Retinopathy Progression and Visual Outcomes After Phacoemulsification in Patients With Diabetes Mellitus

Robert A. Mittra, MD; Jesus L. Borrillo, MD; Sundeep Dev, MD; William F. Mieler, MD; Steven B. Koenig, MD

Objectives: To determine the rate of progression of diabetic retinopathy after phacoemulsification surgery, and whether surgeon experience and/or surgical duration adversely affect visual outcome.

Methods: A retrospective review of 150 eyes of 119 diabetic patients who underwent phacoemulsification surgery during a 5-year period was performed. Data collected included patient age, sex, type and duration of diabetes, diabetic control, associated systemic health factors, preoperative visual acuity and retinopathy grade, duration of surgery, intraoperative complications, and postoperative course. The effect of these factors on visual outcome and rate of retinopathy progression was studied by means of univariate and stepwise multivariate logistic regression analyses. Resident and private cases were compared.

Results: Visual acuity improved by 2 or more lines in 117 eyes (78%); 93 eyes (62%) had a final visual acuity of at least 20/40. Retinopathy progression was seen in 37 eyes (25%) with 6 to 10 months of follow-up. Preoperative nonproliferative diabetic retinopathy, proliferative diabetic retinopathy, and limited surgical experience were statistically associated with retinopathy progression and poor visual outcome.

Conclusions: The visual results and rate of retinopathy progression after phacoemulsification surgery in our series did not differ significantly from those reported that used other techniques. Nonproliferative and proliferative diabetic retinopathy and surgical inexperience resulted in an increased rate of retinopathy progression.

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From the Department of Ophthalmology, Eye Institute, Medical College of Wisconsin, Milwaukee (Drs Mittra, Borrillo, Dev, Mieler, and Koenig); and Retina Associates of Cleveland, Cleveland, Ohio (Dr Mittra). Dr Mieler is now with the Cullen Eye Institute, Baylor College of Medicine, Houston, Tex.

THE DEVELOPMENT or progression of retinopathy after intracapsular (ICCE) and extracapsular cataract extraction (ECCE) in diabetic patients has been well documented.[1-21] All types of progression have been noted, including the development of diabetic retinopathy (DR) where none previously existed, the development of macular edema from background retinopathy, and the development of proliferative disease from nonproliferative retinopathy. Rubeosis iridis and neovascular glaucoma have also been seen after ICCE, ECCE, and YAG laser capsulotomy.[1,14,17] Although more severe retinopathy progression was noted with ICCE, progression of DR has continued to be a significant problem, despite the advancement of surgical technique.

Cystoid macular edema (CME) is more common after cataract extraction in diabetic patients with preoperative retinopathy.[22,23] This may be caused, in part, by the increased breakdown of the blood-retinal barrier (BRB) or the enhanced inflammation that is seen in diabetic patients after cataract extraction.[24,25] Progression of retinopathy has also been noted in the setting of nonsurgical inflammation such as sarcoid uveitis, human immunodeficiency virus infection, and endophthalmitis.[26,27] The smaller incision size and shorter surgical duration provided by phacoemulsification surgery results in decreased postoperative inflammation and may result in less breakdown of the BRB.[28-34] If postoperative inflammation and breakdown of the BRB are involved in the pathogenesis of progression of DR after cataract extraction, then phacoemulsification surgery theoretically should result in a decreased rate of retinopathy production.

Two recent studies have evaluated phacoemulsification surgery in diabetic patients. Antcliff et al[35] in a retrospective study showed no difference between phacoemulsification and ECCE with regard to visual acuity or retinopathy progression. Wagner et al[36] showed no progression of retinopathy with phacoemulsification surgery when compared with fellow eyes in a prospective study. Both of these studies consisted predominantly of eyes that had

PATIENTS AND METHODS

By use of the surgical log of the Eye Institute of the Medical College of Wisconsin, Milwaukee, all cataract extractions performed using phacoemulsification techniques from January 1, 1992, through July 31, 1997, were reviewed. Informed consent was obtained for the surgery in all cases. Consecutive patients who had diabetes mellitus at the time of cataract extraction were identified. All patients were taking insulin or an oral hypoglycemic agent (no patients with diet-controlled diabetes were included). Phacoemulsification was performed using standard techniques. Private cases were performed by a single surgeon (S.B.K.). Resident surgeons had attending supervision in all instances. Patients were given topical ciprofloxacin hydrochloride and 1% prednisolone acetate postoperatively. Postoperative color fundus photography, fluorescein angiography, and laser therapy (YAG capsulotomy, focal/grid laser therapy for macular edema, and panretinal photocoagulation [PRP] for proliferative DR [PDR]) were performed when necessary.

The hospital chart, Eye Institute clinical record, and operative notes were reviewed thoroughly for each patient, and the following data were recorded: age and sex of patient; eye undergoing operation; type of diabetic therapy (insulin or oral); presence or absence of renal and heart disease and hypertension; fasting serum glucose level; preoperative best-corrected (pinhole or manifest refraction) distance visual acuity (Snellen charts); retinopathy stage; history of preoperative laser or other eye surgery; duration of cataract surgery from anesthesia records; operative complications; surgeon experience (private attending or resident); best-corrected postoperative visual acuity at 4 to 6 weeks, 2.5 to 4 months, and 6 to 10 months; retinopathy stage at each of the follow-up periods; and any complications or operative procedures performed during the follow-up periods.

All patients entered into the study were required to have at least 6 months of follow-up with documented results of fundus examination. Retinopathy progression was defined as follows: (1) the development of any retinopathy where none previously existed, (2) the development or progression of macular edema to clinical significance as defined by the Early Treatment Diabetic Retinopathy Study,[39] and (3) the development of PDR from nonproliferative DR (NPDR) or the recurrence of active PDR. Postoperative focal/grid laser therapy was performed for clinically significant macular edema as defined in the Early Treatment Diabetic Retinopathy Study, and PRP was performed for retinopathy with high-risk characteristics as defined in the Diabetic Retinopathy Study.[39,40]

For all cases, color photographs and fluorescein angiography were reviewed when available to ensure that the chart data recorded were accurate. For all cases of retinopathy progression, the applicable photographs and fluorescein angiography were reviewed. Particular attention was given to the distinction between pseudophakic CME and progression of diabetic macular edema (DME). Cases most consistent with CME were those with a petalloid pattern of hyperfluorescence and staining of the optic nerve without significant progression of microaneurysms or lipid exudate. Cases consistent with DME were those that displayed increased amounts of lipid exudate and hemorrhage without findings more characteristic of CME.

Statistical analysis of the data was performed by means of the Fisher exact test and *t* test to determine visual outcomes and retinopathy progression for various groups of patients. A univariate and a multivariate stepwise logistic regression were performed with SAS statistical software (SAS Institute Inc, Cary, NC) to determine which patient and surgical factors had a statistically significant (defined as $P<.05$) effect on postoperative visual outcome and retinopathy progression. Stepwise logistic regression is a technique that isolates the strongest predictors of a given outcome. Initial minimum significance to enter the stepwise progression was 0.30, and minimum significance to stay in the progression was 0.35. Specifically, this technique was used to study the relationship between retinopathy progression and the following factors: age, sex, insulin treatment, hypertension, renal disease, cardiovascular disease, retinopathy stage (no NPDR, NPDR, or treated PDR), duration of surgery, intact posterior capsule, surgery performed by a private physician vs that performed by a resident physician (private vs resident surgery), and fasting serum glucose level. The analysis was performed with control for the preoperative visual acuity. The same statistical technique was used to study the relationship between visual acuity improvement and the study factors noted above. Visual improvement was defined as an outcome of 20/20 or a difference of 0.20 logMAR units between preoperative and postoperative visual acuity. Odds ratios were calculated, with a ratio of greater than 1.00 indicating a greater risk for the condition. All visual acuities were converted to logMAR units for statistical analysis.[41]

no retinopathy on results of preoperative examination. This particular subset of eyes is known to do well after cataract extraction, with a low incidence of retinopathy progression and visual results approaching that of nondiabetic patients.[6,9,37] We sought to determine if phacoemulsification surgery would result in a decreased risk of progression in a large number of eyes with all levels of preoperative retinopathy. Furthermore, we wanted to determine whether prolonged surgical time, which is associated with increased postoperative inflammation, would effect a higher retinopathy progression rate.[38] Finally, we wanted to ascertain what effect on retinopathy progression there was, if any, with variations in surgeon experience and operative complications.

RESULTS

PATIENT CHARACTERISTICS AND PREOPERATIVE DATA

Of the 148 patients identified, 119 (150 eyes) had complete follow-up and clinical data as defined above and were included in the study. The average age at time of cataract extraction was 62.2 years. There were 79 female and 40 male patients. Of the 119 patients, 80 (67%) were receiving insulin, with the remainder taking hypoglycemic agents. Eighty-one patients (68%) had hypertension; 26 (22%), renal disease; and 49 (41%), coronary artery disease. Residents performed procedures in 105 eyes; an attending phy-

Table 1. Retinopathy Progression According to Preoperative Level of Disease and Physician Status*

Progression	Resident Physician, No. (%) of Eyes	Private Physician, No. (%) of Eyes
No retinopathy	5/48 (10)	0/8 (0)
NPDR	20/41 (49)	2/8 (25)
Treated PDR	6/16 (38)	4/29 (14)
All Eyes	**31/105** (30)	**6/45** (13)

**NPDR indicates nonproliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy.*

sician, in 45 eyes. The average preoperative visual acuity was 20/100 (range, hand motions to 20/30). The patient characteristics of the resident and private surgery groups, including the preoperative visual acuity, were not significantly different.

Preoperative laser therapy was performed on 53 eyes. Eight eyes underwent focal/grid laser therapy for DME; 32 eyes, PRP for proliferative retinopathy; and 13 additional eyes, both procedures. Laser therapy was performed in advance of cataract extraction, and the retinopathy was judged to be stable before cataract extraction except in 2 eyes with active DME that could not be treated because of the density of the cataract. Laser therapy was applied as soon as possible after removal of the lens.

One of these eyes received PRP for proliferative disease before cataract extraction and had a resolving vitreous hemorrhage at the time of surgery.

For 3 eyes, the cataract was advanced, and preoperative assessment of retinopathy was not possible. Immediately after lens removal, the retinopathy was judged and recorded. All 3 of these eyes had no retinopathy. Fifty-six eyes (37%) had no preoperative retinopathy, 49 (33%) had NPDR, and 45 (30%) had treated PDR.

INTRAOPERATIVE DATA

Phacoemulsification with placement of a posterior chamber intraocular lens was performed in all eyes except 1 that required placement of an anterior chamber lens. A posterior capsular tear was noted in 18 eyes (12%). Sixteen tears occurred in resident cases and 2 in private cases, a difference that was statistically significant ($P=.03$). The average surgical time for all cases was 53.3 minutes. Surgical time was longer in resident cases, however, with the average resident case taking 62.4 minutes and the average private case taking 28.8 minutes ($P<.001$). Longer cases were statistically associated with the development of a capsular tear. In 1 case, an inadvertent perforation during the retrobulbar anesthetic injection occurred. A postoperative vitreous hemorrhage with traction retinal detachment developed in this patient.

POSTOPERATIVE DATA

Retinopathy progression was demonstrated in 37 eyes (25%) during the follow-up period. Nonproliferative retinopathy developed in 5 eyes from no retinopathy preoperatively (1 with clinically significant [CS] DME); new or recurrent macular edema, in 26 eyes; and new or recurrent PDR, in 6 eyes (3 with CSDME also). Five of 56 eyes (5 resident cases, 0 private cases) that did not have preoperative retinopathy showed progression. Twenty-two of 49 eyes (20 resident cases, 2 private cases) with NPDR had progressive disease, and 10 of 45 eyes (6 resident, 4 private) with treated PDR had progressive disease (**Table 1**). The difference in progression between eyes in resident vs private cases was statistically significant ($P=.04$).

Eyes with progressive disease had a worse final visual outcome, with average visual acuity of 0.48 logMAR units (Snellen, 20/60) at 6 to 10 months compared with 0.26 logMAR units (Snellen, >20/40) for those eyes without progression ($P=.006$). Eyes with progressive disease had an average surgical time of 60.9 minutes, whereas those without progression of retinopathy had a surgical time of 47.6 minutes ($P=.01$).

There was significant improvement in visual acuity postoperatively for all levels of preoperative retinopathy (none, $P<.001$; NPDR, $P<.001$; treated PDR, $P=.001$; and overall, $P<.001$). Visual acuity improved by at least 2 lines in 117 eyes (78%). Visual acuity was at least 20/40 in 93 eyes (62%), and at least 20/25 in 71 (47%). The overall average change in visual acuity at 6 to 10 months of follow-up was 0.41 logMAR units (approximately 4 lines of vision). **Table 2** displays the average postoperative visual acuity and percentage of patients achieving at least 20/40 or no better than 20/200 visual acuity for different levels of preoperative retinopathy.

Conversely, the preoperative visual acuity was 20/200 or worse in 14 eyes (9%) (14 patients). The average age of these patients with poor outcome was 68.5 years. Ten patients were female, 12 were insulin dependent, 8 had hypertension, and 9 had cardiovascular disease. Seven eyes underwent surgery with a private attending surgeon and 7 with residents. The mean preoperative visual acuity for this group of eyes was poor (1.12 logMAR units, or <20/200). Ten eyes had a visual acuity of less than 20/200 preoperatively due to previous tractional retinal detachment (n=2), macular hole (n=1), anterior ischemic optic neuropathy (n=1), severe PDR (n=3), and severe macular edema (n=3).

Postoperatively, a traction retinal detachment developed in 1 of these eyes, and macular ischemia developed in another. Of 4 eyes with a preoperative visual acuity of better than 20/200, a traction retinal detachment after cataract extraction developed in 1 patient, another demonstrated macular ischemia postoperatively, and CSDME requiring laser therapy developed in 2 eyes. The average surgical time for this group of eyes was not statistically different from that of eyes with good visual outcomes.

Laser therapy was recommended to all patients in whom CSDME or PDR with high-risk characteristics developed postoperatively. Twenty-seven eyes (18%) received postoperative focal/grid laser treatment, and 6 eyes (4%) received postoperative PRP (1 eye had PRP during a vitrectomy procedure). A YAG laser capsulotomy was recommended in 11 eyes and performed in 10 (7%). Two pars plana vitrectomies were performed during the postoperative period. One patient had a persistent wound leak, and the other had a dislocated posterior chamber lens postoperatively that was repositioned at 3 weeks.

Table 2. Average Postoperative Visual Acuity and Percentage of Patients 20/40 or Better for Different Levels of Preoperative Retinopathy*

Preoperative Retinopathy	Average Postoperative Visual Acuity, logMAR Unit†	Visual Acuity	
		Patients With ≥20/40 in Each Group, No. (%) of Eyes	Patients With ≤20/200 in Each Group, No. (%) of Eyes
None	0.19 (20/30)	38/56 (68)	2/56 (4)
NPDR	0.30 (20/40)	33/49 (67)	4/49 (8)
PDR	0.47 (20/60)	24/45 (53)	8/45 (18)

*Abbreviations are given in the footnote to Table 1.
†Data given in parentheses are approximate visual outcomes in Snellen visual acuity.

Table 3. Univariate Logistic Regression for Retinopathy Progression*

Variable	Odds Ratio (95% Confidence Limits)	P
NPDR	8.31 (2.83, 24.41)	<.001†
Treated PDR	2.91 (0.92, 9.26)	.07
Sex	1.31 (0.58, 3.00)	.52
Age >65 y	0.62 (0.29, 1.32)	.22
Insulin therapy	1.98 (0.86, 4.60)	.11
Hypertension	0.64 (0.30, 1.37)	.25
Renal disease	1.26 (0.52, 3.03)	.61
Cardiovascular disease	0.82 (0.38, 1.77)	.61
Surgical duration >60 min	1.54 (0.73, 3.26)	.26
Ruptured posterior capsule	0.85 (0.31, 2.37)	.76
Private physician	0.37 (0.14, 0.96)	.04†

*Abbreviations are given in the footnote to Table 1. Odds ratio of greater than 1.00 denotes increased risk; less than 1.00, decreased risk; and 1.00, no apparent increased or decreased risk.
†Denotes statistical significance.

Table 4. Univariate Logistic Regression for Visual Improvement of at Least 2 Lines*

Variable	Odds Ratio (95% Confidence Limits)	P
NPDR	0.34 (0.13, 0.90)	.03†
Treated PDR	0.25 (0.10, 0.65)	.005†
Sex	1.32 (0.62, 2.80)	.47
Age >65 y	0.83 (0.41, 1.70)	.61
Insulin therapy	0.56 (0.25, 1.23)	.15
Hypertension	2.38 (1.14, 4.94)	.02†
Renal disease	0.82 (0.35, 1.92)	.64
Cardiovascular disease	0.90 (0.43, 1.86)	.78
Surgical duration >60 min	1.54 (0.73, 3.25)	.26
Ruptured posterior capsule	1.24 (0.47, 3.30)	.67
Private physician	1.30 (0.58, 2.88)	.53

*Abbreviations are given in the footnote to Table 1. Odds ratios are defined in the first footnote to Table 3.
†Denotes statistical significance.

Univariate logistic regression analysis of the data using a number of patient and surgical factors outlined above showed that NPDR and surgical inexperience were associated with retinopathy progression (**Table 3**). The presence of NPDR and PDR were associated with a decreased visual outcome, whereas the presence of hypertension was associated with visual improvement (**Table 4**).

Stepwise multivariate logistic regression revealed that NPDR, treated PDR, and resident surgery were associated with retinopathy progression (**Table 5**). Private surgery and hypertension were associated with visual improvement, whereas NPDR and PDR were not (**Table 6**).

Table 5. Stepwise Logistic Regression Analysis for Retinopathy Progression*

Variable	Odds Ratio (95% Confidence Limits)	P
NPDR	12.06 (3.70, 39.32)	<.001†
Treated PDR	6.94 (1.82, 26.44)	.005†
Hypertension	0.60 (0.24, 1.46)	.26
Cardiovascular disease	0.54 (0.21, 1.40)	.20
Resident physician	3.89 (1.23, 12.35)	.02†

*Abbreviations are given in the footnote to Table 1. Odds ratios are defined in the first footnote to Table 3.
†Denotes statistical significance.

COMMENT

Our retrospective series of phacoemulsification in diabetic patients shows that even with a significant percentage of eyes displaying preoperative retinopathy of some type (63%), good visual outcomes are still possible. Final visual acuity of 20/40 or better was seen in 62% of eyes and of 0/25 or better in 47% of eyes. These outcomes are slightly worse than those obtained by Antcliff et al[35] (74% of eyes with 20/40 or better) in another series of diabetic phacoemulsification surgery; however, most of the patients in that series did not have preoperative retinopathy. Poor visual outcome (20/200 or worse) was seen in 9% of eyes in our study. This appeared to be related to poor preoperative visual acuity secondary to causes other than cataract (eg, ischemic optic neuropathy, retinal detachment) or to postoperative progression of DR.

Progression of retinopathy was seen in 25% of eyes in our study. This percentage is lower than that seen in many recent series of phacoemulsification and ECCE in diabetic patients (Antcliff et al,[35] 34%; Pollack et al,[7] 38%; and Henricsson et al,[16] 43%); however, comparison between studies with different patient populations and levels of preoperative retinopathy are problematic. In an ear-

Table 6. Stepwise Logistic Regression Analysis for Visual Improvement of at Least 2 Lines*

Variable	Odds Ratio (95% Confidence Limits)	*P*
Hypertension	3.46 (1.48, 8.08)	.004†
Surgical duration	2.19 (0.80, 6.00)	.13
Ruptured posterior capsule	1.97 (0.61, 6.32)	.26
Private physician	10.57 (2.59, 43.07)	.001†
NPDR	0.34 (0.12, 0.99)	.05†
Treated PDR	0.11 (0.03, 0.39)	<.001†

**Abbreviations are given in the footnote to Table 1. Odds ratios are defined in the first footnote to Table 3.*

†*Denotes statistical significance.*

lier study performed at our institution that used ECCE techniques, diabetic patients with preoperative nonproliferative retinopathy showed a progression rate of 37%.[5] If we examine patients in our current study with preexisting NPDR, 45% of these eyes had progressive disease. From this historical analysis, surgery using phacoemulsification techniques does not appear to decrease the rate of retinopathy progression.

A statistically significant difference in progression was seen when comparing eyes that underwent surgery by attending surgeons with that performed by residents ($P=.04$). Resident surgery was significantly longer ($P<.001$) and resulted in more instances of capsular rupture ($P=.03$). Eyes with progressive disease had a longer surgery duration ($P=.01$) and displayed a worse visual outcome ($P=.006$). The association of surgeon experience with progression of DR after cataract extraction is one that, to our knowledge, has not been noted previously in the literature.

A stepwise logistic regression analysis disclosed several factors strongly associated with retinopathy progression. These included NPDR (odds ratio [OR], 12.06), PDR (OR, 6.94), and resident surgery (OR, 3.89). The strongest of these factors, NPDR, has consistently been shown in previous studies, such as those by Jaffe,[5] Pollack,[7] and Henricsson[16] et al, to be associated with postcataract retinopathy progression. Diabetic patients with any retinopathy should be counseled as to the risk that cataract extraction might exacerbate their level of retinopathy, and of the possibility that they may require postoperative laser surgery. Logistic regression also disclosed that the presence of preoperative retinopathy (NPDR or PDR) made it less likely to have significant visual improvement after cataract extraction. Hypertension was associated with visual improvement in the statistical analysis. The reason for this association is unclear.

Our study shows that surgical inexperience leads to progression of retinopathy after cataract extraction. Although resident surgery was significantly longer than private surgery, surgery duration alone was not statistically significant in the stepwise regression model. Longer surgery is associated with increased postoperative inflammation,[38] and this may result in an increased breakdown of the BRB and play a role in the progression of DR. Several recent studies have shown an association between ocular inflammation and progression of DR. Progression has been noted after episodes of sarcoid uveitis, with grades I to IV infection, and after endophthalmitis.[26,27] If inflammation proves to be critical in the development of progression after cataract extraction in diabetic patients, then aggressive preoperative and postoperative therapy with anti-inflammatory medications and attempts to shorten the procedure time may be of benefit in preventing its occurrence. The current trend with phacoemulsification is to avoid postoperative conjunctival steroid injections and to use nonsteroidal anti-inflammatory agents postoperatively. This practice with diabetic patients may potentially increase the risk of progression of retinopathy based on part of the data presented above.

Our study is limited by its retrospective nature and reliance on chart data. Data were not available for fellow eyes, as both eyes were not specifically examined during follow-up visits. Hence, symmetry of progression of DR could not be assessed.

CONCLUSIONS

We found that cataract extraction in diabetic eyes with and without preoperative retinopathy resulted in similar visual outcomes and rates of retinopathy progression, as seen in previous studies that used ECCE and phacoemulsification techniques. A higher progression of retinopathy and a decreased chance for visual improvement was seen with resident surgery and with the presence of preoperative diabetic retinopathy. Resident surgery was significantly longer and resulted in more instances of capsular rupture. Eyes that displayed retinopathy progression had decreased visual outcomes and longer surgery times. Cataract extraction in patients with diabetic retinopathy probably should not be performed by beginning-level residents.

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Corresponding author: William F. Mieler, MD, Cullen Eye Institute, Baylor College of Medicine, 6565 Fannin St, NC-205, Houston, TX 77030 (e-mail: wmieler@bcm.tmc.edu).

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A look at the past . . .

Some pathologists believe that sarcoidosis is a type of noncaseating tuberculosis, while others maintain that it is a separate disease entity of unknown origin. The similarity of the clinical manifestations of sarcoidosis and tuberculosis and the resemblance of the biopsy findings frequently make the differential diagnosis of these diseases difficult. In cases in which the presence of acid-fast bacilli can be demonstrated, there is no question about the diagnosis; in the absence of clinical signs of tuberculosis and in cases in which examination fails to disclose *Mycobacterium tuberculosis*, the biopsy findings may be considered characteristic of either tuberculosis or sarcoidosis.

Reference: Benedict WL. Sarcoidosis involving the orbit: report of two cases. *Arch Ophthalmol*. 1949;42:546.