A Comparison of Macular Translocation with Patch Graft in Neovascular Age-Related Macular Degeneration

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Purpose. To compare the long-term outcomes of macular translocation (MT) and autologous RPE–choroid patch graft (PG) in patients with neovascular age-related macular degeneration (AMD).

Methods. This is a retrospective review of the first 12 patients who underwent MT and the first 12 patients who underwent PG. Visual acuity (VA), contrast sensitivity (CS), clinical findings, and complications were recorded. Microperimetry and fundus imaging were reviewed. Outcome measures were the change in VA and CS over 3 years in each group and rates of complication. Microperimetry and fixation in three best cases from each group were described.

Results. The two groups were matched for age and VA. Median follow-up durations were 41 (MT) and 38 (PG) months. Median VA (logMAR) was maintained in the MT group: 0.90 at baseline and 0.69 at 3 years (P = 0.09) whereas in the PG group, median VA declined from 0.87 to 1.38 at 3 years (P < 0.001). Both surgical modalities had high rates of detachment and macular edema. Although more extensive RPE damage occurred in PG, the graft resisted growth of recurrent choroidal neovascularization toward the fovea. Near normal VA was achievable by each technique but macular sensitivity and fixation were superior in the MT group.

Conclusions. In the present cohort, MT maintained VA for 3 years but PG did not. This outcome may be related to the differences in surgical approach, source of RPE, and choroidal perfusion. The authors recommend MT in preference to PG for treatment of patients with the second eye affected by neovascular AMD unsuitable for other treatment. (Invest Ophthalmol Vis Sci. 2009;50:1848–1855) DOI:10.1167/iovs.08-2845

Age-related macular degeneration (AMD) is a disease that primarily involves the retinal pigment epithelium (RPE), Bruch’s membrane, and the choroidal circulation resulting in secondary loss of retinal function.1 Choroidal neovascularization (CNV) is a devastating complication that can now be treated using anti-vascular endothelial growth factor (anti-VEGF) agents. However, treatment of patients who present with or subsequently develop massive submacular hemorrhage, RPE tear, or geographic atrophy (GA) remains controversial. Surgical reconstruction of the submacular space, or maculoplasty may be an option for these patients.2

Concepts in surgical treatment for neovascular age-related macular degeneration (AMD) have evolved over the past two decades.3 At its conception, the intent of surgery was similar to those of nonsurgical approaches such as laser photocoagulation, photodynamic therapy (PDT), and anti-VEGF agents, in that they either removed, ablated, or induced regression of the CNV.4-6 However, macular translocation with 360° retinotomy (MT) and autologous RPE–choroid patch graft (PG) have been investigated as an alternative approach to treatment of the residual effect in the submacular RPE and choroid after removal of CNV.7-10 Aisenbrey et al.11 reported the long-term outcomes (mean follow-up of 38.2 months) after MT, with three quarters of eyes losing fewer than three lines. MacLaren et al.12 reported long-term survival of macular PG in four patients, although they had loss of fixation and autofluorescence signal over the grafts after 5 years. Instead of harvesting PG from the macular region, van Meurs and Van Den Biesen10 described a modified technique of using equatorial PG to reconstitute submacular RPE defect. The same group reported a slightly higher rate of vision stabilization and improvement after PG surgery in the 11 patients who were observed for 4 years.13 However, there has been no report comparing the long-term outcomes and quality of visual function between MT and equatorial PG when performed in the same center by the same surgeon.

We have reported the 6-month to 1-year outcome of MT in 26 patients and equatorial PG in 12 patients from our institution.14,15 In this study, we sought to compare the 3-year outcomes after the use of these two surgical techniques. To explore the best possible visual outcome, we also describe the quality of vision, measured by detailed microperimetry, in the three best cases from each group.

Materials and Methods

Patients

The medical charts from the first 12 patients who underwent MT (from May 2003 to April 2005) and the first 12 patients who underwent PG (from August 2004 to June 2005) were reviewed. At the time of enrollment, anti-VEGF therapy was not available, and PDT was indicated only for treatment of predominantly classic lesions, as outlined by the National Institute for Health and Clinical Excellence of the United Kingdom. This research adhered to the tenets of the Declaration of Helsinki and was approved by our institutional review board, the Research Governance Committee of Moorfields Eye Hospital. All patients gave consent to participate in the original pilot studies in MT and PG surgery, which were previously approved by the Ethics Committee.

Surgical Technique

The surgical techniques of MT and PG are similar to those described previously.8,10,16 All surgical procedures were performed by the same
author (LDC) except for three PGs, which were performed by another author (GWA).

In brief, MT surgery began with phacoemulsification with intraocular lens (IOL) implant, followed by vitrectomy, detachment of the posterior hyaloid and vitreous base shaving. Retinal detachment was induced using a flexible, dual-bore 41-gauge cannula (1270.0.100; Synergetics, St. Louis, MO) and extended to total detachment by two or three air-fluid exchanges. After a 360° retinotomy was created with the vitreous cutter, the temporal retina was flapped over the disc, nasally, with Eckardt ring-end forceps (1286-QM; DORC, Zuidland, The Netherlands) to allow removal of the CNV and any subretinal fluid. A small bubble of perfluoro-n-octane heavy liquid (Perfluoron; Alcon Laboratories Inc., Fort Worth, TX) was then placed onto the disc to flatten the posterior pole. A Tano stiff diamond-dusted membrane scraper (model 20.07; Synergetics) was used to grip the retinal surface and rotate the fovea away from the RPE defect. The entire vitreous cavity was filled with heavy liquid followed by a 360° laser retinotomy. Heavy liquid was then directly exchanged for silicone oil. Two months after MT a combined counterrotation surgery and removal of silicone oil was performed.

For PG surgery, we performed vitrectomy, separation of the hyaloid and removal of CNV through a superonasal or supertemporal macular retinotomy. The donor site, at the superior equator, was first surrounded with contiguous argon laser photocoagulation and the graft was then cut out with vertical scissors and separated from the sclera. While the graft was grasped on the choroidal side by a specialized aspirating reflux spatula, the retina was peeled off and the remaining RPE–choroid patch inserted into the submacular space. The macular bleb detachment was then flattened with perfluoro-n-octane liquid which also facilitated the release of PG from the spatula. After laser retinotomy around the donor site, the eye was filled with silicone oil. Two months later, the patients underwent combined phacoemulsification, silicone oil removal, and IOL implant.

Case Mix Matching
The first 12 cases from the initial pilot studies were chosen to match surgical learning curves. To determine whether the two patient groups were similar, an experienced observer (PJP) performed masked grading of baseline lesion characteristic and size for all 24 patients, according to the Macular Photocoagulation Study criteria. Surgical notes were reviewed to identify intraoperative complications and for scoring of intraoperative course using the scoring system for PG as described by Maaijwee et al.18

Outcome Variables
The main outcome measure was recorded best corrected visual acuity (VA) at baseline and 1, 2, and 3 years after surgery. Secondary outcome measures included contrast sensitivity (CS) and anatomical status of the retina, macula, and RPE.

We reviewed the documented clinical findings, fundus angiographies, and autofluorescence and optical coherence tomography (OCT) images to determine whether there was atrophy of the retina and RPE, macular edema, or recurrent CNV. The last observation carried forward method was required for the 3-year VA and CS data in two patients from each group. Three cases with the best VA from each group were chosen for further descriptive analysis of fixation and retinal sensitivity derived from microperimetry.

Best corrected VA measurements from the Early Treatment of Diabetic Retinopathy Study (ETDRS) chart or the Snellen chart were converted to logarithm of the minimum angle of resolution (logMAR) for analysis.19 CS was measured on the Pelli-Robson chart at 1 m and expressed as the logarithm of CS (logCS).20 Clinical documentation of epiretinal membrane, macular edema, CNV, and retina–RPE atrophy were noted and confirmed by review of fundus imaging. Fundus color photography was performed (TRC-50 IA/IMAGEnet H1024 system; Topcon, Tokyo, Japan), and OCT was acquired (StratusOCT, software ver. 4.0; Carl Zeiss Meditec, Inc., Dublin, CA, or the 3D OCT-1000, software version 2.12; Topcon). The status of the RPE was examined by fundus autofluorescence and captured with a scanning laser ophthalmoscope (SLO; Heidelberg Retina Angiograph II [HRA II], Heidelberg Engineering GmbH, Dossenheim, Germany).

A microperimeter (MP-1; Nidek Technologies, Padova, Italy) was also used for assessment of fixation stability and retinal sensitivity in selected patients. A fixation test was performed with a 1° white cross fixation target, with the patient instructed to look at the center of the cross. A 30-second recording of fixation loci was made and stability was quantified in two ways: by the proportion of fixation points within 2° from the gravitational center of all fixation points as proposed by Fuji et al.5,21 or by the bivariate contour ellipse area (BCEA) as described by Steinman.22,23 Blink artifacts, seen as isolated large fixation deviation from the gravitational center in the fixation time profile graph provided by the software (NAVIS, ver. 1.7.2; Nidek), were removed to allow calculation of BCEA. Microperimetry was performed with manually customized and preset test grids, 4-2 staircase strategy and Goldmann III size stimulus of 200-ms duration. The local defect map provided by the software was used for analysis. Mean sensitivity within central 10° and 20° were calculated. The local defect map was overlaid and correlated with autofluorescence images.

Statistical Analysis
Baseline characteristics were compared between the MT and PG groups with the Fisher exact test (sex, lesion type) and Mann-Whitney U test (age, duration of symptoms, lesions size, VA, and CS). Change in VA and CS between baseline and follow up visits were analyzed with the nonparametric repeated-measures Friedman test. Data were analyzed with commercial software (Statistical Package for the Social Sciences, ver. 14.0; SPSS, Inc., Chicago, IL). P < 0.05 was considered statistically significant.

RESULTS
Baseline Features
The median age for the MT and PG groups were 72 and 78 years, respectively (P = 0.05). Distribution of sex was not significantly different between the two groups (P = 0.1). A summary of lesion characteristics and size in each group is shown in Table 1. The duration of symptoms before surgery in the MT group was longer compared with the PG group, mean of 11 and 5 weeks (P < 0.001). Six and eight patients in the MT and PG group, respectively, had >50% of the lesion component comprising of CNV. There was a large variation in the size of the lesion, ranging from 4 to 46 disc areas with the median size being 8 and 17 disc areas in the MT and PG group, respectively (P = 0.4). There was no significant difference in the baseline median VA (logMAR) between the MT (0.90 or 20/160) and the PG groups (0.87 or 20/150) (P = 0.44). However, median CS (logCS) was better in the PG (0.75) than the MT (0.38) group (U = 39.0, P = 0.05) at baseline. All patients had foveal fixation determined on the slit lamp before surgery.14

Surgical Outcomes
MT surgery was combined with phacoemulsification and intraocular lens (IOL) implant in 11 patients. Chorioretinal adhesion at the macula precluded translocation in two patients. The remaining nine patients had 45° to 60° of foveal rotation without any complication. Combined globe counterrotation (10/12) and removal of oil (11/12) was performed a median of 12 weeks after MT. Residual oil required further surgery in three patients and the median time to final removal of oil was 15 weeks. In two patients, residual torsion of greater than 50° required further extracocular muscle surgery at ~9 months.
PG surgery was performed in 11 phakic eyes. We found that 9 of 12 had CNV removal in one piece, 11 of 12 had insertion of graft in one move, 3 of 12 had no submacular manipulation, 5 of 12 had two or more manipulations of the graft, and none had significant submacular choroidal hemorrhage. One patient had intraoperative giant retinal tear. Combined phacoemulsification (11/12) and removal of oil and the IOL implant were performed a median of 17 weeks after PG. However, in three patients, oil was reinjected for repair of retinal detachment and removed at 6 and 22 months later in two patients, respectively. The retina was attached at 1 year in all 24 patients. However, within the first year, three patients in the MT group had three detachments under the oil that were repaired, and one patient in each group still had oil tamponade at 45 (PG) and 48 (MT) months.

**Functional Outcomes**

The median (range) follow-up duration was 41 (24–56) and 38 (26–45) months in the MT and PG groups, respectively. In the MT group, five (42%) and three (25%) eyes at 1 and 3 years, respectively, had 3 lines or more gain in VA. In contrast, only 1 patient (8%) had gain of 3 lines at 1 year but none at 3 years after PG. At 3 years, nine (75%) and six (50%) of the patients from MT and PG groups had a less than 3-line loss of VA, respectively. At both 1 and 3 years, six (50%) eyes and one (8%) eye from the MT and PG groups, respectively, had VA of 20/80 (0.60 logMAR) or better. Figure 1 shows the change in VA and CS over 3 years after MT and autologous retinal pigment epithelium-choroid PG.

**Structural Outcomes**

All 24 patients had postoperative serial OCT and fundus autofluorescence imaging for correlation with clinical findings. In the MT group, clinical and OCT assessments of the macula at 1 year revealed no retinal thickening, intraretinal

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**Table 1. Baseline Features of Patients Undergoing Macular Translocation and Patch Graft Surgeries**

<table>
<thead>
<tr>
<th>Baseline Features</th>
<th>MT</th>
<th>PG</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>72 (57, 95)</td>
<td>78 (73, 91)</td>
<td>0.05*</td>
</tr>
<tr>
<td>Predominant lesion type</td>
<td>6 (0, 0, 5)</td>
<td>0.7†</td>
<td></td>
</tr>
<tr>
<td>CNV (classic, mixed, occult)</td>
<td>6 (5, 1)</td>
<td>0.41*</td>
<td></td>
</tr>
<tr>
<td>Total lesion size (DA)</td>
<td>8.4 (3.6, 40.4)</td>
<td>17.4 (5.1, 46.6)</td>
<td>0.41*</td>
</tr>
<tr>
<td>Duration of symptoms (wk)</td>
<td>10.5</td>
<td>5.0</td>
<td>0.00*</td>
</tr>
<tr>
<td>Baseline VA (logMAR)</td>
<td>0.90 (0, 1.70)</td>
<td>0.87 (0.38, 1.20)</td>
<td>0.44*</td>
</tr>
<tr>
<td>Baseline CS (logCS)</td>
<td>0.38 (0.00, 1.05)</td>
<td>0.75 (0.15, 1.35)</td>
<td>0.05*</td>
</tr>
<tr>
<td>Surgery dates</td>
<td>Range: May 2003 to April 2005</td>
<td>August 2003 to June 2005</td>
<td></td>
</tr>
<tr>
<td>Surgeons</td>
<td>LDC (9 eyes)</td>
<td>GWA (3 eyes)</td>
<td>—</td>
</tr>
</tbody>
</table>

* Mann-Whitney U test.
† Fisher exact test.
cysts, subretinal fluid, or subretinal tissue in 6 of 12 eyes. However, one developed a full-thickness macular hole and two showed small intraretinal cystic changes on OCT after 2 years. In the other six eyes, large intraretinal cysts were present, of which, two had insufficient or no foveal rotation, two were related to CNV detected at 2 to 3 months after MT, and two were associated with dense epiretinal membranes that developed at 6 to 7 months after MT. In the latter two patients, edema did not resolve despite peeling of the membranes. Overall, four patients had residual or recurrent CNV, all detected within the first 3 months.

In the PG group, all patients had distorted outer retinal structure due to the irregular RPE surface of the graft (Fig. 2). Although foveal depression was seen in 6 patients, all 12 had cystic changes in the retina over the graft accompanied by various amounts of atrophy and thickening. Overall, four patients developed recurrent CNV (2 within 1 year and 2 after 1 year). None of the recurrent CNV invaded the PG. All grafts also had focal hyperpigmentation which became darker over time. Donor sites were free from any CNV during follow-up.

The intensity of autofluorescence in the foveal region did not appear to change over time but the size of RPE defect (at the inferior arcade after MT or surrounding the entire PG) enlarged (Fig. 2). Loss of autofluorescence around the PG was prominent in all cases of PG (Fig. 2).

**Microperimetry in the Best Cases**

Table 2 summarizes the outcomes in the three best cases of each group. Figure 3 shows that in MT, dense scotomas were present only in areas where CNV was removed (dark areas on fundus autofluorescence image) but relative scotoma (below 3 SD of the normal retinal sensitivity in NAVIS software database; Nidek) was widespread. In contrast, the region with dense scotoma was large after PG, even over parts of the graft itself and the surrounding area despite the presence of an autofluorescence signal (Fig. 3).

**Table 2. Comparisons of Foveal and Macular Functions in the Three Best Cases from MT and PG Surgeries**

<table>
<thead>
<tr>
<th>ID</th>
<th>Predominant Lesion Features (Size, DA)</th>
<th>VA (logMAR), Symptom Duration (wk)</th>
<th>Follow-Up Time Point (mo)</th>
<th>Visual Function</th>
<th>Fixation Stability*</th>
<th>Retinal Sensitivity†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CS (log CS)</td>
<td>VA (logMAR)</td>
<td>% within 2°</td>
<td>BCEA (minarc²)</td>
<td>10°, MS (min, max, dB), Number of Loci</td>
</tr>
<tr>
<td>MT03</td>
<td>CNV, occult (9)</td>
<td>0.44, 6</td>
<td>28</td>
<td>0.10</td>
<td>1.65</td>
<td>100</td>
</tr>
<tr>
<td>MT08</td>
<td>CNV, occult (4)</td>
<td>0.60, 12</td>
<td>24</td>
<td>0.38</td>
<td>1.50</td>
<td>100</td>
</tr>
<tr>
<td>MT09</td>
<td>CNV, occult (7)</td>
<td>1.60, 6</td>
<td>20</td>
<td>0.12</td>
<td>1.65</td>
<td>100</td>
</tr>
<tr>
<td>PG04</td>
<td>CNV, occult (12)</td>
<td>0.86, 3</td>
<td>12</td>
<td>0.10</td>
<td>0.90</td>
<td>99</td>
</tr>
<tr>
<td>PG05</td>
<td>CNV, occult (47)</td>
<td>0.46, 6</td>
<td>16</td>
<td>0.64</td>
<td>1.05</td>
<td>100</td>
</tr>
<tr>
<td>PG08</td>
<td>Hemorrhage (27)</td>
<td>1.04, 2</td>
<td>9</td>
<td>0.68</td>
<td>1.05</td>
<td>98</td>
</tr>
</tbody>
</table>

* All viewed a 1° white cross over 30-second recording at a rate of 25 Hz or every 40 ms.
† All viewed a Goldmann III, 200-ms stimulus, shown in a 4-2 strategy. Number of test loci also shown.
FIGURE 3. Pre- and postoperative images from patients MT03 (a–d), MT09 (e–h), PG04 (i–l), and PG08 (m–p). VA is shown in the bottom right corner and microperimetry color codes are shown at the bottom of the figure. Preoperative FA of patient MT03 at 2 minutes showed subfoveal occult CNV with subretinal hemorrhage (a). Postoperative microperimetry (using size Goldmann III, 200 ms white stimulus) at 28 months showed good retinal sensitivity in the macular region (b). Total deviation plot superimposed on autofluorescence (AF) image showed relative scotoma in central macula, dense scotoma over area of RPE defect but normal sensitivity (green) superonasally (c). Postoperative FA showed normal choroidal flush under the macula at 30 seconds (d). Preoperative FA of MT09 at 90 seconds showed subfoveal occult CNV with superior RPE rip (e). Postoperative microperimetry at 20 months showed retinal sensitivity present in the macular region (f). Total deviation plot superimposed on an AF image showed relative scotoma in most of the macular region and a dense scotoma over the area of RPE defect (g). Postoperative FA showed normal choroidal flush under the macula at 15 seconds (h). Preoperative FA of PG04 at 1 minute showed subfoveal minimally classic CNV (i). Postoperative microperimetry at 12 months showed a central island of sensitivity in the region of the graft (j). Total deviation plot superimposed on the AF image showed a dense ring scotoma surrounding an island of relative scotoma over the graft (k). Postoperative FA showed uneven choroidal flush in some areas of the graft at 20 seconds (l). Preoperative FA of PG08 at 2 minutes showed subfoveal massive subretinal hemorrhage (m). Postoperative microperimetry at 9 months showed retinal sensitivity in the nasal region of the graft (n). Total deviation plot superimposed on the AF image showed a relative scotoma over the graft but no area with normal sensitivity (o). Postoperative FA showed an uneven choroidal flush in some areas of the graft at 30 seconds (p).
**DISCUSSION**

This comparative study shows that in the best cases, either MT or PG can restore foveal function in patients with neovascular AMD; achieving near-normal levels of VA (0.10 logMAR or 20/25) and CS (1.65 logCS) within the first year. However, the long-term visual and structural outcomes of MT appears to be superior compared with PG. This difference does not appear to be related to the case mix or the surgical learning curves, discussed next.

Factors that have been proposed to determine visual outcomes after MT are preoperative features such as fixation stability, VA, duration of symptoms, lesion composition, and operative variables such as surgical experience and learning curve. Similarly, outcomes of PG surgery have also been shown to be related to lesion composition and intraoperative course. The baseline features of the two groups are unlikely to explain the superior outcome after MT in our cohort. Regardless of the specific preoperative prognostic factors, timing has been proposed as the most critical determinant since both MT and PG are rescue procedures that require the presence of viable photoreceptors. In our cohorts, the baseline VA, fixation and lesion composition were similar for the two groups; however, the shorter duration of symptoms in the PG group favor a better outcome after PG. A wide range of total lesion size was found in each group and the median lesion size in the PG group was larger than that in the MT group. However, this was not statistically significant. Furthermore, previous studies have reported that the lesion size was not a predictor of VA outcome in either MT or PG.

Although we have chosen only the first 12 cases, including all intra- and postoperative complications arising from surgical learning curves, the outcomes of MT and PG are similar to much larger case series of each technique. Aisenbrey et al. reported a 75% rate of less than a 3-line loss at 3 years (similar to results from our group) in a subset of 52 patients in a cohort of 90 patients. However, they showed a gradual loss of VA from a median of 1.00 logMAR at baseline to 1.20 logMAR at final examination after MT. In contrast, we found the median VA improved from 0.90 to 0.69 logMAR at 3 years. This inconsistency may be related to the high rate (61%) of secondary geographic atrophy (GA) in their study. Although we did not observe any secondary GA within the first three years after MT, the sharp drop in survival (defined as less than 3 line loss), as shown in the Kaplan-Meier plot in their report, suggests that GA may occur later. Early postoperative complication is unlikely to explain the difference, given the rates of retinal detachment (25%), macular edema (50%), and recurrent CNV (8%) in our first 12 cases are similar to those published previously.

Maaijwee et al. reported the 1- to 4-year outcome in a cohort of 83 patients with slightly poorer preoperative VA (0.95 logMAR) than our group (0.87 logMAR). They showed that the overall VA improved to a mean of 0.89 and 0.79 logMAR after 1 and 3 years. In contrast, our PG group had a decline of VA, to 1.43 and 1.38 logMAR at the same time points. Despite the difference in VA, the proportion of patients with VA of 20/80 or better was similar at 2 years: 17% (2/12) in our cohort and 13% (6/45), as reported by Maaijwee et al. The low postoperative VA in our group may be related to the high rates of retinal detachment (33%), graft hemorrhage (50%), and macular edema (50%), as shown in previous larger series of PG. From a review of the surgical notes, we found five patients who required two or more submacular manipulations of the graft. It is difficult to compare our scores of intraoperative course with that reported by Maaijwee et al. because their study was prospective and included a large number of cases.

Given that the case mix is similar and the learning curves are matched, the difference in outcome may be explained by other factors. We propose and discuss below, the contributions of surgical trauma and the source of RPE and choroidal perfusion to the better outcome with MT than with PG.

Surgical trauma to macular photoreceptors and donor RPE can occur during MT and PG surgery. Both techniques require mechanical retinal detachment (by subretinal injection or retinal peeling) at the recipient site, to allow removal of the CNV complex, and at the donor site, to enable translocation of the macula or the RPE–choroid patch. Trauma to photoreceptors and RPE occur during induced detachment because of disruption of the strong adhesive bond between these two layers. RPE damage after harvesting of PG has been demonstrated by electron microscopy. Further insult to the RPE and photoreceptor cells is likely to occur during insertion and manipulation of the PG in the submacular space. In contrast, rotation of the macula under heavy liquid is a much more controlled maneuver and is likely to be less traumatic than PG insertion, provided total retinal detachment has been induced. The microperimetry results showed contrasting patterns of scotoma that may reflect differences in the extent of iatrogenic damage to macular photoreceptor cells. In MT, a large scotoma inferior to the fovea corresponded to the area of RPE defect created by CNV excision. However, in patients undergoing PG, the ring scotoma in the absence of large areas of RPE defect may be related to surgical trauma to the macular photoreceptors during graft insertion and manipulation. Although the remaining central island of vision over the graft can maintain stable fixation and high spatial resolution, it does not provide the necessary horizontal visual span for reading tasks. Furthermore, should the central island of vision be lost, the alternative retinal fixation locus may be pushed much farther away from the fovea, since there is no adjacent functioning retina. Damage to the RPE and retina may also occur during silicone oil tamponade, although both have similar duration of oil in situ. Overall, PG technique may be more traumatic to macular photoreceptor cells and RPE than is MT. However, surgical trauma alone may not be the only explanation of the difference in outcome.

The source of RPE in MT is located at the vascular arcade (paramacula) when the macula is rotated 45° around the disc. In contrast, RPE outside the vascular arcade (equatorial) is chosen for harvesting of autologous RPE–choroid PG. Several studies have found topographic differences in RPE gene expression and Bruch’s membrane composition. Therefore, it is likely that there are also topographic differences in RPE function and that equatorial RPE may not be as suitable as paramacular RPE in providing long-term support for foveal cones. This result is consistent with our findings of delayed cystic degeneration or cystoid macular edema over the PG. However, the late occurrence of de novo GA after MT suggests that even paramacular RPE may not be an ideal substitute for submacular RPE in patients with AMD.

A major difference between the two types of surgical modalities is that in MT, perfused retina is rotated onto perfused choroid whereas in PG surgery, the RPE-choroid patch is a free graft that may not become perfused for several days after the procedure. During these first few days, the underlying damaged choroidal bed may not provide enough metabolic support for the outer retina through the entire thickness of the graft. Evidence of the first vascular connection between the graft and choroidal bed in a pig model appeared at 1 week. Clinically, perfusion of the graft can be visible on fluorescein or indocyanine green angiography in some patients at 1 week. Although most grafts are perfused by 1 month, it may be delayed for as long as 3 months. Graft reperfusion may depend on the vascularity of the wound bed, which may
be compromised by prior PDT or during the removal of CNV, and the presence of proangiogenic factors, which can be reduced by recent anti-VEGF therapy. Both of these are not relevant in MT. While graft perfusion is being established in the first few days, ischemic damage to the outer retina is likely to limit visual outcome. Despite this limitation, one advantage of PG is that it appears to resist invasion by recurrent CNV. This may be related to the thicker and less porous elastic layer of equatorial Bruch’s membrane or antiangiogenic factors produced by the equatorial RPE–choroid.14,40–50

Although this is the first comparison between the two types of surgical approaches in the treatment of neovascular AMD, its limitation is the small sample size. However, despite the small number of cases, we have shown that case mix and learning curves are unlikely to have contributed to the difference in outcome. We propose that lesser surgical trauma, the use of paramacular RPE, and instantaneous choroidal perfusion explain the superior outcome after MT. The difference in outcome is further supported by detailed microperimetry which revealed that normal fixation stability (BCEA of <1200 minarc2) and a retinal sensitivity of greater than 10 dB within the central 10° can be achieved consistently after MT but not after PG.22,51,52

In conclusion, current surgical techniques may be an option for patients with neovascular AMD who are otherwise ineligible for or nonresponsive to anti-VEGF therapy. Although both types of surgical approaches can rescue foveal function, our data suggest that MT with 360° retinotomy will achieve long-term visual outcome superior to that of PG in our cohort of patients. Therefore, we recommend MT in preference to PG as an option for treatment of second eyes with acute neovascular AMD unsuitable for anti-VEGF agents.35

References


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