis

The preoperative variables recorded included age, sex, refractive error, IOP, best-corrected visual acuity, lens status, extent of retinal detachment, duration of macular detachment (determined by a careful

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preoperative interview with all patients), and retinal breaks (number, type, size, and location).

Intraoperative variables included the type of gas used as an intravitreal tamponade, placement of an encircling element, combined cataract surgery, whether or not drainage of subretinal fluid was performed in the scleral buckling cases, operating time, and complications.

The postoperative variables recorded were initial and final anatomic success rate, changes in refractive errors, best-corrected visual acuity at 1, 3, 6, 12, and 24 months, if available, after the initial surgery, complications, and subsequent surgical interventions for recurrence of retinal detachment.

To compare the surgical outcome between the two surgical procedures fairly, a stepwise logistic regression analysis was first performed on the 167 cases to eliminate patients for whom scleral buckling or primary vitrectomy was the procedure of choice rather than vice versa. The preoperative logistic variables that significantly influenced the choice of the surgical procedure are shown with their responding frequencies and regression coefficients in Table 1. Because the use of a propensity score is an observational-study analogue of randomization in a case-controlled study,[17] based on this analysis, a propensity score was further estimated with a modification of a method described by Rubin.[18] The propensity scores ranged from 0.0 to 1.0 and represented the probability (0–100%) that a patient would undergo scleral buckling rather than primary vitrectomy. Patients with the more extreme propensity scores (propensity score >0.6 or <0.4) were eliminated from further analysis. That is, only data from patients with an approximately equal chance (range, 41–59%) of undergoing either of the surgical procedures were saved for subsequent analysis.

The anatomic success rate and the time course of the retinal redetachment for both treatment groups were analyzed and compared using Kaplan-Meier survival curves.

Table 1. Logistic Regression Analysis to Determine Use of Scleral Buckling in the 167 Patients Satisfying Initial Inclusion Criteria

Preoperative Characteristics	Frequency (Mean)	Coefficient	*P* Value
Retinal break			
At or anterior to equator (%)	56	1.84	<.001
Number of breaks	1.7	1.67	.03
Size of breaks (DD)	1.4	0.65	.04

DD: disk diameter.

To adjust for patient risk factors that may affect visual outcome, a multiple linear regression analysis was carried out to identify the independent predictors associated with a 24-month postoperative visual acuity. The eyes in each treatment group were then further subdivided into two subgroups based on the preoperative factors to determine whether the results for one procedure were better than the other for obtaining early visual recovery.

Statistical analysis of visual functional outcome and retinal reattachment status was performed with data obtained only from patients with clinical visits up to the 24-month follow-up examination.

Visual acuity was measured with a Landolt C visual acuity chart. For statistical comparison, visual acuity was expressed as a logarithm of the minimum angle of resolution (logMAR) equivalents. For purposes of analysis, visual acuities of counting fingers, hand motions, and light perception were assigned decimal values of .004, .002, and .0002, respectively.

The data were analyzed with descriptive statistics: the chi-square test and Fisher's exact test for categoric variables, and the Mann-Whitney *U*-test for continuous variables. A *P* value <. 05 was considered to be significant.

Table 2. Salient Features of 102 Study Eyes Versus Excluded 65 Eyes After Adjustment for Preoperative Characteristics

	Study Eyes (n = 102)	Excluded Eyes (n = 65)	
	No. (%)	No. (%)	*P* Value
Eyes undergoing primary vitrectomy	47 (46)	15 (23)	.34
Preoperative VA < 0.1	53 (52)	31 (48)	.64
Postoperative VA ≥ 0.4*	48 (47)	29 (45)	.87
Single operation success*	93 (91)	61 (92)	.77
Final anatomic success*	102 (100)	64 (98)	.34

VA: visual acuity.
*Measurement at 6-month postoperative visit.

Results

Patient Characteristics and Follow-up

A total of 102 eyes of 102 patients were selected for the final visual and anatomic data analysis; 55 eyes of 55 patients that underwent scleral buckling, and 47 eyes of 47 patients that underwent primary vitrectomy. Fifty-seven cases (35 scleral buckle cases with a small, single retinal break located in the periphery, and 22 primary vitrectomy cases with large and unusually shaped posterior breaks) were not included in the analysis because these cases had greater than a 60% probability of undergoing one procedure rather than the other. The other eight cases (five scleral buckle cases and three primary vitrectomy cases) were also excluded for final data analysis because of the absence of a 24-month follow-up examination.

Table 3. Characteristics of Patients in Study

Variable	Scleral Buckling	Primary Vitrectomy	*P* Value
Patients/eyes	55/55	47/47	
Age (y)			
Mean ± SD	54.3 ± 11.4	58.7 ± 12.9	.44*
Range	40–87	39–88	
Sex [no. (%)]			
Male	29 (53)	28 (60)	.55†
Female	26 (47)	19 (40)	
Visual acuity			
Median	0.1	0.05	.04*
Range	HM-0.4	LP-0.2	
< 0.1	24 (44)	29 (62)	.08†
0.1–0.5 [no. (%)]	31 (56)	18 (38)	
Intraocular pressure (mm Hg)			
Mean ± SD	11.4 ± 5.1	9.7 ± 4.9	.29*
Range	3–21	1–23	
< 7 mm Hg [no. (%)]	13 (24)	18 (38)	.13†
Refraction (D)			
Mean ± SD	−4.6 ± 4.3	−5.1 ± 5.4	.81*
< −6 D [no. (%)]	24 (44)	19 (40	.84†
Status of lens [n (%)]			
Phakic	49 (89)	37 (79)	.18†
IOL	6 (11)	10 (21)	
Detachment quadrants [no. (%)]			
≤ 2	34 (62)	21 (40)	.11†
> 2	21 (38)	26 (60)	
Retinal breaks			
Median	1	2	
Range	1–4	1–8	
Location [no. (%)]			
Anterior	36 (65)	22 (47)	.07†
Posterior	19 (35)	25 (53)	
Status of macular detachment [no. (%)]			
Bullous	39 (46)	37 (79)	.49†
Shallow	16 (33)	10 (21)	
Duration of macular detachment [no. (%)]			
< 7 days	36 (66)	18 (38)	.84†
≥ 7 days	19 (34)	29 (62)	
Duration of follow-up (mo)			
Mean ± SD	36.1 ± 13.6	34.6 ± 11.4	.87*
Range	24–57	24–52	

HM: hand motion; LP: light perception; D: diopters; IOL: intraocular lens; SD: standard deviation; CD: choroidal detachment (complicated 37 cases); Anterior: located on or anterior to equator; Posterior: located posterior to equator.

*Based on Mann-Whitney *U*-test.

†Based on Fisher's exact test.

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Although 65 cases were excluded from the final data analysis after adjusting for the preoperative characteristics, the salient features of the 102 study patients are compared with the 65 excluded patients in Table 2. These data show that the features of these two groups of patients, including single operation success rate, are comparable ($P > .05$).

The characteristics of the 102 study patients are summarized in Table 3. The postoperative follow-up period ranged from 24 to 57 months (35.3 ± 12.3 months, mean ± standard deviation). There were no statistically significant differences in the baseline characteristics between the scleral buckle group and the primary vitrectomy group with the exception of the preoperative visual acuity ($P = .04$) after logistically adjusting for the preoperative characteristics.

Surgical Details and Final Anatomic Outcomes

The intraoperative details are summarized in Table 4. Of the 55 eyes in the scleral buckle group, 52 eyes (95%) were managed by drainage of subretinal fluid. An encircling band was combined with a segmental scleral buckle in 35 eyes (64%). Intravitreal gas injection was performed in 13 eyes (24%); 10 eyes (18%) were managed with air without long-acting gas and 3 eyes (5%) with SF_6 gas. Of the 47 eyes in the primary vitrectomy group, 40 eyes (85%) received an intravitreal injection of SF_6 gas and 7 eyes (15%) were managed with only air tamponade.

Vitrectomy combined with cataract surgery was performed in 15 eyes (32%) and an encircling band was used in 12 eyes (26%). Although the average duration of the primary vitrectomy procedure was longer than that of the scleral buckle procedure, the difference in duration between the treatment groups did not reach statistical significance ($P = .13$).

Regarding the anatomic outcomes, 50 eyes (91%) in the scleral buckle group and 43 (91%) in the primary vitrectomy group achieved retinal attachment after one operation. At the final follow-up examination, all eyes (102 eyes) in both groups achieved retinal attachment after one or more operations. Kaplan-Meier analysis (Figure 1) showed no significant difference between the scleral buckling and primary vitrectomy groups ($P = .72$) with respect to the development of postoperative retinal detachment, which in both groups occurred in the first 3 postoperative months.

Table 4. Intraoperative Data

Scleral buckling (n = 55)	
Surgical technique [No. (%)]	
Cryoretinopexy	55 (100)
Drainage of subretinal fluid	52 (95)
Encircling element	35 (64)
Intravitreal gas tamponade	13 (24)
Air	10 (18)
SF_6	3 (5)
Supplemental laser photocoagulation	3 (5)
Operating time (min)	
Mean ± SD	56 ± 23*
Range	35–120
Primary vitrectomy (n = 47)	
Surgical technique [No. (%)]	
Endolaser photocoagulation	47 (100)
Drainage of subretinal fluid	47 (100)
Intravitreal gas tamponade	47 (100)
SF_6	40 (85)
Air	7 (15)
Combined cataract surgery	15 (32)
Simultaneous IOL implantation	11 (23)
Subsequent IOL implantation	4 (9)
Encircling element	12 (26)
Supplemental laser photocoagulation	2 (4)
Operating time (min)	
Mean ± SD	78 ± 24*
Range	45–150

SF_6: sulfur hexafluoride; IOL: intraocular lens; SD: standard deviation.

*No statistical significant ($P = 0.13$, Mann-Whitney U-test).

Predictors of Visual Improvement

Table 5 shows the results of multiple linear regression analysis to evaluate the influence of preopera-

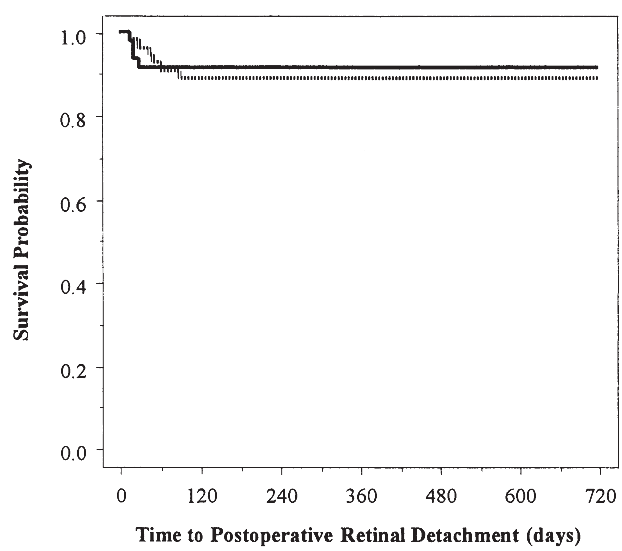

Figure 1. Kaplan-Meier survival analysis comparing scleral buckle and primary vitrectomy with respect to time of onset and incidence of recurrence of retinal detachment. No significant differences were observed ($P = .72$) between two treatment groups in development of postoperative retinal detachment, all of which occurred in the first 3 postoperative months.

Table 5. Results of Multiple Linear Regression Analysis of Preoperative Variables on Visual Acuity 24 Months Postoperatively

Variable	Regression Coefficient	*P* Value
Age	0.033	.062
Preoperative LogMAR	−0.934	<.001
Preoperative IOP	−0.199	.021
Refraction	0.023	.783
Detachment quadrants	−0.052	.057
Duration or macular detachment	0.166	.019
Duration of follow-up	0.014	.835

LogMAR: logarithm of the minimum angle of resolution; IOP: intraocular pressure.

tive variables on the final visual outcome. Of the independent variables, the preoperative visual acuity (logMAR) ($P < .001$), the duration of macular detachment ($P = .019$), and the preoperative IOP ($P = .021$) significantly correlated with the 24-month postoperative visual acuity. Age and the extent of the retinal detachment showed a borderline but not significant correlation ($P < .10$). Furthermore, stepwise multiple regression analysis was performed to determine whether all variables were independent significant predictors of visual improvement in each treatment group. The three best predictors that were significant by multivariate analysis were identical in both groups, viz, the preoperative visual acuity, the duration of macular detachment, and the preoperative IOP.

The regression coefficients and multiple correlation coefficients are listed in Table 6. By combining these variables in a three-variable model, the visual improvement at the 24-month follow-up examination could be explained in 78% and 81% of cases in the scleral buckle group and the primary vitrectomy group, respectively. No other variables shown in Table 5 met the *F* test for entry into the model, and the subset regression confirmed that only minimal improvement in r^2 could be obtained by including age and the extent of the retinal detachment (data not shown).

In comparison, there was no significant factor predictive of postoperative retinal detachment at the final follow-up examination. Only the presence of a pseudophakic retinal detachment at presentation showed a borderline, but nonsignificant ($P = .09$) increased risk of postoperative retinal redetachment.

Comparison of Visual Outcomes

Table 7 shows the time course of the mean changes in best-corrected visual acuity in both treatment groups. For both treatment groups, the mean visual acuity improved immediately at 1 month postoperatively and continued to improve up to 24 months postoperatively. No statistically significant differences could be found at any follow-up visits in the mean visual acuities between the two treatment groups, with the exception of the preoperative mean visual acuity in the scleral buckle group that was significantly better ($P = .04$) than in the primary vitrectomy group. In contrast, the improvement of logMAR in the primary vitrectomy group was significantly better ($P = .03$) than in the scleral buckle group at the final examination.

To evaluate the impact of the two surgical techniques on visual recovery, the 93 eyes (50 eyes that underwent scleral buckling and 43 eyes that underwent primary vitrectomy) that were successfully repaired with a single surgery, were further analyzed by subdividing them into two subgroups based on the three best predictors. This allowed for adjustments for underlying differences between the groups. Table 8 shows the time courses of the mean changes in best-corrected visual acuity based on subdividing the eyes in the scleral buckle group and the primary vitrectomy group into two subsets based on whether the preoperative visual acuity was better than 0.1 at baseline. Of the eyes with a preoperative visual acuity less

Table 6. Predictors of Visual Improvement* in Study Eyes†

	Scleral Buckling (n = 55)			Primary Vitrectomy (n = 47)		
Variable	Coefficient (SE)	*P* Value	r^2	Coefficient (SE)	*P* Value	r^2
Preoperative VA (LogMAR)	1.38 (0.27)	<.001	0.78	1.27 (0.31)	.002	0.81
Duration of macular detachment (d)	0.81 (0.43)	.008		0.91 (0.39)	.013	
Preoperative IOP (mm Hg)	0.09 (0.18)	.031	0.11 (0.22)	0.11 (0.22)	.028	

r^2: multiple correlation coefficient by stepwise multiple regression analysis; SE: standard error; VA: visual acuity; LogMAR: logarithm of minimum angle of resolution; IOP: intraocular pressure.

*Visual improvement was calculated as variation between pre- and postoperative LogMAR.

†Only eyes with retinal reattachment after single surgery were analyzed.

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Table 7. Visual Recovery of Eyes in Both Treatment Groups

	Scleral Buckling (n = 55)	Primary Vitrectomy (n = 47)	*P* Value
Changes in mean VA			
Preoperative	0.12	0.05	.04
Postoperative			
1 mo	0.21	0.24	.42
3 mo	0.32	0.35	.71
6 mo	0.36	0.40	.76
12 mo	0.41	0.42	> .99
24 mo	0.42	0.45	.85
Improvement in MAR (SD)*	0.54 (0.43)	0.95 (0.61)	.03
P value	< .001	< .001	
Postoperative VA ≥ 0.4 [n (%)]	28 (51)	35 (53)	

VA: visual acuity; MAR: averaged logMAR; SD: standard deviation.
*Comparison of preoperative data with data obtained 24 months postoperatively.

than 0.1 and no statistically significant differences in the mean preoperative visual acuity between the two treatment groups, the mean visual acuity in the primary vitrectomy group improved significantly ($P <$ .05) better than that in the scleral buckle group up to the 12-month follow-up visit. Although the difference did not reach significance ($P = .06$) at the final examination, the mean visual acuity in the vitrectomy group was still better than in the scleral buckle group. In contrast, in eyes with a preoperative visual acuity equal to or better than 0.1, the difference was not significant even though the mean best-corrected visual acuity in the scleral buckle group was better than that in the primary vitrectomy group throughout the study period.

Table 9 shows the time course of the mean changes in best-corrected visual acuity by subdividing eyes in the scleral buckle group and the primary vitrectomy group into two subgroups based on whether preoperative hypotony (IOP < 7 mm Hg) was a complication. In eyes without preoperative hypotony, no significant difference in the mean visual acuity was found between the scleral buckle group and the primary vitrectomy group throughout the follow-up period. In contrast, in the eyes complicated by preoperative hypotony, the mean postoperative visual acuity in the primary vitrectomy group recovered significantly better ($P < .05$) than that in the scleral buckle group up to 6 months postoperatively.

Of the 27 eyes with preoperative hypotony, choroidal detachment was a complication in 4 of 12 eyes (33%) in the scleral buckle group and in 6 of 15 eyes (40%) in the primary vitrectomy group. The influence of choroidal detachment on visual recovery was not different between the two groups (data not shown).

Table 10 shows the time course of the mean change in best-corrected visual acuity by subdividing eyes in the scleral buckle group and the primary vitrectomy group into two subsets based on the duration of macular detachment. In both treatment groups, the mean best-corrected visual acuity in eyes in which the macular detachment was present for 7 days or longer tended

Table 8. Visual Recovery of Study Eyes Based on Preoperative Visual Acuity

	Preoperative VA < 0.1			Preoperative VA ≥ 0.1		
	Scleral Buckling (n = 22)	Primary Vitrectomy (n = 26)	*P*	Scleral Buckling (n = 28)	Primary Vitrectomy (n = 17)	*P*
Changes in mean VA						
Preoperative	0.03	0.01	.38	0.24	0.28	.46
Postoperative						
1 mo	0.06	0.15	.04	0.41	0.38	.78
3 mo	0.13	0.26	.03	0.53	0.43	.19
6 mo	0.18	0.33	.01	0.52	0.43	.29
12 mo	0.22	0.36	.03	0.57	0.44	.11
24 mo	0.21	0.37	.06	0.62	0.51	.14

Comparison of preoperative data with data obtained 24 months postoperatively. VA: visual acuity.

Table 9. Visual Recovery of Study Eyes Based on Preoperative Intraocular Pressure

	Preoperative IOP < 7 mm Hg			Preoperative IOP ≥ 7 mm Hg		
	Scleral Buckling (n = 12)	Primary Vitrectomy (n = 15)	P	Scleral Buckling (n = 38)	Primary Vitrectomy (n = 28)	P
Changes in mean VA						
Preoperative	0.01	0.01	.31	0.20	0.11	.10
Postoperative						
1 mo	0.05	0.15	.03	0.31	0.27	.47
3 mo	0.11	0.22	.02	0.42	0.41	.98
6 mo	0.14	0.25	.04	0.51	0.51	>.99
12 mo	0.18	0.26	.20	0.56	0.53	.87
24 mo.	0.19	0.25	.46	0.59	0.58	.91

Comparison of preoperative data with data obtained 24 months postoperatively. IOP: intraocular pressure; VA: visual acuity.

to be worse than that of eyes with a macular detachment of less than 7 days at every follow-up visit. When the duration of macular detachment did not exceed 7 days, no significant differences in the mean visual acuity were observed between the groups. However, if the macula was detached for 7 days or longer, the mean visual acuity in the primary vitrectomy group was significantly better ($P < .05$) than that in the scleral buckle group at all follow-up visits except at 1 month postoperatively.

An analysis was also performed to compare the 9 eyes with postoperative retinal detachment. The types of secondary procedures and the final visual outcomes are summarized in Table 11. No significant difference in visual outcomes was noted between eyes that had undergone a previous scleral buckle or a previous primary vitrectomy.

Complications and Subsequent Visual Prognosis

Surgically induced complications are shown in Table 12. Although intraoperative complications were noted in both treatment groups, no serious visual disturbances attributable to these complications were found throughout the study period.

Proliferative vitreoretinopathy of grade C or worse developed in 2 eyes (3.6%) in the scleral buckle group and 2 eyes (4.2%) in the primary vitrectomy group ($P > .99$). In contrast, the incidence of postoperative cataract progression was significantly higher ($P < .001$) in the primary vitrectomy group than in the scleral buckle group (14/22 eyes [64%] vs. 6/49 eyes [12%], respectively). Of the 20 eyes with postoperative cataract progression, 3/49 eyes (6%) in the scleral buckle group and 10/22 eyes (45%) in the vitrectomy group required subsequent cataract surgery to treat the secondary visual impairment. The mean interval between the initial retinal detachment surgery and cataract surgery was significantly shorter ($P = .01$) in the vitrectomy group (12.8 ± 5.2 months) than in the scleral buckle group (22.3 ± 4.8 months). Figure 2 shows the time course of the mean change in best-corrected visual acuity of the 15 eyes that underwent combined cataract surgery and the 22 eyes that underwent lens-sparing vitrectomy, both in the primary vitrectomy group. Because of the small sample size, no

Table 10. Visual Recovery of Study Eyes Based on Duration of Macular Detachment

	Duration of Macula-off ≤ 7 Days			Duration of Macula-off > 7 Days		
	Scleral Buckling (n = 33)	Primary Vitrectomy (n = 28)	P	Scleral Buckling (n = 17)	Primary Vitrectomy (n = 15)	P
Changes in mean VA						
Preoperative	0.15	0.09	.46	0.04	0.01	.59
Postoperative						
1 mo	0.23	0.24	.94	0.11	0.19	.06
3 mo	0.41	0.40	>.99	0.13	0.24	.04
6 mo	0.50	0.48	.69	0.14	0.27	.03
12 mo	0.62	0.55	.37	0.14	0.25	.04
24 mo	0.67	0.62	.58	0.15	0.29	.03

Comparison of preoperative data with data obtained 24 months postoperatively. VA: visual acuity.

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Table 11. Subsequent Treatment and Final Visual Acuity in Cases with Retinal Redetachment

	Scleral Buckling (n = 5)	Primary Vitrectomy (n = 4)
Subsequent procedure		
Intravitreal gas injection with laser photocoagulation	1	2
SB revision without vitrectomy	1	0
Vitrectomy ± encircling	3 (2*)	2 (2*)
Mean VA by 24 months postoperatively	0.15†	0.13†

SB: scleral buckling; VA: visual acuity.
*Eyes that developed proliferative vitreoretinopathy.
†$P = .81$, no difference between scleral buckling and primary vitrectomy group.

significant difference in the postoperative mean visual acuity was noted between the lens-sparing and the combined cataract vitrectomy groups up to 6 months postoperatively. However, the visual function continuously improved postoperatively in the former group, but decreased in the latter group from 6 months postoperatively. At 12 months postoperatively, the difference in the mean visual acuity between the two groups reached borderline significance ($P = .06$).

Regarding other postoperative complications, the incidence of macular pucker was higher in the scleral buckle group (7%) than in the primary vitrectomy group (2%) ($P = .37$), and only 1 eye in the scleral buckle group required further intervention for membrane removal. Ocular hypertension was noted in 1 eye, but the IOP was controlled by a topical antiglaucoma drug during the study period.

Discussion

In this retrospective study, we observed a single-procedure success rate of approximately 91% in both treatment groups after adjusting for the patients' preoperative characteristics. Following a second operation, our final reattachment rate of 100% in both treatment groups compares favorably with previous studies.[1,5–7,14,15] Kaplan-Meier analysis confirmed that there was no statistical difference ($P = .72$) in the development of postoperative retinal detachment between these two groups. Especially noteworthy in the present study is that the single-procedure success rate of 91% for primary vitrectomy is at the high extreme compared with previously published studies, in which the success rates ranged from 64–79%.[2,7] The incidence of proliferative vitreoretinopathy (4.2%) was also extremely low compared with previous reports.[5–7] The differences in the anatomic success rates and incidence of proliferative vitreoretinopathy between our study and previous reports may be explained by case selection, patient compliance, and differences in surgical experience. We can conclude from our results that primary vitrectomy for cases meeting our entry criteria is a useful technique and compares favorably with scleral buckling with respect to anatomic outcome.

Table 12. Surgically Induced Complications

	Total (n = 102)	Scleral Buckling (n = 55)	Primary Vitrectomy (n = 47)	
Complication	No. (%)	No. (%)	No. (%)	*P**
Intraoperative				
Iatrogenic retinal tears	7 (7)	2 (4)	5 (11)	.24
Subretinal or vitreous bleeding	4 (4)	3 (5)	1 (2)	.62
Postoperative				
Cataract progression	20 (28)†	6 (12)‡	14 (64)§	< .001
Epimacular membrane formation	5 (5)	4 (7)	1 (2)	.37
Proliferative vitreoretinopathy	4 (4)	2 (3.6)	2 (4.2)	> .99
Ocular hypertension	1 (1)	0 (0)	1 (2)‖	> .99

*Based on Fisher's exact test.
†Seventy-four eyes remained phakic postoperatively; therefore, n = 71.
‡Forty-nine eyes remained phakic postoperatively; therefore, n = 49.
§Twenty-two eyes remained phakic postoperatively; therefore, n = 22.
‖Intraocular pressure was controlled by topical administration of antiglaucoma drugs.

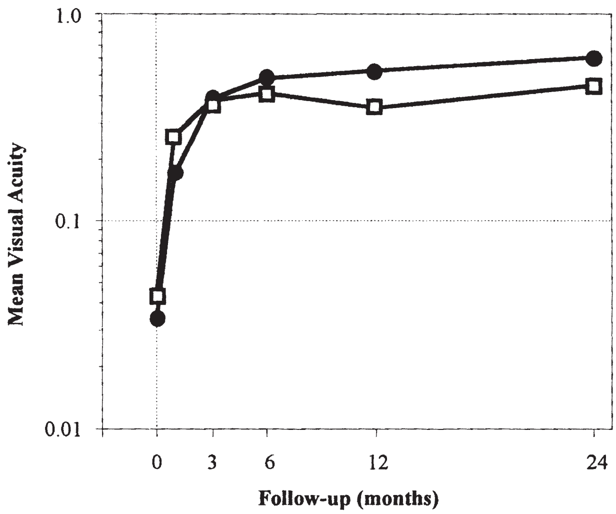

Figure 2. Mean visual acuity changes in eyes treated with combined cataract and vitreous surgery and lens-sparing vitrectomy. Circles indicate eyes that underwent combined cataract and vitreous surgery; squares indicate eyes that underwent lens-sparing vitrectomy.

In our series, visual acuity improved significantly ($P < .001$) in both treatment groups at the 24-month examination. A total of 53 eyes (52%) achieved a best-corrected visual acuity of 0.4 or better; with 51% of the eyes having undergone scleral buckling and 53% of the eyes having undergone primary vitrectomy. These results are comparable to most previous studies, which reported that a recovery in visual acuity of 20/50 or better ranged from 42% to 60%,[4–7,10,11,14,15] and no differences in visual recovery could be found between the two treatment groups. However, because the preoperative factors, ie, preoperative visual acuity, age, and duration of retinal detachment, may bias postoperative visual results, the impact of different surgical procedures on visual recovery cannot be evaluated reliably from only the postoperative visual results.

Based on the multiple regression analysis, we found that the preoperative visual acuity, preoperative IOP, and the duration of macular detachment are the three best predictors of the improvement of the postoperative visual acuity. Using these predictors, approximately 80% of the postoperative visual changes could be explained in both treatment groups. Our results agree with those of other studies concerning retinal detachment after scleral buckling and pneumatic retinopexy,[14,15] suggesting that predictors of visual recovery in macula-off retinal detachments do not differ between surgical techniques.

However, to compare retrospectively the differences in the impact of surgery on changes in visual acuity, the underlying biases between the treatment groups should be adjusted before the comparison. Therefore, we further subdivided the eyes in each group into two subgroups based on the three best predictors. This revealed a noteworthy finding. The visual recovery appeared not to differ between eyes treated with scleral buckling or primary vitrectomy at every postoperative visit in the overall group analysis. However, in the subgroup analysis, we found that primary vitrectomy is more effective than scleral buckling for achieving early visual recovery in eyes with poor preoperative visual acuity (<0.1), ocular hypotony (IOP < 7 mm Hg), or prolonged macular detachment (more than 7 days).

In a series of histopathologic studies of retinal detachment in monkey eyes, Machemer[21] reported that damage to the photoreceptor outer segments was closely related to the height and the duration of the retinal detachment. In another experimental study of the recovery of photoreceptor cells after retinal reattachment in cat eyes, Anderson et al[22] reported that morphologic recovery in the cone outer segments was generally poorer than that in rods, and the degree of abnormality depended on the duration of the retinal detachment. Furthermore, Cook et al[23] reported in an animal study that apoptotic photoreceptor degeneration occurred immediately after retinal detachment and this pathogenic change may progress throughout the duration of retinal detachment. These experimental results support our suggestion that rapid therapeutic intervention to reattach the macula is important for preventing degenerative changes in the photoreceptor cells at the macula and to obtain early visual rehabilitation in human eyes.

In cases treated with scleral buckling surgery, although retinal reattachment can be funduscopically observed after external subretinal fluid drainage, some subretinal fluid may still remain in the submacular space because of its high viscosity. Persistent ocular hypotony may also prevent fluid absorption postoperatively, especially in cases complicated by preoperative ocular hypotony, choroidal detachment, and prolonged macular detachment. The finding of delayed subretinal fluid absorption in scleral buckling cases could be observed by cross-sectional imaging of the macula using optic coherence tomography (not shown). During this delay in fluid absorption, photoreceptor degeneration or apoptosis at the macula may result in poor visual recovery. Furthermore, corneal refractive changes,[24] choroidal circulation disturbances,[25] and inadvertent complications, such as infection related to the scleral buckling procedure,[26,27] may also prevent early visual recovery after surgery. The IOP may be easier to control during vitrectomy than during scleral buckling. Intraocular gas tamponading may also effectively reattach the detached macula immediately after vitrectomy. Therefore, as shown, primary vitrectomy is more effective than scleral buckling for achieving early visual recovery and long-term visual stability in eyes with complications such as poor preoperative visual acuity, ocular hypotony, or prolonged macular detachment.

On the other hand, no statistical differences in visual recovery were found between the treatment groups in those eyes with relatively favorable preoperative vision (>0.1) and eyes without ocular hypotony. In these eyes, the duration of macular detachment was often shorter (4.1 $\pm$ 2.5 days) and the retinal detachment was either shallow or the demarcation line of detachment extended only to the fovea. Based on our results, we believe that there are no differences in visual recovery between the two procedures in these cases because the photoreceptor damage at the macula is not serious and not markedly different between the treatment groups. Therefore, when determining which surgical technique to perform in these cases, attention should be paid to other considerations, such as patient compliance and surgical cost.

Of the eyes that underwent a second surgery, no statistically significant difference in the final visual outcome was observed between the two treatment groups. We conclude that visual recovery in the eyes that undergo a second surgery does not differ between the scleral buckle group and primary vitrectomy group, provided successful retinal reattachment is finally obtained. Our results are consistent with those of previous studies that compared pneumatic retinopexy and scleral buckling.[16]

Cataract progression is recognized as a major drawback of primary vitrectomy.[2,5–8] Our results demonstrated that combined cataract surgery and vitrectomy may be an effective strategy to maintain long-term visual function in selected cases. Despite the fact that the mean postoperative visual acuity continuously improved in both combined cataract surgery and vitrectomy and lens-sparing vitrectomy groups up to 12 months after the initial surgery, the visual acuity in eyes with lens sparing began to decrease thereafter. By the final examination, 45% of these eyes required cataract surgery. Even though nuclear progression was not an indication for subsequent cataract surgery in the remaining eyes, refractive shifting to myopia, which we did not assess in this study, may occur and result in anisophoria.[28,29] Because significant postoperative cataract formation is highly likely to occur in older patients[30] and a second operation is less tolerated than in young patients, a combined cataract surgery and vitrectomy is recommended to maintain useful visual function.

There are number of limitations in the present study, eg, its retrospective nature, the nonrandomized protocol, small numbers in the subdivided groups, and the preferred technique used in the later segment of the investigation. Thus, the statistical power of the study did not allow us to assign statistical significance to small differences in outcome, such as that seen for the development of proliferative vitreoretinopathy. Although we realize that a prospective randomized trial is desirable to provide optimal information, the current medical environment does not favor conducting such a study.[17] Nevertheless, important information was obtained in the present study using a regression model to adjust for the underlying differences between the treatment groups. Based on our results, we believe that, at present, no single surgical technique can be considered as optimal for all "routine" types of retinal detachment. Instead, the results of preferred alternative strategies, such as primary vitrectomy and pneumatic retinopexy, will vary because of the characteristics of individual cases.

In summary, we found that primary vitrectomy is more effective than scleral buckling for obtaining early visual recovery and stability in eyes with macula-off retinal detachment accompanied by preoperative poor visual acuity, ocular hypotony, or prolonged macular detachment. We believe that primary vitrectomy is indicated in these cases. However, because of the limitations of the present study, a prospective, randomized, multicenter clinical trial is recommended in the near future to determine the further appropriate use of pars plana vitrectomy as the primary surgery for macula-off retinal detachment.

The preliminary data of this paper was previously published in part in the *Nippon Ganka Gakkai Zasshi* (*J Jpn Ophthalmol Soc*) 1999;103:215–22. It appears here in a modified form after peer review and editing for the *Japanese Journal of Ophthalmology.*

This paper was presented in part at the 52nd Annual Meeting of the *Rinsho Ganka* (*Jpn J Clin Ophthalmol*), Kobe, October 1998.

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