Visual outcome after phacoemulsification and IOL implantation in diabetic patients

Anna Zaczech, Göran Olivestedt, Charlotta Zetterström

Abstract

Aims—To follow visual acuity (VA) and progression of diabetic retinopathy (DR) after phacoemulsification in diabetic patients with different stages of DR and controls.

Methods—This prospective study included 27 diabetic patients with no or mild to moderate non-proliferative DR; 25 patients with moderate to severe non-proliferative, or proliferative DR; and 22 non-diabetic controls. All patients underwent uncomplicated, phacoemulsification surgery, with implantation of a heparin-surface modified (HSM) poly(methylmethacrylate) (PMMA) intraocular lens (IOL) into the capsular bag. Colour fundus photographs and fluorescein angiograms (FA) were taken at 1 week (baseline), 3 months, and 1 year postoperatively to determine stability or progression of DR.

Results—The VA of 46 diabetic eyes (88%) was improved 1 year after surgery and only six eyes (12%) were unchanged or worse. 41 diabetic eyes (79%) achieved a VA of 0.5 or better and 11 eyes (21%) had a final VA lower than 0.5. Significantly lower final corrected VA was found 1 year after surgery in eyes with advanced DR (median 0.5; range 0.1–1.0) compared with controls (1.0; 0.1–1.0). Eyes with no or mild to moderate DR (1.0; 0.1–1.0). Eyes with mild to moderate DR and clinically significant macular oedema (CMO) 1 week postoperatively had a lower final VA than those without CMO. Angiographic cystoid macular oedema (CMO) was detected within FA in 15% of all diabetic eyes 1 week postoperatively. 41 eyes (79%) showed no change or improvement of the retinal status 1 year after cataract surgery. Progression was found in 11 eyes (21%), mainly in eyes with mild to moderate DR and to severe DR. Eyes with an indication for laser photoagulation at baseline showed a significantly higher rate of progression of DR after surgery than those without indication for laser treatment.

Conclusions—The final visual outcome was improved in the majority of diabetic eyes. Eyes with CMO at the time of surgery had the worst prognosis regarding postoperative VA.

Materials and methods

PATIENTS

This study included 55 consecutive patients with DM and 22 controls, who underwent uncomplicated, standardised phacoemulsification surgery, with implantation of an HSM IOL into the capsular bag at St Erik’s Eye Hospital, Stockholm (Table 1). The diabetic patients were referred from the diabetes outpatient clinic at the hospital and ophthalmologists in the Stockholm area. Eyes with glaucoma, uveitis, age related macular degeneration, a history of trauma, or any previous ocular surgical procedures were excluded. During the study, one patient died and two patients were lost to follow up; so, the number of patients with DM who finished the study was 52. For each diabetic patient a standardised medical protocol was done with information of the type and duration of diabetes, sex and age, and any diabetic medications.

Control patients were also selected from patients referred for cataract surgery to St Erik’s Eye Hospital. The same exclusion crite-
Laser photoocoagulation was performed in diabetic eyes according to the indications defined by the Early Treatment Diabetic Retinopathy Study (ETDRS). Laser treatment consisted of panretinal photoocoagulation (scatter) for proliferative and severe non-proliferative diabetic retinopathy. Focal or grid argon laser photoocoagulation was performed for CSMO or according to fluorescein angiography (FA) photographs. Some of the patients had previously undergone laser photoocoagulation treatment, but not during the 4 months before surgery (Table 1). Postoperative laser treatment was performed no sooner than 2 weeks after the operation (Table 1).

**DIABETIC RETINOPATHY STATUS AND FUNDUS PHOTOGRAPHY**

Diabetic retinopathy (DR) was documented with a Canon (CF-60 UV) fundus camera. Seven colour fundus photographs with stereo pairs of the macula and fluorescein angiograms were taken after pharmacological mydriasis at 1 week (baseline), 3 months, and 1 year postoperatively in patients with diabetes mellitus. All colour photographs and fluorescein angiograms were graded by a retinal specialist (GO) in a masked fashion concerning both patients and time. In most cases, the preoperative level of DR was difficult to estimate because of dense cataract. Therefore, the baseline stage of DR was estimated according to the photographic examinations performed at the outpatient visit 1 week after surgery.

Levels of DR were defined according to the Wisconsin Epidemiologic Study of Diabetic Retinopathy Classification. Levels of retinopathy were then divided into four groups: no DR (level 0), mild to moderate DR (levels 1–3), moderate to severe DR (levels 4–6), and proliferative DR (levels 7–8). Clinically significant macular oedema (CSMO) was classified according to the Early Treatment Diabetic Retinopathy Study Research Group. The diagnosis of angiographic cystoid macular oedema (CMO) was based on fluorescein angiography, which revealed the typical appearance of CMO as described by Gass and Norton.

Based on colour fundus photographs and fluorescein angiograms performed at 1 week, 3 months, and 1 year after surgery, the diabetic retinal findings were classified into three groups. The first group was defined as “no change”, where no aggravation of DR was found. The second group, defined as “better”, consisted of eyes wherein DR improved within the stage or reduced to a lower level of DR. The third group consisted of eyes with progression of DR. Progression was considered to have occurred after surgery when (1) a patient with no pre-existing DR developed non-proliferative DR or proliferative DR, with or without progression within the macula; (2) a patient with pre-existing DR showed aggravation of changes, with or without progression within the macula; (3) a patient with PDR showed postoperative recurrence of proliferative or other changes, with or without progression within the macula. Stability or changes in
retinopathy levels were estimated according to the number of microaneurysms and haemorrhages. The number of microaneurysms and haemorrhages in the macular region was rated using a special grid for grading fluorescein angiograms within a radius of 20.0 mm of the fovea. Microaneurysms were graded from the vascular phase on fluorescein angiograms, and haemorrhages from colour fundus photographs. The number of haemorrhages in the whole retina was also calculated from seven colour fundus photographs and separately, in the upper and lower parts in the temporal and nasal side of the retina. All microaneurysms and haemorrhages were graded on a scale of 0, no abnormalities, less than 5, from 5–10, and more than 10. Macular oedema or any leakage from retinal vessels was estimated from the late stages of fluorescein angiograms. They were graded as no abnormalities, mild, moderate, or severe. A postoperative incidence of CMO alone without any other evidence of progression of DR was not considered as a progression of DR.

**STATISTICAL METHODS**

Mann–Whitney test and Kruskal–Wallis one way analysis of variance (ANOVA) combined with multiple comparisons (mc) were used to compare differences in visual acuity between groups. Friedman’s two way analysis of variance (ANOVA), combined with comparisons with baseline (cb), was used to evaluate the change of visual acuity after surgery in each diabetic group and controls.

The Fisher exact, two tailed test was used for analysis of data on a nominal scale. p Values less than 0.05 were considered statistically significant.

**Results**

**VISUAL ACUITY**

One year after surgery, visual acuity (VA) with the best spectacle correction was significantly improved compared with preoperative VA in all study groups (Table 2).

**Control group**

All non-diabetic control patients had improved visual acuity at 1 year after surgery compared with preoperative VA (Fig 1). One patient from this group had a VA of 0.5 compared with 0.8 at 1 week after surgery because of persistent clinical CMO (Fig 1).

**Group with diabetes mellitus**

The visual outcome with the best spectacle correction 1 year after surgery, was improved in 46 eyes (88%) of the 52 diabetic eyes (Table 3). Only three eyes (6%) had a final visual acuity worse than before operation and three eyes (6%) had the final VA unchanged (Figs 2 and 3). Forty one eyes (79%) of the 52 diabetic

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Best corrected visual acuity (VA) in diabetic patients with different stages of diabetic retinopathy (DR) and controls, before and after surgery. All values of VA are given as median (range).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
<td><strong>Preoperative</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.4 (0.01–0.8)</td>
</tr>
<tr>
<td>No DR or mild-moderate DR</td>
<td>0.3 (0.13–0.65)</td>
</tr>
<tr>
<td>Advanced DR</td>
<td>0.16 (0.01–0.6)*</td>
</tr>
</tbody>
</table>

*Significantly different from control group and group with no DR or mild to moderate DR (Kruskal–Wallis ANOVA and multiple comparisons, p<0.05).

**Table 3** Visual acuity (VA) 1 year after surgery compared with preoperative VA in patients with diabetes mellitus (DM) with different stages of diabetic retinopathy (DR) and controls.

<table>
<thead>
<tr>
<th>No of eyes</th>
<th>Improved</th>
<th>Unchanged or worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>No DR or mild-dr DM</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>Advanced DR</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Total with DM</td>
<td>52</td>
<td>46 (88%)</td>
</tr>
</tbody>
</table>

**Figure 1** Visual acuity after phacoemulsification in control group 1 year postoperatively.

**Figure 2** Visual acuity after phacoemulsification in the diabetic group with no DR or mild to moderate DR, with and without clinically significant macular oedema 1 year postoperatively.
eyes achieved a visual acuity 0.5 or better, and 11 eyes (21%) had a final VA lower than 0.5.

**Group with no DR or mild to moderate DR**
The best corrected visual acuity, 1 year after cataract surgery, in eyes with no DR or mild to moderate DR was not significantly different from that of non-diabetic control patients (Table 2). The visual acuity improved in 26 of 27 eyes to 0.5 or better (median 1.0; range 0.5–1.0) 1 year postoperatively compared with preoperative values (Fig 2). Only one patient had a poor final visual result (0.1) caused by unsuccessfully treated CSMO and persistent cluster of haemorrhages found 1 week postoperatively (Fig 2). An additional comparison showed that five eyes with CSMO 1 week postoperatively had significantly lower visual acuity 3 months and 1 year after surgery compared with 22 eyes without CSMO (Mann–Whitney test, p<0.05) (Table 4). Cystoid macular oedema, determined by fluorescein angiography 1 week postoperatively, was found in four eyes with mild to moderate DR, and completely resolved in all, with a good visual acuity (1.0; 0.8–1.0) 1 year after surgery. Angiographic CMO was associated with CSMO only in one eye with mild to moderate DR.

**Group with advanced DR**
Eyes with advanced DR had significantly worse visual acuity than eyes in the control group and eyes with mild to moderate DR preoperatively.

**Table 4** Visual acuity (VA) up to 1 year after surgery in diabetic patients with no or mild to moderate diabetic retinopathy (DR) and advanced DR, with and without clinically significant macular oedema (CSMO) found 1 week after surgery. All values of VA are given as median (range)

<table>
<thead>
<tr>
<th>Group</th>
<th>Preoperative</th>
<th>1 week</th>
<th>3 months</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>No DR or mild-moderate DR</td>
<td>CSMO—No</td>
<td>0.3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>n=22</td>
<td>(0.01–0.65)</td>
<td>(0.3–1.0)</td>
<td>(0.65–1.0)</td>
</tr>
<tr>
<td></td>
<td>CSMO—Yes</td>
<td>0.3</td>
<td>0.65</td>
<td>0.8*</td>
</tr>
<tr>
<td></td>
<td>n=5</td>
<td>(0.13–0.5)</td>
<td>(0.3–1.0)</td>
<td>(0.3–1.0)</td>
</tr>
<tr>
<td>Advanced DR</td>
<td>CSMO—No</td>
<td>0.16</td>
<td>0.65</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>n=13</td>
<td>(0.01–0.6)</td>
<td>(0.1–1.0)</td>
<td>(0.1–1.0)</td>
</tr>
<tr>
<td></td>
<td>CSMO—Yes</td>
<td>0.15</td>
<td>0.45</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>n=12</td>
<td>(0.01–0.5)</td>
<td>(0.1–0.8)</td>
<td>(0.1–0.8)</td>
</tr>
</tbody>
</table>

*Significantly different from eyes without CSMO within the same group (Mann–Whitney test, p<0.05).

**Table 5** Progression of diabetic retinopathy (DR) following cataract surgery

<table>
<thead>
<tr>
<th>No of eyes</th>
<th>No change</th>
<th>Improved</th>
<th>Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>No DR</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Mild-moderate DR</td>
<td>18</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Advanced DR</td>
<td>25</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>25</td>
<td>16</td>
</tr>
</tbody>
</table>

100% 48% 31% 21%

**PROGRESSION OF DIABETIC RETINOPATHY**
Table 5 summarises the progression of diabetic retinopathy. Following cataract surgery, DR showed no change or improved in 41 eyes (79%), and progressed in 11 eyes (21%) (Table 5). No eye without retinopathy progressed to non-proliferative or proliferative DR. Progression was found in 11 eyes (25.6%) with DR, in four eyes with mild to moderate DR, in six eyes with moderate to severe DR, and in one eye with proliferative DR. Two eyes, one eye with mild to moderate DR and a second eye with moderate to severe DR, progressed to proliferative DR. The second eye also developed vitreous haemorrhage, which resolved after laser photocoagulation. Progression appeared in five eyes during 3 months postoperatively and in six eyes from 3 months until 1 year after surgery. New postoperative cases of CSMO were found 1 year postoperatively in two eyes, in one with mild to moderate DR and in a second with moderate to severe DR.

Cystoid macula oedema was found in eight diabetic eyes (8/91; about 15%) based on fluorescein angiograms only at 1 week postoperatively. Cystoid macular oedema was associated with CSMO in one eye with mild to moderate DR and in three eyes with moderate to severe
No progression Progression Differences between groups

<table>
<thead>
<tr>
<th>No of eyes (%)</th>
<th>41 (79%)</th>
<th>11 (21%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)†</td>
<td>73 (53–86)</td>
<td>75 (49–83)</td>
</tr>
<tr>
<td>Male/female</td>
<td>17/24</td>
<td>3/8</td>
</tr>
<tr>
<td>Type 1/type 2</td>
<td>5/36</td>
<td>1/10</td>
</tr>
<tr>
<td>Insulin treatment</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>Duration of diabetes (years)‡</td>
<td>19 (5–55)</td>
<td>14 (8–31)</td>
</tr>
<tr>
<td>Final visual acuity†</td>
<td>0.8 (0.1–1.0)</td>
<td>0.65 (0.1–1.0)</td>
</tr>
<tr>
<td>CSMO at baseline</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Postop CSMO, new cases</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Angiographic CMO at baseline</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Indication for laser treatment at baseline</td>
<td>21</td>
<td>10</td>
</tr>
</tbody>
</table>

CSMO = clinically significant macular oedema; CMO = cystoid macular oedema; baseline = 1 week after surgery.

†Values are given as median (range); ‡significant difference between groups (Fisher exact test, p<0.05).

The breakdown of blood-aqueous barrier (BAB) by surgical trauma produces postoperative inflammation with a pigment dispersion, a fibrinoid reaction, and development of posterior synechiae. The advantage of phacoemulsification is that this technique with a small incision reduces the postoperative breakdown of BAB. Therefore, significantly less fibrinoid reaction is found in the anterior chamber of diabetic eye during first postoperative week after phacoemulsification, compared with ECCE.

The surgical procedure may also contribute to the progression of diabetic retinopathy, and deterioration of pre-existing diabetic maculopathy. CMO occurs more frequently in eyes with diabetes than in non-diabetics, and more often in eyes with retinopathy than without retinopathy.

In other studies, the incidence of angiographic CMO found after ECCE varied from 30% to 50%, with and without DR. In contrast, in our study angiographic CMO was found in only 15% of all diabetic eyes. In addition, angiographic CMO was not recorded in eyes with no DR and was not more pronounced in eyes with CSMO. The possible explanation for these results is that a phacoemulsification technique with a small incision was used. In addition, an HSM PMMA IOL was implanted in the capsular bag, and these lenses may reduce postoperative inflammation.

The degree of postoperative inflammation in diabetic eyes after phacoemulsification is related principally to the preoperative DR, which depends mostly on the course of DM. The highest postoperative flare values were found in diabetic eyes with advanced stages of DR and those with CSMO. These results indicate that the activity and severity of pre-existing retinopathy seem to be one of the major risk factors for postoperative complications. Some previous clinical studies showed that patients with maculopathy at the time of surgery had the worst postoperative prognosis relative to visual acuity after ECCE or phacoemulsification. In the present study, we also found that the postoperative visual acuity reflects the status of the macula at 1 week postoperatively. However, eyes with CSMO and angiographic CMO had a similar rate of progression of retinopathy to eyes without maculopathy. In our study, eyes that progressed, had active retinopathy 1 week postoperatively, particularly those with moderate to severe DR and mild to moderate DR. According to our results and other studies, we believe that VA after cataract surgery depends on the severity of diabetic retinopathy at the time of surgery.

We conclude that the final visual outcome was improved in the majority of diabetic eyes. Eyes with CSMO at the time of surgery had the worst prognosis regarding postoperative visual acuity. The activity of diabetic retinopathy at the time of surgery appears to be a major factor causing the progression of retinopathy after cataract surgery.
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