Macular Translocation With 360° Retinotomy for Exudative Age-Related Macular Degeneration

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Background: Macular rotation surgery comprises surgical extraction of choroidal neovascular membranes in age-related macular degeneration (AMD) and translocation of the foveal neural retina over adjacent retinal pigment epithelium.

Objective: To determine whether macular translocation with 360° retinotomy can stabilize and/or improve visual acuity in patients with subfoveal choroidal neovascularization (CNV) secondary to AMD.

Design: This study consisted of a standardized surgical procedure on a series of 90 consecutive patients and follow-up examinations at fixed intervals for 12 months.

Participants: All patients in this study had experienced recent visual loss resulting from subfoveal CNV caused by AMD. Twenty-six patients had major macular subretinal hemorrhage, 39 patients had occult subfoveal CNV, and 25 patients had classic subfoveal CNV.

Methods: Macular translocation surgery was performed between 1997 and 1999. The patients were examined preoperatively and at 3, 6, and 12 months postoperatively, including visual acuity, microperimetry, angiography, and orthoptic assessment.

Results: Visual acuity increased by 15 or more letters in 24 patients, remained stable in 37 patients, and deteriorated by 15 or more letters in 29 patients at 12 months postoperatively. A secondary procedure was necessary in 17 patients because of severe complications; proliferative vitreoretinopathy was observed in 17 eyes, macular pucker in 5 eyes, and macular hole in 1 patient.

Conclusion: Macular translocation is a technically demanding surgical procedure. Although the procedure has a high rate of surgical and postoperative complications, the functional and anatomical results appear to be promising for selected patients with subfoveal CNV secondary to AMD.

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AGE-RELATED macular degeneration (AMD) is the leading cause of legal blindness among the elderly in the Western world.[1-3] There are 2 main manifestations of late AMD: exudative or neovascular AMD and nonexudative or atrophic AMD. Approximately 10% to 20% of patients with AMD develop the exudative form of this disease, which is characterized by choroidal neovascularization (CNV).[1] Growth of new vessels from the choroid through the Bruch membrane and in the subretinal space causes exudation and hemorrhagic lesions with progressive visual loss, eventually resulting in the formation of a disciform scar with loss of photoreceptors.

Currently the only treatments for CNV that have proved effective are laser photocoagulation for extrafoveal classic CNV and photodynamic therapy for the small group of subfoveal predominantly classic CNV.[4-8] Furthermore, even when these treatments are successful, retreatments are required in many cases because of persistence or recurrence of CNV after photocoagulation and reperfusion after photodynamic therapy.[4,9]

Increasing prevalence and absence of a treatment modality resulting in improved visual function for the majority of patients have prompted the search for alternative treatments. Radiation therapy has not proved to be effective in the treatment of subfoveal CNV secondary to AMD.[10] Despite encouraging results of phase 1-2 studies, the long-term efficacy of a specific antiangiogenic treatment remains to be evaluated. Antiangiogenic drugs are now being investigated, but it is too early to determine whether these will be effective.[11] Surgical extraction of subfoveal neovascular membranes is not particularly helpful, since the underlying retinal pigment epithelium (RPE) is often damaged or removed.[12-16] Several modifications of the simple extraction have been

PATIENTS AND METHODS

PATIENTS

Between December 3, 1997, and December 23, 1999, 90 eyes of 90 patients were followed up in a prospective consecutive case series. Criteria for inclusion consisted of (1) age of 50 years or older, (2) best-corrected visual acuity of 20/50 or less in the eligible eye, (3) evidence of drusen, (4) new or recurrent CNV that involved the geometric center of the foveal avascular zone or subfoveal hemorrhages secondary to CNV, and (5) informed consent. The alternatives, potential benefits, risks, and complications of macular translocation were explained to the patients in detail before recruitment.

Ocular criteria for exclusion consisted of disciform lesions, pigment epithelial tears, polypoidal vasculopathy, deep retinal anomalous complexes, and eyes with recurrent membranes after conventional membrane extraction or laser photocoagulation. Patients with recurrent lesions following laser photocoagulation were also excluded, as were patients with a history of heart attack or stroke and presenile dementia.

The age of the patients (29 men and 61 women) ranged from 58 to 90 years (mean, 75.0 years; SD, 6.2 years). The affected eye was the right eye in 47 patients and the left eye in 43 patients. In 2 patients the operated-on eye was the eye with the worst visual acuity, whereas in 67 patients the operated-on eye had a visual acuity better than the contralateral eye, which had a visual acuity less than 10/200.

EXAMINATION METHODS

To establish a baseline, all patients underwent a comprehensive ophthalmologic examination preoperatively, including anterior segment biomicroscopy, intraocular pressure measurement, and fundus examination with slitlamp biomicroscopy.

Best-corrected distance visual acuity was measured by a certified visual examiner with the use of the Early Treatment Diabetic Retinopathy Study chart according to a fixed protocol. The distance visual acuity charts have 5 letters per line, with a doubling of the minimum angle of resolution every 3 lines. For each vision test, the 2 eyes of the patient were tested with different charts.

Color photographs of the macula and the disc of each eye as well as fluorescein and indocyanine green angiograms were taken by a certified photographer. Microperimetry of the macula of the study eye was performed by scanning laser ophthalmoscopy.

Orthoptic examinations usually included measurements of subjective monocular cyclorotation by Maddox rod cylinder at a distance of 40 cm and the light bar of Harms screen at a distance of 1 m. Additionally, the Hirschberg test, the cover test, the test with Bagolini striated glasses, and the Titmus test were performed.

Patients had a complete medical history, physical examination, electrocardiogram, chest radiography, and blood test to screen for major-organ pathologic conditions.

On the basis of a review of angiograms, patients were assigned to 1 of 3 groups: hemorrhagic CNV, 26 patients with major macular subretinal hemorrhage (at least 1 disc area involving the fovea); occult CNV, 39 patients with purely occult or predominantly occult subfoveal CNV; and classic CNV, 25 patients with purely classic or predominantly classic subfoveal CNV.

SURGICAL TECHNIQUE

Macular Translocation (n=90)

The macular translocation procedure is illustrated in **Figure 1**. Surgery was performed by 3 surgeons (P.E., P.W., and K.U.B.-S.) with the patient under general anesthesia. In the phakic eyes (n=53), the lens was removed by means of phacoemulsification through a corneoscleral approach and a foldable acrylic posterior chamber lens (Acrysof MA60BM; Alcon Pharma GmbH, Freiberg, Germany) was implanted. In 7 eyes, the intraocular lens was implanted secondarily at the time of silicone oil removal. In all patients, a 3-port pars plana vitrectomy was performed, a posterior vitreous detachment was induced, and the peripheral vitrectomy was completed as far as possible. To induce the retinal detachment, balanced saline solution was injected through a small retinotomy usually performed in the inferior midperiphery with a specially designed detachment cannula (Cannula for Retina Detachment; Geuder, Heidelberg, Germany). In a series of 22 patients, a calcium- and magnesium-free infusion fluid (BSS Minus; Alcon Pharma GmbH) was used to facilitate the retinal detachment according to the recommendations of Faude et al.[28] The injection of this solution into 1 retinotomy was sufficient to create a total retinal detachment in the majority of eyes. Once the retina was detached, perfluorocarbon liquid (F-Octane; Ruck, Eschweiler, Germany) was injected into the vitreous cavity and a 360° peripheral retinotomy was performed just posterior to the ora serrata. The perfluorocarbon was subsequently removed. With

suggested to improve its success rate.[17] Transplantation of iris pigment epithelial or RPE cells after removal of CNV may be beneficial, but only a limited series of pilot studies is available.[18-20] Another approach to circumvent the loss of the RPE is to translocate the fovea surgically over adjacent healthier RPE. The idea of translocating the retina was first proposed in 1983 by Lindsey et al.[21] Machemer and Steinhorst[22] reported the result of this surgical procedure, which included a 360° retinotomy and macular rotation, in humans in 1993. Various modifications of this technique have been described, including the so-called limited retinal rotation, which does not require a 360° retinotomy.[23-26] The combination of macular translocation with ocular counterrotation of the globe was a milestone in the development of the procedure, as it may compensate for induced cyclotropia and diplopia.[23,27]

Herein we report the functional and anatomical effects of macular translocation combined with 360° peripheral retinotomy in a prospective case series of 90 patients who underwent controlled surgery and follow-up examination for 1 year.

the use of a silicone-tipped extension needle, the temporal retina was lifted and pulled nasally. With caution it was possible to extract the neovascular membrane and to detach it from the underlying Bruch membrane with a microforceps. Any hemorrhage from feeder vessels was coagulated by bipolar diathermy. Semifluorane liquid (F_6H_8; Fluoron GmbH, Neu-Ulm, Germany) was injected into the vitreous cavity to stabilize the posterior retina. The retina was translocated to its new position with a silicone-tipped extrusion needle. The fovea was usually rotated superiorly (n = 85); in only 5 cases it was rotated inferiorly. Once the fovea was rotated to the desired position, the retina was entirely unfolded by injection of perfluorocarbon liquid. Laser retinopexy was applied around the midperipheral retinotomies and adjacent to the border of the 360° peripheral retinotomy. The perfluorocarbon-semifluorane liquid mixture was exchanged for silicone oil, 5000 centistokes (Silikon 5000; AcriTec, Munich, Germany).

Muscle Surgery (n = 75)

The excyclorotation of the eye was performed in combination with the primary vitrectomy in 53 patients. The superior oblique was recessed partially 10 to 12 mm by deinsertion of the anterior four fifths of the muscle and stitching the anterior edge to the sclera about 12 to 14 mm from the limbus. The lateral half of the insertion of the superior rectus was deinserted, with care taken not to interrupt more than 1 of the 2 anterior ciliary arteries. The free lateral edge was pulled over the medial half and, under slight traction, fixed about 2 to 4 mm medial to the superior rectus muscle insertion. Similarly, the upper half of the medial rectus was pulled downward and fixed under its inferior margin. The medial half of the inferior rectus was moved temporally and the inferior half of the external rectus was moved superiorly. Finally, the anterior margin of the inferior oblique was folded. The anterior margin was slung by a whip suture at a distance of 10 to 12 mm from the insertion; the suture was stitched 2 to 4 mm before the insertion. If subjective cyclorotation persisted, the eye muscles were surgically revised at the time of silicone oil removal.

In a second series of 22 patients, eye muscle surgery was not performed together with primary retinal surgery but with silicone oil removal. In these cases, subjective cyclorotation caused by retinal rotation could be assessed before muscle surgery. Thus, ocular counterrotation could be adjusted. The surgical procedure consisted of one or a combination of the following techniques, depending on subjective and objective incyclorotation and depending on the preoperative angles of squint: recession of the superior-oblique (full tendon or anterior margin; standard, about 10 mm full tendon), advancement of the inferior oblique (full tendon or anterior margin; standard, about 12 mm anterior margin), downward transposition of the internal rectus (full tendon, no split muscle technique; standard, about 8 mm), and upward transposition of the external rectus (full tendon, no split muscle technique; standard, about 8 mm). The muscle surgery procedures described above are modifications of the procedures described by Eckardt et al[23] and Freedman et al.[29] Twenty of the 75 patients who had undergone counterrotation and vitrectomy required revisional muscle surgery.

PATIENT FOLLOW-UP

All patients were scheduled to return approximately 6 weeks and 3, 6, 9, and 12 months after surgery (within 2 weeks before or after that date). At each regularly scheduled postoperative follow-up visit, examinations were essentially the same as preoperatively except for scanning laser ophthalmoscopy and orthoptic status. Orthoptic examinations were performed after primary surgery and before silicone oil removal. If eye muscle surgery was performed together with silicone oil removal, an additional orthoptic examination was carried out after this surgery.

STATISTICAL METHODS

The primary efficacy outcome was the change in visual acuity (logMAR and Snellen equivalent) of the study eye at 1 year after study entry compared with the baseline examination.

The data were described by means, SDs, and frequencies, as well as corresponding 95% confidence intervals (CIs). We fitted a 3-factor analysis of covariance model (between the factors surgeon [surgeons 1, 2, and 3], eye [left and right eyes], and CNV [classic, occult, hemorrhage, and other]; covariable, age) to the data of the change in visual acuity (logMAR and Snellen equivalent) after 12 months from baseline. As outlined above, missing values of the 3 patients who could not be measured at some time points were substituted by the last measured value. Detailed comparisons were performed with 95% CIs corresponding to the least significant difference *t* test. Effects were assessed as significant if the *P* value of the corresponding test fell below .05. Computations were performed with SAS software (PROC MEANS, GLM, FREQ; SAS Institute Inc, Cary, NC) under MacOS (Apple Computer, Inc, Cupertino, Calif).

RESULTS

Ninety eyes in 90 patients were treated with macular translocation. The baseline characteristics of visual acuity of these patients were subdivided into the main CNV groups (**Table 1**). Preoperatively best-corrected visual acuity ranged from hand movements (logMAR, 2.0) to 20/50 (logMAR, 0.4), with a median of 20/200 (logMAR, 1.0) and was balanced between the subgroups (classic CNV, occult CNV, and hemorrhages), except that patients with occult CNV had significantly better visual acuity than patients with hemorrhages. At baseline examination, a subjective cyclorotation in the study eyes of approximately 1° of excyclorotation or incyclorotation was measured. Preoperative fluorescein angiography showed classic subfoveal CNV in 25 eyes and occult subfoveal CNV in 39 eyes (**Figure 2**). Subfoveal hemorrhage secondary to CNV was present in 26 eyes. One-year follow-up was completed in 87 patients. Only 3 patients were unavailable for follow-up between the month 9 examination and the month 12 examination: 2 died of causes unrelated to the treatment and 1

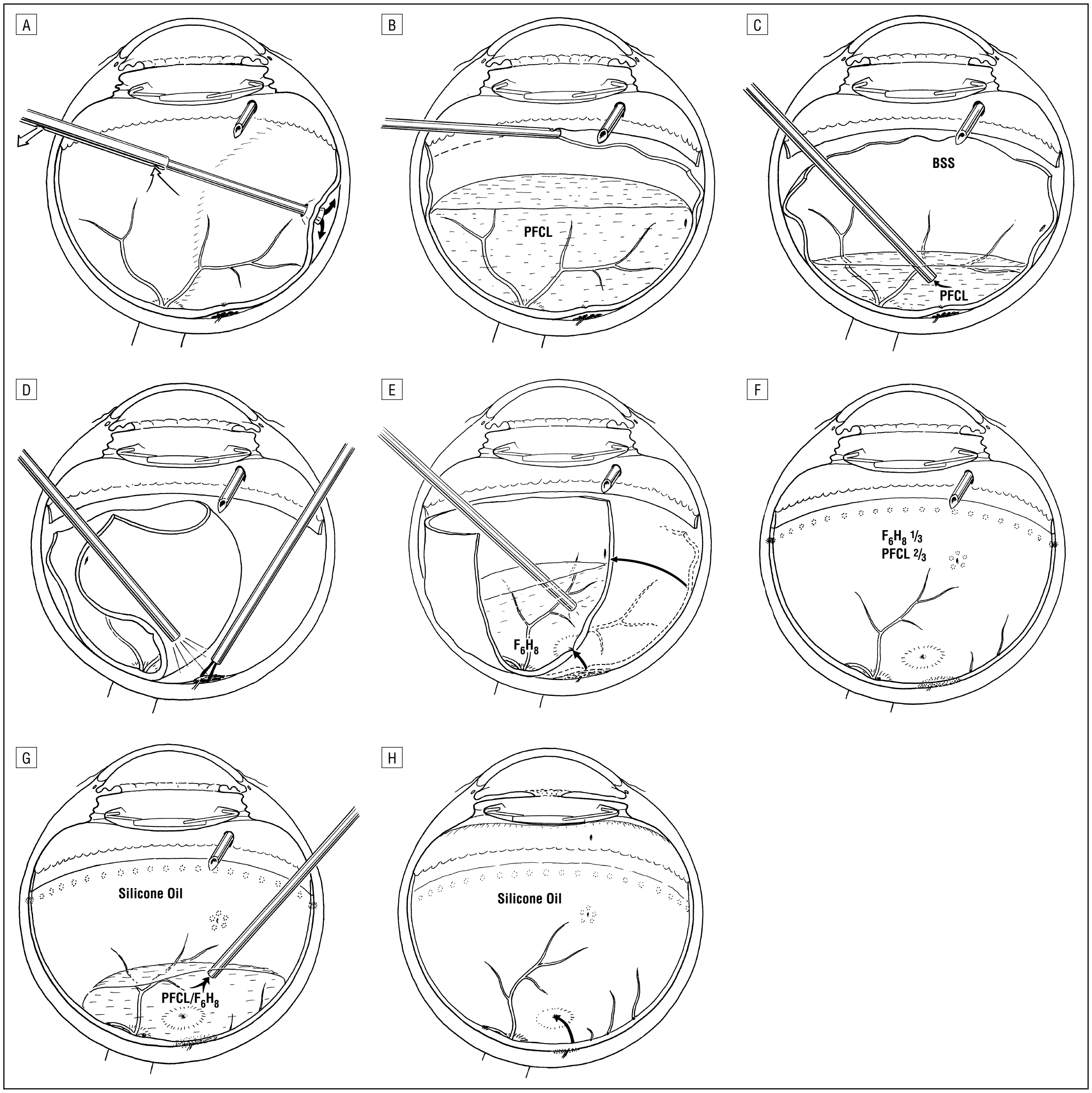

Figure 1. Schematic drawings of the macular translocation procedure. A, Phacoemulsification, 3-port pars plana vitrectomy, induction of posterior vitreous detachment, completion of peripheral vitrectomy, and injection of balanced saline solution (BSS) through a small retinotomy in the inferior midperiphery. B, Perfluorocarbon liquid (PFCL) injection, 360° retinotomy posterior to ora serrata, and PFCL removal. C, BSS injection and induction of retinal detachment, with the retina pulled nasally. D, Extraction of choroidal neovascular complex and coagulation of hemorrhages from feeder vessels. E, Semifluorane liquid (F_6H_8) injection, rotation of the retina to the new position (arrows), and retina unfolded by injection of PFCL. F, Peripheral laser retinopexy. G, PFCL/F_6H_8 and silicone oil exchange. H, Retinal reattachment, silicone oil tamponade, and macula translocated (arrow).

was unable to be examined because of severe systemic disease.

VISUAL OUTCOMES

One year after macular translocation, best-corrected visual acuity ranged from hand movements (logMAR, 2.0) to 20/40 (logMAR, 0.3), with a median of 20/200 (logMAR, 1.0). Twenty-four patients showed improvement in visual acuity of 3 lines or more from baseline on the Early Treatment Diabetic Retinopathy Study chart, 37 patients retained stable visual acuity with a change of less than 3 lines, and 29 patients showed decreased visual acuity of 3 lines or more. Intraoperative or postoperative complications occurred in 11 patients with loss of 3 lines or more. The change in visual acuity from baseline at 3-, 6-, 9-, and 12-month examinations is presented in **Table 2**. For the primary outcome at the 12-month examination, no significant change in visual acuity (logMAR and Snellen equivalent) compared with baseline was observed. Analysis of variance for the change in visual acuity at the 12-month examination showed that visual outcome was not influenced by patient age or by the surgeon but was significantly influenced by the CNV type (**Table 3**). Significantly better visual acuity outcome was observed in patients with classic CNV (mean difference, 0.35; 95% CI, 0.13-0.57) or hemorrhages (mean difference, 0.29; 95% CI, 0.07-0.51) than in patients with occult CNV (**Table 4**). Subgroup analysis of change in visual acuity over time from baseline showed a decrease of 3 lines or more at all time points for patients with occult CNV (mean, 0.25; SD, 0.46; 95% CI, 0.10-0.39) and a trend toward visual acuity improvement without being clinically significant for patients with classic CNV (mean, −0.10; SD, 0.44; 95% CI, −0.28 to 0.08) or hemorrhages (mean, −0.04; SD, 0.43; 95% CI, −0.21 to 0.13) (**Table 5**).

Table 1. Baseline Visual Acuity in Subgroups*

CNV	No. of Patients	Visual Acuity, LogMAR		95% CLM	
		Mean	SD	Lower	Upper
All	90	1.00	0.36	0.94	1.08
Classic	25	1.01	0.33	0.87	1.14
Occult	39	0.85	0.29	0.75	0.94
Hemorrhage	26	1.23	0.38	1.08	1.39

*CNV indicates choroidal neovascularization; CLM, confidence limit of the mean.

ORTHOPTIC OUTCOMES

Cyclorotation measurement could be performed postoperatively in 57 patients. After muscle surgery, the angle of subjective cyclorotation was less than 7° in 15 patients (26%) and larger than 7° in 42 patients (74%). In 5 patients, we obtained a positive test for binocular single vision by means of Bagolini striated glasses. One of these patients even had a positive Titmus test. A total of 21 (28%) of 75 patients complained about persistent diplopia after the first counterrotation. Thus, in 20 patients, revision surgery on the eye muscles had to be performed; all of these patients belonged to the first series of muscle surgery combined with vitrectomy. The 15 patients who did not receive eye muscle surgery because of exclusion and adaptation phenomena complained of neither diplopia nor persistent impression of tilted images, and no additional eye muscle surgery in this group was necessary.

ANGIOGRAPHIC OUTCOMES

An interpretable 1-year follow-up angiogram was available in 80 patients, since 3 patients were lost to follow-up, 4 refused angiography, and in 3 patients the angiogram was of poor quality because of cloudy media. Preoperatively,

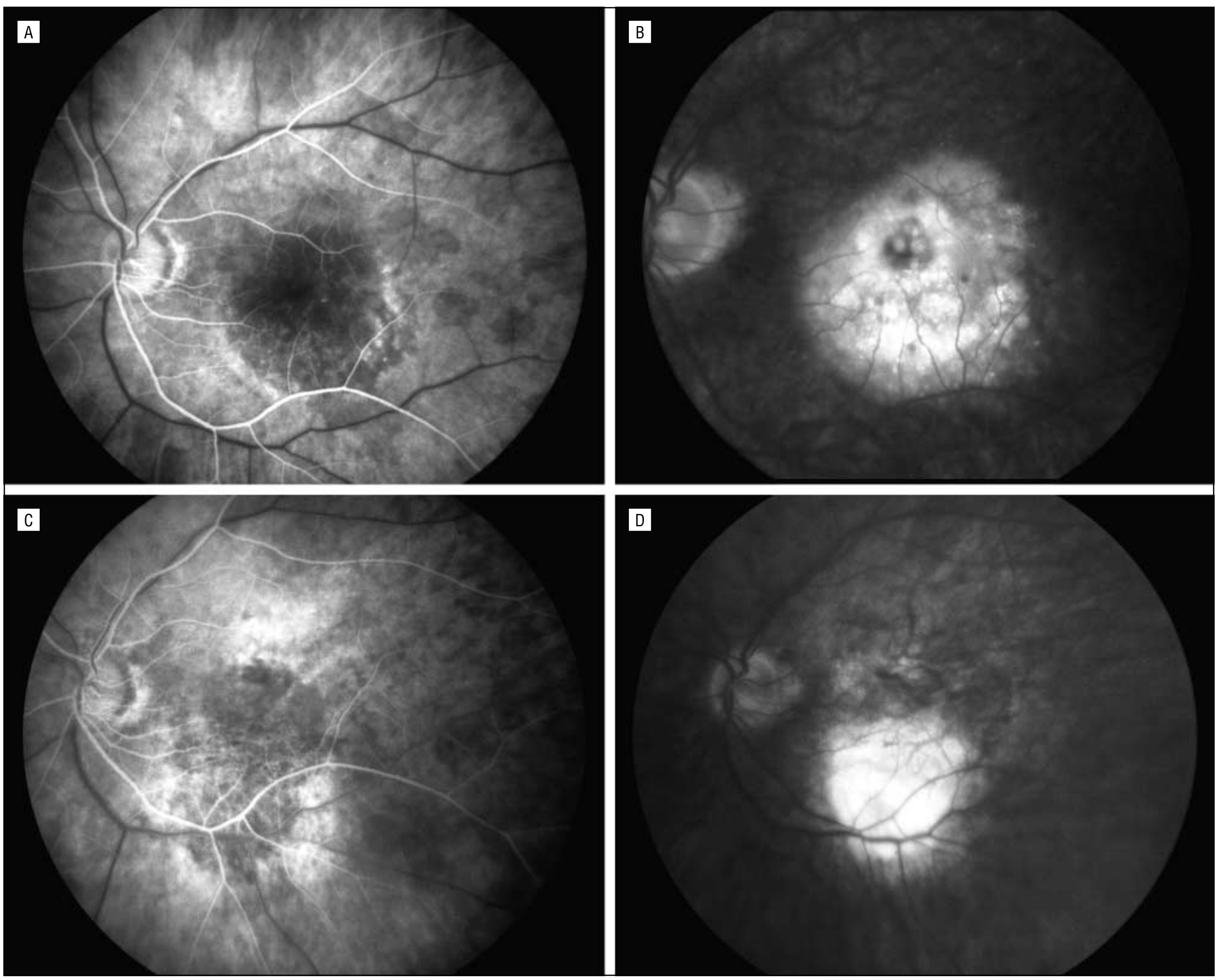

Figure 2. A and B, Preoperative fluorescein angiogram (early and late phases, respectively) of the left eye of a 68-year-old male patient, demonstrating occult subfoveal neovascularization. C and D, Postoperative fluorescein angiogram (early and late phases, respectively), 12 months after macular translocation.

Table 2. Change in Visual Acuity Over Time From Baseline*

Follow-up, mo	No. of Patients	Visual Acuity Change, LogMAR		95% CLM	
		Mean	SD	Lower	Upper
12	90	0.07	0.47	−0.03	0.16
9	90	0.16	0.05	0.05	0.26
6	90	0.14	0.46	0.04	0.24
3	90	0.14	0.42	0.05	0.23

*CLM indicates confidence limit of the mean.

Table 3. Analysis of Variance Table for Visual Acuity Change After 12 Months*

Variable	*df*	Visual Acuity Change, LogMAR		F Value	*P* Value
		Sum of Square	Mean Square		
Surgeon	2	0.33	0.16	0.78	.46
Eye	1	0.05	0.05	0.26	.61
Surgeon × eye	2	0.11	0.05	0.26	.77
CNV	2	1.48	0.74	3.53	.03
Surgeon × CNV	4	0.51	0.13	0.61	.65
Eye × CNV	2	0.11	0.06	0.27	.77
Age	1	0.03	0.03	0.12	.73
Error	75	15.74	0.21	. . .	. . .

*CNV indicates choroidal neovascularization; ellipses, not applicable.

Table 4. Confidence Intervals Corresponding to the Least Significant Differences *t* Test*

CNV Comparison	Lower 95% CLM	Difference Between Limits	Upper 95% CLM
Occult-hemorrhage	0.07	0.29	0.51
Occult-classic	0.13	0.35	0.57
Hemorrhage-classic	−0.18	0.06	0.30

*CNV indicates choroidal neovascularization; CLM, confidence limit of the mean.

Table 5. Subgroup Analysis of Visual Acuity Changes Over Time From Baseline*

CNV	No. of Patients	Follow-up, mo	Visual Acuity Change, LogMAR		95% CLM	
			Mean	SD	Lower	Upper
Classic	25	12	−0.10	0.44	−0.28	0.08
Classic	25	9	−0.04	0.48	−0.24	0.16
Classic	25	6	0.01	0.45	−0.18	0.19
Classic	25	3	−0.01	0.43	−0.19	0.17
Occult	39	12	0.25	0.46	0.10	0.39
Occult	39	9	0.38	0.47	0.23	0.53
Occult	39	6	0.30	0.41	0.17	0.43
Occult	39	3	0.27	0.37	0.15	0.39
Hemorrhage	26	12	−0.04	0.43	−0.21	0.13
Hemorrhage	26	9	0.02	0.45	−0.17	0.20
Hemorrhage	26	6	0.03	0.47	−0.16	0.22
Hemorrhage	26	3	0.10	0.45	−0.08	0.28

*CNV indicates choroidal neovascularization; CLM, confidence limit of the mean.

the size of the choroidal neovascular complex varied from 0.5 to 4.5 disc diameters (median, 2.0 disc diameters) in patients with classic CNV, 0.75 to 7.5 disc diameters (median, 2.5 disc diameters) in patients with occult CNV, and 1 to 9 disc diameters (median, 4.0 disc diameters) for patients with subretinal hemorrhages. Postoperatively, the extent of the atrophic lesion was 1.5 to 6.5 disc diameters (median, 2.0 disc diameters) for the first group, 1 to 4.5 disc diameters (median, 3.0 disc diameters) for the second group, and 1.5 to 4 disc diameters (median, 3.0 disc diameters) for the last group. The linear correlation coefficients between preoperative diameter and the change in visual acuity of 0.25 for classic CNV, 0.07 for occult CNV, and −0.16 for hemorrhages suggest that there is no correlation between size of CNV and visual outcome.

The extent of retinal rotation was sufficient to relocate the center of the fovea away from the atrophic zone in 71 eyes, whereas in 9 eyes the fovea remained within an area of retinal atrophy; most of these 9 eyes belonged to patients with massive subretinal hemorrhage preoperatively. Comparison of preoperative and postoperative fluorescein and indocyanine green angiography allowed calculation of the direction and angle of macular translocation: the foveal center was displaced superiorly in 85 eyes and inferiorly in 5 eyes. The extent of translocation varied from 10° to 60° (median, 31°).

COMPLICATIONS

Immediately after surgery, all eyes showed corneal erosion, which occurred spontaneous or secondary to corneal abrasion that was done to improve intraoperative visibility. In 2 patients, the acrylic intraocular lenses that were implanted during the original surgical procedure had to be exchanged because of dislocation and iris capture. In 1 eye, silicone oil droplets that adhered to a previously implanted silicone intraocular lens were removed with semifluorane liquid. Two eyes showed persistent ocular hypotony after macular translocation and silicone oil removal, with intraocular pressure not rising above 8 mm Hg. One patient developed persistent corneal decompensation and required a corneal transplant. Recurrent CNV occurred in 3 patients, with the vessels always growing toward the new foveal center; in 2 of these patients, the recurrent membrane complex was removed surgically, and in the other patient the CNV was treated by photocoagulation since it was excentric to the new foveal center. Proliferative vitreoretinopathy developed in 17 eyes after vitrectomy; 9 eyes developed it with silicone oil in place and 8 eyes developed it after silicone oil removal. A macular pucker was observed in 5 eyes, peripheral epiretinal membranes in 7 eyes, and a persistent macular hole in 1 eye. All vitreoretinal and epiretinal membranes were removed surgically, and the retina was reattached surgically in all eyes. The overall rate of retinal detachment (**Table 6**) was 19%. The rate of retinal detachment was higher for eyes with occult CNV (mean, 23%; 95% CI, 11.1%-39.3%) than for eyes with classic CNV (mean, 12%; 95% CI, 2.5%-31.2%). The final reattachment rate was 100%; in 3 of 90 eyes this was achieved by a permanent silicone oil tamponade. Subretinal perfluorocarbon droplets of various sizes could be observed in 5 eyes and were usually removed during silicone oil removal via a small retinotomy. Silicone oil removal took place after 46 to 451 days (median, 119 days); permanent silicone oil tamponade was indicated in 3 patients. Seventy-five patients showed conspicuous areas of hyperpigmentation and hypopigmentation reflecting alterations of the RPE within the arcades. Macular edema seen as late intraretinal fluorescein leakage, presumably from retinal vascular origin rather than occult recurrence, often with cystoid aspect, was observed in 26 eyes. Recurrent CNV, a vascular net with progressive leakage in the late phase, was detected in 3 patients by angiography. No systemic medical complications related to the treatments in this study were observed.

Table 6. Complications: Rate of Retinal Detachment

	No Retinal Detachment	Retinal Detachment	Total
Classic			
No.	22	3	**25**
% Of all patients	24.4	3.3	27.8
% Of classic	88.0	12.0	**100.0**
% Of column total	30.1	17.6	. . .
Occult			
No.	30	9	**39**
% Of all patients	33.3	10.0	43.3
% Of occult	76.9	23.1	**100.0**
% Of column total	41.1	52.9	. . .
Hemorrhage			
No.	21	5	**26**
% Of all patients	23.3	5.6	28.9
% Of hemorrhage	80.8	19.2	**100.0**
% Of column total	28.8	29.4	. . .
Total			
No.	**73**	**17**	**90**
% Of all patients	81.1	18.9	**100.0**

COMMENT

In this report we present the results of a large consecutive series of patients who underwent macular translocation with 360° retinotomy for the treatment of exudative AMD with a follow-up of at least 1 year.

The technique used in the series of 90 patients reported herein is a modification of the macular translocation technique originally proposed by Machemer and Steinhorst.[22,30] In this surgical approach, the retina is detached from the RPE and rotated, so that the fovea is relocated in contact with an area of healthy-appearing RPE. Theoretically, if the fovea is relocated in contact with healthy RPE, there is the potential of improved visual function. Currently, 2 surgical approaches are used to achieve translocation of the macula: macular translocation with large retinotomies of up to 360° or limited rotation using scleral shortening or scleral imbrication. Macular translocation with a large retinotomy allows the treatment of larger lesions than is possible with the technique of limited rotation first described by de Juan et al[24] and modified by other investigators.[31-35]

In regard to binocular vision or subjective monocular cyclorotation, reestablishment of binocular function after macular translocation is feasible and was achieved in our study in part by counterrotation of the globe. Seventy-two percent of the patients without binocular function excluded 1 eye and thus had no complaints, whereas 28% of patients without binocular function were disturbed by persistent diplopia. The search for more effective techniques of muscle surgery and a refined indication for macular translocation and counterrotation of the globe could help to reduce the number of patients with diplopia and cyclorotation.[36]

In a small number of our patients who underwent macular translocation, we performed conventional and multifocal electroretinograms preoperatively and at 1 month postoperatively. The electrophysical data from these patients showed a reduction of photopic and scotopic amplitudes after macular translocation with 360° retinotomy. The mean b-wave amplitude reduction of the scotopic electroretinogram was about 67%, and the reduction of the photopic ERG was about 43%. Our electroretinographic results[37] do not agree with the findings in the 1 patient described by Potter and coworkers,[38] who recorded a significant increase in mean foveal amplitude after macular translocation surgery.

At present, macular translocation seems to be a promising therapeutic option for stabilizing or improving vision in patients with AMD. Compared with other available treatment modalities for AMD, we found a stabilization of baseline visual acuity during 1 year in our series. Our results show that visual acuity improved significantly in 24 of 90 patients after 12 months. In 25 of 90 patients, a secondary procedure was necessary because of formation of proliferative vitreoretinopathy, which could be reduced by improving the surgical technique and shortening the duration of surgery. A concern with macular translocation is that visual acuity worsened in some patients, even when no intraoperative or postoperative complications were present. Histologic examinations suggest that the worsening visual acuity may result from the translocation of a substantial part of the pigment epithelium along with the retina.[39] The association between the type of membrane, the condition of the pigment epithelium, and the adhesion between pigment epithelium and retina has been discussed elsewhere.[39,40]

The specific indications for macular translocation have not yet been defined. The results of our study show a significantly better functional outcome after macular translocation in patients with classic CNV or hemorrhages than in patients with occult CNV. One reason for better functional results in eyes with classic membranes might be a shorter period of deterioration of visual acuity preoperatively. This factor could be related to a higher improvement rate in this group of patients.

Furthermore, the rate of retinal detachment, the predominant retinal complication after macular translocation, was lower in patients with classic CNV than in patients with occult CNV. Since few trials have been reported, and usually with small numbers of patients and short follow-up, it is difficult to compare our result with those of other published studies.[41] The study by Eckardt et al[23] is the major study that used techniques similar to those reported herein. Eckardt et al reported the results from 30 patients who underwent macular translocation with a 360° retinotomy in patients with CNV secondary to AMD, which included occult and classic CNV as well as subretinal hemorrhage. Eckardt et al combined macular translocation with muscle surgery for counterrotation of the globe to compensate for torsional diplopia and tilted image. During an average 10.5 months of follow-up, 22 of 30 patients showed stable or better visual acuity, and only 4 eyes showed a loss of visual acuity of 3 or more lines. Other complications observed during the follow-up period included recurrence of AMD in 3 patients, proliferative vitreoretinopathy in 3 patients, macular pucker in 2 patients, cystoid macular edema in 4 patients, and corneal decompensation requiring keratoplasty in 1 patient.[23] Machemer and Steinhorst[22] described 3 patients with submacular hemorrhage secondary to AMD who underwent macular translocation by creation of a total retinal detachment and a 360° peripheral retinotomy, removal of the subretinal hemorrhage, and rotation of the retina. In these patients, retinal rotation varied from 30° to 80°; patients complained of postoperative cyclotorsion of 30° to 50°, and 2 of the 3 patients developed severe proliferative vitreoretinopathy. Ninomiya et al[42] reported macular translocation in 2 patients in whom the temporal retina was detached; they created a 180° retinal flap, removed the neovascular membrane, relocated the macula, and reattached the retina with silicone oil. Both patients developed epiretinal membranes postoperatively; 1 patient underwent 4 reoperations to reattach the retina and to excise proliferative vitreoretinopathy and neovascular glaucoma membranes. Visual acuity increased in the first patient and markedly decreased in the second patient.[42] Wolf et al[43] reported improvement in visual acuity in only 1 of 7 patients treated with macular translocation with the use of a 360° retinotomy without muscle surgery. Postoperative complications included retinal detachment in 3 eyes and macular pucker in 1 eye.[43]

Compared with laser photocoagulation and photodynamic therapy, macular translocation with 360° retinotomy offers the possibility to treat patients with classic CNV as well as occult CNV or massive hemorrhages. Precise indications for macular translocation have not been well defined and should evolve as more information becomes available from controlled prospective trials. As more experience is gained with these surgical techniques and more refinements are introduced, the visual outcome could also improve. A critical problem in comparing results from various investigators is the fact that macular translocation surgery requires substantial experience in vitreoretinal surgery. The future role of macular translocation with 360° retinotomy is currently being evaluated in prospective randomized multicenter studies.

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