

## Continuing Medical Education:

# Visual function 5 years or more after macular translocation surgery for myopic choroidal neovascularisation and age-related macular degeneration

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### Learning objectives

Upon completion of this activity, participants will be able to:

1. Distinguish features of macular translocation surgery
2. Analyse adverse events associated with macular translocation surgery
3. Evaluate the efficacy of macular translocation surgery for AMD at 1 and 5 years postoperatively

### Authors/Editors disclosure information

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# Visual function 5 years or more after macular translocation surgery for myopic choroidal neovascularisation and age-related macular degeneration

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## Abstract

**Purpose** To evaluate the changes in the best-corrected visual acuity (BCVA) after 1 year and after  $\geq 5$  years after macular translocation for age-related macular degeneration (AMD) or myopic choroidal neovascularisation (mCNV). **Methods** The medical records of 61 consecutive patients who underwent macular translocation with  $360^\circ$  retinotomy for AMD (35 eyes) or mCNV (26 eyes) were reviewed. Overall, 40 patients, 17 mCNV and 23 AMD, were followed for at least 5 years. BCVA and area of the Goldmann visual field (VF) measured before, 12 months after surgery, and at the final visit.

**Results** In the 23 AMD eyes followed for  $\geq 5$  years, the mean preoperative BCVA was  $1.149 \pm 0.105$  logMAR units, which significantly improved to  $0.69 \pm 0.06$  logMAR units at 1 year ( $P < 0.001$ ). This BCVA was maintained at  $0.633 \pm 0.083$  logMAR units on their final examination. In the 17 eyes with mCNV followed for  $\geq 5$  years, the mean preoperative BCVA was  $1.083 \pm 0.119$  logMAR units, which was significantly improved to  $0.689 \pm 0.121$  logMAR units at 1 year ( $P = 0.001$ ). This BCVA was maintained at  $0.678 \pm 0.142$  logMAR units on their final examination. The area of the VF was significantly decreased at 12 months and did not change significantly thereafter.

**Conclusions** Our results show that macular translocation surgery significantly improves

the BCVA and significantly decreases the VF area of eyes with mCNV or AMD after first 1 year. The BCVA and VF area do not change significantly from the values at 1 year for at least 5 years.

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**Keywords:** AMD; myopic CNV; long-term result; macular translocation; visual acuity; visual field

## Introduction

Age-related macular degeneration (AMD) is the leading cause of legal blindness in the elderly of industrialised countries.<sup>1</sup> There are two types of AMD; the dry type and the wet type. The wet type is associated with subretinal choroidal neovascularisation (CNV). High myopia can also lead to visual reductions and development of a CNV (myopic CNV (mCNV)).<sup>2</sup>

At present, an intravitreal injection of anti-vascular endothelial growth factor is generally used to treat CNVs. However, if the retinal pigment epithelium (RPE) underlying the fovea is damaged, the effectiveness of this therapy on the visual acuity (VA) is limited. To overcome this problem, new therapies such as RPE cell transplantation and transplantation of stem cells are being tried.<sup>3,4</sup>

Macular translocation surgery has also been used to treat AMD. In this surgery, the macular

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area is moved from the underlying damaged RPE to an area of healthier RPE.<sup>5-7</sup> This technique involves the detachment of the entire retina from the RPE by a subretinal infusion of fluid followed by an axial rotation of the macula.<sup>8-12</sup> Although this surgery improves the VA after 1 to 2 years,<sup>8,9,11,13-15</sup> it is rarely performed now because of the difficult surgical procedures and the production of severe strabismus. However, the long-term results of this surgery have provided important information on whether an impaired sensory retina moved onto healthy RPE can recover and maintain good visual function for long periods.

The outcome of macular translocation surgery for AMD is still controversial. Most studies have reported favourable outcomes but for follow-up periods of  $\leq 2$  years after the surgery.<sup>9,11,12,15-20</sup> On the other hand, there are two reports on the visual outcome of macular translocation surgery with follow-up periods of  $\geq 3$  years,<sup>21,22</sup> and the visual outcomes were reported to be poor in both. However, in these two reports, the visual improvement was not attained even in the first year. In the other study, 32 patients were studied retrospectively, but one-third of the patients were not included in the analyses because they were not followed for more than 5 years.<sup>21</sup> Thus, this study may have excluded patients that may have good vision if followed longer. For eyes with a mCNV, the findings  $\geq 5$  years after macular translocation surgery were presented but the results of only five cases were reported.<sup>22</sup>

We have recorded focal electroretinograms from the translocated macular area and found it was significantly better than that before operation at 22 months postoperatively.<sup>18,20</sup> However, the results after longer follow-up periods have not been reported.

Thus, the purpose of this study was to determine the visual outcomes  $\geq 5$  years after macular translocation surgery with 360° retinotomy in eyes with mCNV or AMD.

We analysed all 61 patients 1 year after macular translocation surgery, and separately analysed 40 of these patients who were followed for  $\geq 5$  years.

## Patients and methods

This research was conducted in accordance with the Institutional Guidelines of Nagoya University and conformed to the tenets of the World Medical Association Declaration of Helsinki.

### Patients

Macular translocation surgery was performed on one eye of 62 patients with a subfoveal CNV at the Nagoya University Hospital from February 2000 to July 2004. An informed consent was obtained from each patient for the surgery after they were provided information on other

treatment options including photocoagulation, removal only, and observation only. Because one patient developed dementia and could not return to our hospital after discharge, the results from 61 eyes from 61 patients were analysed. There were 35 patients with AMD (26 men and 9 women) and 26 patients with mCNV (5 men and 21 women). The mean age at operation was  $73.0 \pm 6.5$  years with a range of 62-87 years in the eyes with AMD and  $62.6 \pm 9.7$  years with a range of 40-77 years in eyes with a mCNV (Tables 1 and 2). The mean size of the lesion was  $3890 \pm 1164 \mu\text{m}$  with a range of 1060-6947  $\mu\text{m}$  in the eyes with AMD and  $2511 \pm 832 \mu\text{m}$  with a range of 1248-4190  $\mu\text{m}$  in the eyes with a mCNV. All patients were Japanese, and they were followed for a mean of  $67.5 \pm 25.9$  months with a range of 15-105 months. Three patients were followed for 15, 18, and 18 months, and all others were followed for at least 24 months.

Overall, 23 AMD patients and 17 mCNV patients were followed for  $\geq 5$  years. The type of AMD was predominantly classic in 16 eyes, minimally classic in 5 eyes, and occult with no classic signs in 14 eyes.

The patients' medical records were reviewed, and the best-corrected VA (BCVA) and the area of the visual field (VF) before, 12 months after surgery, and at the final examination were analysed. The BCVA was measured with a standard Japanese VA chart in decimal units and converted to the logarithm of the minimal angle of resolution (logMAR) units for statistical analyses. The BCVAs expressed in logMAR units are shown in Table 1. When the change of the BCVA was  $\pm > 2$  logMAR units, the change was taken to be significant.

The VFs were determined by Goldmann perimetry (with V-4), and the area of the VF in degrees<sup>2</sup> was measured with the SCION Image software (NIH, Bethesda, MD, USA). When the VF area changed by  $\pm > 30\%$ , it was taken to be a significant decrease.

### Surgical techniques

Initially, a pars plana posterior lensectomy was performed followed by pars plana vitrectomy. After the vitrectomy, four separate dome-shaped retinal detachments (RDs) were created by subretinal injections of saline solutions. This was followed by fluid-air exchange of the vitreous to induce a total RD. After a 360° retinotomy at the ora serrata, the CNV was removed and heavy perfluorocarbon liquid was injected into the vitreous. Then, the entire detached retina was rotated around the optic disc axis. The holes made for the 360° retinotomy were sealed by endophotocoagulation, and the perfluorocarbon liquid was replaced by silicone oil. The silicone oil was removed after several months, and an intraocular lens was implanted in patients who requested the implantation.<sup>18-20</sup>

**Table 1** Characteristics of the patients with age-related macular degeneration

AMD patient	Age (years)	Eye	Secondary procedures	Complication	Diplopia	Muscle surgery	Size of CNV ( $\mu\text{m}$ )	Visual acuity			GP (square degree)			Duration of follow-up (months)	
								Initial	12 months	Final	Initial	12 months	Final		
1	M	70	R	SOR	-	.	2930	0.824	0.824	0.824	11 590	6133	6133	31	
2	F	71	L	SOR	-	.	2550	1.000	0.699	0.523	11 347	9415	7787	101	
3	F	67	R	SOR	+	(+)	3298	1.000	0.398	0.301	10 874	11 748	11 225	102	
4	M	63	L	SOR + IOL	+	(+)	3590	0.824	1.000	0.398	12 415	8252	8625	98	
5	M	64	R	SOR, PC	CNV recurrence	-	.	1060	1.000	1.000	1.000	11 141	10 979	11 011	95
6	M	71	R	SOR	-	.	4360	1.000	1.000	1.000	11 566	11 620	9054	96	
7	M	67	L	SOR	+	.	3090	1.000	0.523	0.699	13 867	8836	9384	97	
8	F	78	R	SOR	-	.	2220	0.699	0.398	0.301	10 537	10 017	10 017	48	
9	M	80	L	SOR + IOL	+	.	3888	1.000	1.000	1.000	10 495	7257	6687	37	
10	M	87	L	SOR	-	.	4820	1.000	0.523	0.523	11 698	8037	6287	60	
11	M	77	L	SOR + IOL	+	(+)	3460	1.000	0.523	0.301	8823	9066	9694	72	
12	M	71	L	SOR + IOL	-	.	4530	0.824	0.824	0.523	11 425	9010	7663	76	
13	M	76	R	SOR + IOL, radiation, PDT	CNV recurrence	-	.	2620	0.824	0.824	0.824	7784	2850	3052	56
14	F	63	L	SOR	-	.	4160	1.000	0.222	0.222	12 336	10 580	12 715	74	
15	M	66	R	SOR + IOL	+	(+)	3540	0.824	0.699	0.301	12 755	5777	6593	64	
16	M	75	L	SOR	+	(+)	2552	0.699	0.699	0.824	10 281	9041	4469	66	
17	M	75	R	SOR + IOL	-	.	4930	0.523	0.398	0.301	12 294	9443	9114	60	
18	M	75	R	SOR	-	.	5370	0.523	0.699	0.398	10 657	10 356	9386	55	
19	F	66	L	SOR + IOL	+	(+)	4290	0.699	0.699	1.699	9444	7425	8577	60	
20	M	73	R	SOR, CNV removal	CNV recurrence	-	.	3880	1.097	1.000	1.000	10 668	9454	8630	104
21	M	62	R	SOR, IOL	+	(+)	5430	2.398	0.222	0.222	11 570	7691	8624	70	
22	M	77	R	SOR	+	.	4090	1.222	0.301	0.097	10 938	8445	9929	79	
23	F	79	R	SOR	-	.	6947	2.699	0.699	0.699	12 174	11 202	1397	97	
24	M	74	L	SOR + IOL	+	.	4740	1.155	0.699	0.523	12 547	10 946	10 946	24	
25	F	72	R	SOR	-	.	2240	1.398	0.523	0.301	9862	8742	10 249	97	
26	M	64	L	SOR + IOL	+	(+)	4360	1.523	1.523	1.398	10 928	11 517	8257	94	
27	M	68	R	SOR	+	(+)	2930	1.398	0.699	0.824	13 273	7368	8251	97	
28	M	80	L	SOR + IOL	-	.	3525	1.398	0.398	0.398	11 622	11 647	11 647	15	
29	M	76	R	SOR + IOL	+	.	5160	1.155	1.000	0.699	11 513	9812	8047	74	
30	F	73	L	SOR + IOL	-	.	4210	1.222	1.000	1.000	10 430	10 223	10 223	18	
31	F	87	R	SOR, radiation	CNV recurrence	-	.	4830	1.155	0.699	0.699	9750	9802	5850	60
32	M	79	L	SOR + IOL, RD ope	CNV recurrence	-	.	2620	1.398	1.000	1.000	11 143	6433	8931	36
33	M	80	R	SOR + IOL, PC	CNV recurrence	-	.	4210	1.523	1.046	0.824	11 100	9288	11 524	36
34	M	79	L	SOR	-	.	4660	1.398	1.046	0.824	8481	6424	4828	36	
35	M	70	L	SOR + IOL	-	.	5050	1.097	0.523	0.523	11 538	8328	7739	53	

Abbreviations: CNV, choroidal neovascularisation; F, female; IOL, intraocular lens implantation; L, left; M, male; ope, operation; PC, photocoagulation; R, right; RD, retinal detachment; SOR, silicone oil removal.

The data are presented as the means  $\pm$  SEMs. Wilcoxon signed-rank *t*-tests with the Bonferonni correction were used to compare the BCVA and area of the visual VF before, 12 months after surgery, and at the final examination. *P*-values  $<0.017$  were taken to be statistically significant.

To identify the factors that might influence the final BCVA, multiple regression analyses were performed with the final BCVA as the dependent variable. The independent variables were the gender, age, type of AMD, the preoperative BCVA and at 1 year,  $>5$  years, CNV size at surgery, postoperative complications, and

duration of follow-up. Regression analyses were also performed with the improvement of BCVA as the dependent variable.

All statistical analyses were performed using the SPSS software version 19 (SAS Institute, Cary, NC, USA).

## Results

### Surgical results and complications

The macula was successfully translocated in all eyes. The postoperative complications included rhegmatogenous

**Table 2** Characteristics of the patients with myopic choroidal neovascularisation

Myopic patient	Age (years)	Eye	Secondary procedures	Complication	Diplopia	Muscle surgery	Size of CNV (µm)	Visual acuity			GP (square degree)			Duration of follow-up (months)
								Initial	12 months	Final	Initial	12 months	Final	
36 F	63	L	SOR		-	.	1850	1.000	0.523	0.000	11 542	7400	6426	104
37 F	65	L	SOR		-	.	1679	0.699	0.301	0.301	10 614	5492	6968	94
38 F	66	R	SOR + IOL, MH ope	MH	-	.	2201	0.824	0.097	0.222	12 540	7329	8697	95
39 F	71	L	SOR		-	.	2787	0.699	0.523	0.699	6936	6396	4725	94
40 M	52	R	SOR		-	.	2380	0.699	0.000	0.000	10 660	9048	10 178	84
41 F	48	R	SOR + IOL, RD ope, LEC	RD, secondary Gla	-	.	3147	0.699	0.523	1.699	11 031	5857	1622	84
42 F	75	R	SOR		-	.	3041	0.699	0.301	0.222	8742	6772	6772	24
43 F	71	R	SOR		-	.	2130	0.699	0.097	0.097	8550	7464	5789	72
44 F	67	L	SOR + IOL		-	.	2022	0.699	1.000	1.000	7952	7467	8113	72
45 F	52	L	SOR		-	.	3440	0.824	0.222	0.398	10 636	8750	8750	60
46 F	56	R	SOR + IOL		+	(+)	4190	1.000	0.699	0.523	10 674	8277	10 055	24
47 F	67	L	SOR		-	.	1857	1.000	0.523	0.398	9824	8021	8118	70
48 M	56	R	SOR + IOL		+	(+)	4119	0.523	0.523	0.398	7724	9033	10 121	62
49 F	59	R	SOR		-	.	1743	0.824	0.398	0.398	12 548	7422	11 371	53
50 M	42	L	SOR		-	.	1848	0.523	0.046	0.222	11 521	7704	7717	51
51 F	64	R	SOR		+	(+)	2000	1.699	1.155	1.097	11 084	8006	7917	105
52 M	61	L	SOR, IOL	Aseptic endophthalmitis	-	.	1780	1.301	1.000	0.398	13 068	9397	6005	98
53 F	77	L	SOR		-	.	1278	1.523	1.000	0.523	8319	8870	8870	63
54 F	75	L	SOR + IOL, PC	CNV recurrence	-	.	3170	2.000	1.000	1.000	11 084	9631	8806	96
55 F	60	L	SOR		-	.	3121	1.523	1.699	2.000	10 931	3658	3573	92
56 F	71	R	SOR		-	.	3757	1.523	1.155	1.155	7357	8679	8679	18
57 F	67	R	SOR, MHRD ope	MHRD	-	.	3367	2.000	1.523	1.301	5866	4928	4803	66
58 F	67	L	SOR		-	.	1454	1.097	1.699	1.523	6754	1017	963	39
59 F	68	R	SOR, RD ope	RD	-	.	2292	1.398	1.046	0.824	7843	4481	3115	56
60 M	40	L	SOR + IOL, MHRD ope	MHRD	+	(+)	1800	1.222	0.699	0.523	11 071	9505	8196	52
61 F	68	R	SOR, RD ope	RD	-	.	2842	1.222	1.301	1.000	8787	3370	3830	51

Abbreviations: CNV, choroidal neovascularisation; F, female; Gla, glaucoma; IOL, intraocular lens implantation; LEC, trabeculectomy; M, male; MH, macular hole; MHRD, retinal detachment due to macular hole; ope, operation; RD, retinal detachment; SOR, silicone oil removal.

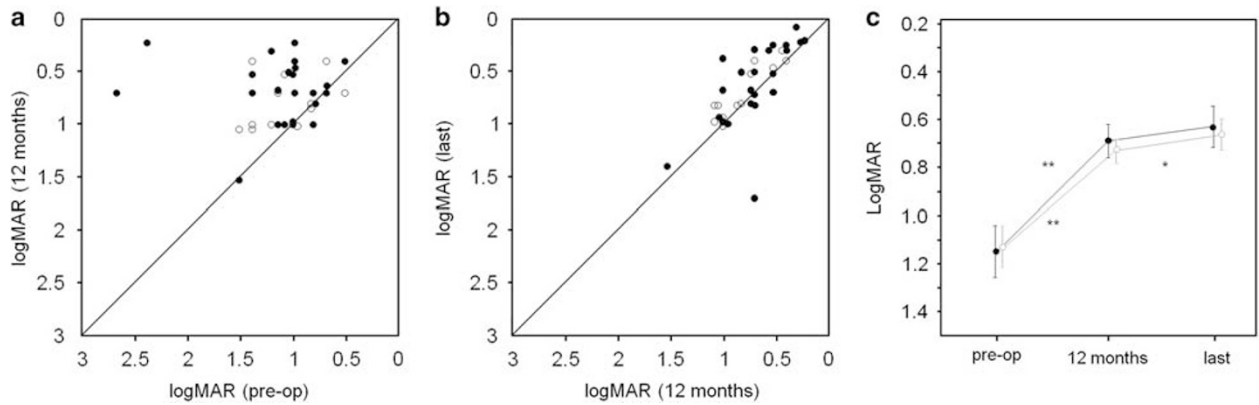
RD in one AMD and three mCNV cases, and a macular hole (MH) in three mCNV eyes with two complicated by a RD. The macula on the new RPE cells was detached in all eyes. Vitrectomy was performed on these patients to reattach the retina. Aseptic endophthalmitis developed in one mCNV eye and was treated with antibiotics and cyclosporine, and secondary glaucoma developed in one mCNV eye that required trabeculectomy. A CNV recurred in five AMD eyes and one mCNV eye at the previously affected foveal area, and these were treated with radiation, CNV removal surgery, photocoagulation, or photodynamic therapy. Proliferative vitreoretinopathy did not occur in any eye.

A RD and a MH developed significantly more frequently in mCNV eyes than in AMD eyes ( $P=0.014$ ;  $\chi^2$ -test), but the rate of recurrence of CNV was not significantly different in the two types of eyes ( $P=0.175$ ;  $\chi^2$ -test).

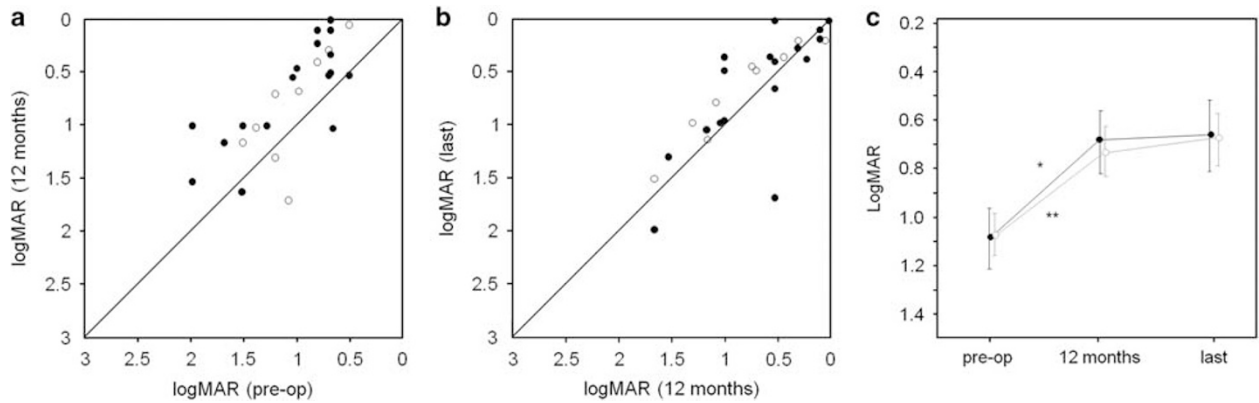
### BCVA in eyes with AMD

The BCVAs of the 35 eyes of patients with AMD before surgery, 12 months after surgery, and at the last follow-up examination (15 months to >5 years) are plotted in Figures 1a and b. The BCVA at 12 months of 19 of 35 eyes (54.3%) was significantly improved and that of the other 16 eyes were not changed significantly from the baseline BCVA. At the last examination (15–105 months), the BCVA had improved significantly in 5 eyes (14.3%), worsened significantly in 1 eye (2.8%), and did not change significantly in 29 eyes (82.9%) from the BCVA at 1 year.

Before surgery, the mean BCVA was  $1.128 \pm 0.075$  logMAR units in the 35 AMD eyes and  $1.149 \pm 0.105$  logMAR units in 23 eyes followed for  $\geq 5$  years. At 12 months, the mean BCVA was  $0.724 \pm 0.049$  logMAR units in the 35 eyes and  $0.690 \pm 0.064$  logMAR units in the



**Figure 1** Effect of macular translocation surgery on the BCVA in the AMD eyes. Overall, 23 eyes were followed for  $\geq 5$  years (filled circle) and 12 eyes were followed for  $< 5$  years (open circle). Scatter plots of the BCVA before and 12 months after surgery (a) and at the final examination (b) are shown. The BCVA is plotted in logMAR units. The mean BCVA of the 35 eyes examined (open circle) and that of the 23 eyes followed for  $\geq 5$  years months (filled circle) are shown (c). The BCVA improved significantly at 12 months and did not decrease significantly thereafter. The error bars represent the SEMs.  $*P = 0.01$ ,  $**P < 0.001$  by Wilcoxon's signed-rank test.



**Figure 2** Effect of macular translocation surgery on the BCVA in myopic eyes with a CNV. Overall, 17 eyes were followed for  $\geq 5$  years (filled circle) and 9 eyes were followed for  $< 60$  months (open circle). Scatter plots of the BCVA before and 12 months after surgery (a) and at the final examination (b) are shown. The BCVAs are plotted in logMAR units. The mean BCVA of the 26 eyes (open circle) and that of 17 eyes followed for  $\geq 5$  years (filled circle) are shown (c). The BCVA significantly improved at 12 months and was stable thereafter. The error bars represent the SEMs.  $*P = 0.001$ ,  $**P < 0.001$  by Wilcoxon's signed-rank test.

23 eyes followed for  $\geq 5$  years. At the last examination, the mean BCVA was  $0.657 \pm 0.060$  logMAR units in the 35 AMD eyes and  $0.633 \pm 0.083$  logMAR units in the 23 eyes followed for  $\geq 5$  years (Figure 1c).

The improvement in the BCVA at 12 months was significant for the 35 eyes ( $P < 0.001$ ) and also for the 23 eyes followed for  $\geq 5$  years. The BCVA did not decrease significantly after 1 year ( $P = 0.010$  for the 35 AMD eyes; Figure 1c).

The last BCVA was significantly associated with the BCVA at 12 months but not significantly associated with the gender, age, type of AMD, preoperative BCVA, CNV size at surgery, postoperative complications, and duration of follow-up. Spearman's rank correlation coefficient showed that the BCVA at the last examination

was significantly correlated with the BCVA at 12 months ( $r = 0.791$ ;  $P < 0.001$ ) but not with that before surgery.

The improvement of the BCVA at the 12 months was significantly associated with the preoperative BCVA, but not significantly associated with the gender, age, CNV size at surgery, postoperative complication, or duration of follow-up. Spearman's rank correlation coefficient also showed that the improvement of BCVA at the 12 months was significantly correlated with the BCVA before surgery ( $r = -0.598$ ;  $P < 0.001$ ).

#### BCVA in myopic eyes with choroidal neovascularisation

The BCVAs of the 26 eyes with a mCNV before surgery, 12 months after surgery, and at the last follow-up

examination are plotted in Figures 2a and b. At 12 months, the BCVA of 19 of 26 eyes (73.1%) had a significant improvement of the BCVA, 2 eyes (7.7%) had a worsening, and 5 eyes (19.2%) remained unchanged. At the last examination (15 months to >5 years), the BCVA had improved significantly in 4 eyes (15.4%), worsened in 2 eyes (7.7%), and remained stable in 20 eyes (76.9%) compared with that at 1 year.

The mean preoperative BCVA was  $1.074 \pm 0.085$  logMAR units in the 26 mCNV eyes and  $1.083 \pm 0.119$  logMAR units in the 17 eyes followed for  $\geq 5$  years. At 12 months, the mean BCVA was  $0.733 \pm 0.099$  logMAR units in the 26 eyes and  $0.689 \pm 0.121$  logMAR units in the 17 eyes followed for  $\geq 5$  years. At the last examination (15 months to 5 years), the BCVA was  $0.689 \pm 0.105$  logMAR units in the 26 mCNV eyes and  $0.678 \pm 0.142$  logMAR units in the 17 eyes followed for  $\geq 5$  years (Figure 2c).

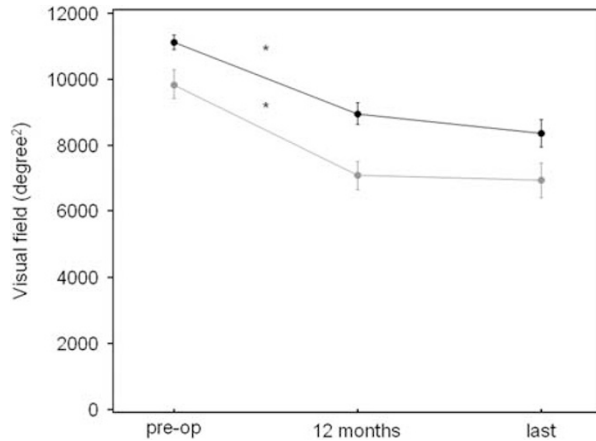
The improvement of the BCVA at 12 months was significant for the 26 eyes ( $P < 0.001$ ) and also for the 17 eyes followed  $\geq 5$  years ( $P = 0.001$ ), and this was maintained thereafter ( $P = 0.206$  and  $P = 0.721$ , respectively; Figure 2c).

The last BCVA was significantly associated with the BCVA at 12 months ( $P < 0.001$ ). However, it was not significantly associated with the gender, age, CNV size at surgery, postoperative complications, BCVA before surgery, or duration of follow-up. Spearman's rank correlation coefficient showed that last BCVA was significantly correlated with the BCVA before surgery ( $P = 0.003$ ,  $r = 0.561$ ), and the improvement of BCVA at 1 year was significantly correlated with the BCVA before surgery ( $P = 0.033$ ,  $r = -0.420$ ).

#### Changes in area of VF

We measured the VFs of the 35 AMD eyes and the 26 eyes with a mCNV. The mean VF area of eyes with AMD and with mCNV before surgery, 12 months after surgery, and at the final examination are shown in Figure 3. Before surgery, the mean VF area was  $11110 \pm 218 \mu\text{m}^2$  in the AMD patients and  $9833 \pm 412 \mu\text{m}^2$  in the mCNV patients. At 12 months after surgery, it was  $8948 \pm 332 \mu\text{m}^2$  in the AMD patients and  $7076 \pm 423 \mu\text{m}^2$  in the mCNV patients. At the last examination, the mean VF area was  $8358 \pm 417 \mu\text{m}^2$  in the AMD patients and  $6930 \pm 532 \mu\text{m}^2$  in the mCNV patients.

The area of the VF was significantly smaller at 12 months in both the AMD ( $P < 0.001$ ) and mCNV ( $P < 0.001$ ) eyes. The area of the VF did not change significantly in both types of patients thereafter ( $P = 0.726$  and  $P = 0.280$ , respectively). Eight mCNV eyes (20.8%) and 13 AMD eyes (37.1%) showed a significant decrease in the VF area, and the other 40 eyes did not change significantly.



**Figure 3** Changes in the area of the VF in mCNV (grey) and AMD (black) eyes are shown. The VF decreased after the surgery but no significant change was observed after 12 months. The error bars represent the SEMs. \* $P < 0.001$  by Wilcoxon's signed-rank test.

#### Discussion

Our findings showed that the BCVAs of eyes with AMD or mCNV were significantly improved by macular translocation surgery after 12 months. The improved BCVA was maintained even after  $\geq 5$  years. From 12 months after surgery to the final examination, only two mCNV eyes and one AMD eye had a decrease of  $> 2$  logMAR lines in the BCVA. The other eyes improved significantly (four myopic and five AMD) or did not change significantly during this period.

For mCNV, Fujii *et al*<sup>23</sup> reported that 4 of 11 eyes showed a significant improvement of  $\geq 2$  Snellen lines and 4 eyes remained unchanged 9.8 months after macular translocation surgery. Fujikado *et al*<sup>24</sup> reported that 8 of 11 eyes had an improvement of greater than 0.2 logMAR units, and only 1 eye had a decrease of 0.2 logMAR units 6.2 months after translocation surgery. Our results at 12 months are consistent with these findings. Yamada *et al*<sup>22</sup> reported that the mean BCVA before operation was maintained until the final follow-up in five of five myopic cases after a mean follow-up time of 6.5 years.

For AMD patients, Mruthyunjaya *et al*<sup>15</sup> reported that better preoperative BCVA was significantly associated with better postoperative BCVA at 12 months. Our results are also consistent with theirs, that is, there was a significant association between the preoperative BCVA and improvement of the BCVA in eyes with AMD.

There are more than 10 studies on the visual outcome of macular translocation surgery for eyes with AMD with follow-up periods of  $< 2$  years, and most of these showed a significant improvement or unchanged BCVA.<sup>9,11,12,15–20</sup> Our findings are consistent with these reports, and our

results for the 35 AMD eyes showed that the mean BCVA improved from  $1.128 \pm 0.075$  to  $0.724 \pm 0.049$  logMAR units at 12 months and did not worsen at the final examination even after follow-up periods of  $\geq 5$  years.

For AMD patients, there are two reports with a follow-up of  $> 5$  years. In one study, Yamada *et al*<sup>22</sup> reported that the BCVA was not significantly changed at 1 year and significantly worsened after  $> 5$  years. These differences from our findings could be because the preoperative BCVA was worse in their patients than ours. In addition, five of their patients developed postoperative proliferative vitreoretinopathy. However, they stated that the retinopathy was treated successfully, and there was no difference in the BCVA between the eyes with complications from those without complications. Our multiple regression analyses showed that the final BCVA was not significantly associated with the kind of complications.

The fact that Yamada *et al*<sup>22</sup> analysed only two-thirds of the patients ( $n = 32$  analysed) operated on can be another reason for the differences. Because the other third were not followed for  $> 5$  years, they were not included in the analyses. It is possible that patients with good BCVA stopped coming to the hospital and were not followed for a long period. To exclude this possibility, we analysed the results of all the patients who had undergone macular translocation surgery and separately for the 40 patients who were followed for  $\geq 5$  years. However, the results of these two analyses were similar; both showed an improvement of the BCVA at 12 months and no significant changes thereafter. Thus, a decrease in the BCVA was not found in our cases at 12 months. Although the reason for the differences in visual outcome at the earlier times are not known, our results suggest that if the outcome is good at 12 months, the final BCVA will be good at 5 years.

The mean follow-up period after macular translocation surgery was 38.2 months in the study by Aisenbrey *et al*,<sup>21</sup> and 52 of their patients (57.8%) were followed for  $\geq 3$  years and 25 patients (27.8%) were followed for  $\geq 5$  years. At 36 months, 75% of their patients had stable or significantly improved BCVA. These findings are not different from our results at 12 months in our patients. They also stated that the patients who were followed for a short period did not show better outcome, and those who were followed for a long period did not show worse outcome. These findings are consistent with our multiple regression results that the follow-up period was not significantly associated with the final BCVA.

Because macular translocation surgery damages the retina, for example, artificial RD and rotation of the retina, it was expected that the area of the VF would be reduced. However, the VF was not significantly

decreased after 12 months, suggesting that the surgical procedures may not be harmful to the retina.

In conclusion, the changes in the visual function of eyes with mCNV and AMD after macular translocation surgery with 360 retinotomy were analysed. Although there are some limitations in this study, related to its retrospective nature, we have found that this surgery can improve the BCVA in the first 12 months, and the BCVA is maintained for  $\geq 5$  years. The survival of retinal function on the new RPE for long period is important for future treatments of CNVs, such as RPE cell transplantation.

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## Summary

### What was known before

- Macular translocation provided favourable outcomes for follow-up periods of (less than or equal to) 2 years after the surgery.

### What this study adds

- Macular translocation can improve the BCVA in the first 12 months, and the BCVA is maintained for (greater than or equal to) 5 years. The area of the VF was significantly smaller at 12 months in both the AMD and mCNV. The area of the VF did not change significantly thereafter for (greater than or equal to) 5 years.
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## Conflict of interest

The authors declare no conflict of interest.

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# Visual function 5 years or more after macular translocation surgery for myopic choroidal neovascularisation and age-related macular degeneration

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1. A 73-year-old man with AMD is being considered for macular translocation surgery. He has many questions about the procedure. What can you tell him?
  - A The entire retina should not be detached during macular translocation surgery
  - B Strabismus is an important complication of the procedure
  - C The viability of the retinal pigment epithelium at the site of macular translocation is not important
  - D Studies have not reported poor visual outcomes associated with macular translocation surgery for AMD
  
2. On the basis of the results, what can you tell the patient about the complications of macular translocation surgery?
  - A mCNV did not recur after surgery
  - B Proliferative vitreoretinopathy occurred in 30% of cases after surgery
  - C RD and MHs occurred more frequently in mCNV eyes than in AMD eyes
  - D Recurrence of CNV occurred more frequently in mCNV eyes than in AMD eyes

3. On the basis of the results, what can this patient expect in terms of visual outcomes at 12 months after macular translocation surgery?
  - A No significant change in BCVA and severe reductions in the VF
  - B No significant change in BCVA or the VF
  - C Improvement in BCVA but severe reductions in the VF
  - D Improvement in BCVA but minimal reduction in the VF
  
4. On the basis of the results, what can this patient expect in terms of visual outcomes between 1 and 5 years after macular translocation surgery?
  - A No significant change in BCVA or the VF
  - B Significant degradation in BCVA but not in the VF
  - C Significant degradation in the VF but not in BCVA
  - D Significant reductions in both BCVA and the VF

**Activity evaluation**

1. The activity supported the learning objectives.				
Strongly disagree			Strongly agree	
1	2	3	4	5
2. The material was organised clearly for learning to occur.				
Strongly disagree			Strongly agree	
1	2	3	4	5
3. The content learned from this activity will impact my practice				
Strongly disagree			Strongly agree	
1	2	3	4	5
4. The activity was presented objectively and free of commercial bias.				
Strongly disagree			Strongly agree	
1	2	3	4	5