Effects of posterior capsular disruption on the outcome of phacoemulsification surgery

M Mulhern, G Kelly, P Barry

The occurrence of a capsular rupture during phacoemulsification is not an uncommon entity, with a reported incidence of up to 5-5% when cases are performed by inexperienced residents,1 as opposed to 0-9% when performed by an experienced phacoscorges.2 Other predisposing factors to capsular rupture include: pseudoexfoliation,3 poorly dilating pupils,4 posterior polar cataract,5 and can opener or linear capsulotomy techniques.6

The management of a posterior capsule rupture is probably the greatest challenge facing the cataract surgeon. The removal of lens matter subsequent to capsular disruption, the need for anterior vitrectomy, and the optimum location for the intraocular lens (IOL), are all problems facing the surgeon intraoperatively, and the solutions will of course be somewhat dependent on the surgeon's experience.

Postoperatively, it is important to analyse the complications of the surgeon's management of the capsular disruption. The visual outcome of these cases must also be determined. Finally, our study examined the prevalence of bilateral capsular disruption. This was calculated by considering patients in this series who had a complicated outcome in two eyes.

Materials and methods
From a retrospective analysis of medical records, 43 cases of capsular disruption occurring during phacoemulsification over a 1 year period were identified. This cohort consisted of 39 patients, as four patients underwent bilateral cataract surgery in the study period and developed bilateral capsular disruption. Fifteen of these cases (35%) in our study group had background ocular pathology (see Table 1), and in five cases it was felt that the visual outcome would be suboptimal.

Fifty eight per cent of cases were carried out under general anaesthesia, and the rest (42%), under local anaesthesia. Local anaesthesia was administered via an inferotemporal periocular injection. A single dose of 5 ml of 4% Xylocaine (lignocaine) using a 1 inch 23 gauge needle usually provided sufficient akinesia, but sometimes this was supplemented by a second injection at the same site, if necessary. After this a Honan balloon was applied for 15 minutes in an effort to reduce vitreous volume by oculopression.7

The surgeons performing the phacoemulsification were all experienced in the technique. After a conjunctival incision at the 11 o'clock position, a scleral tunnel was created. At 2 mm from the surgical limbus an angled crescent-shaped keratome (Alcon) was used to fashion a vertical linear incision of half scleral thickness measuring 5·1 mm – the entrance to the scleral tunnel. This same keratome was then used to create a two tiered scleral tunnel, which ended just distal to the limbal arcades (the so called 'golden line'). A paracentesis was created somewhere between the 2 and 4 o'clock positions. A 3-2 mm keratome was used to perforate into the anterior chamber from the scleral tunnel. Healon (53% of cases) or Viscoat (47% of cases), injected via the paracentesis was used to deepen the anterior chamber, and to stabilise the iris-lens diaphragm. A continuous circular capsulorrhesis was created; this was followed by hydrodissection and hydrodissection using BSS (balanced salt solution). Phacoemulsification surgery proceeded in the usual way – that is, using a 'divide and conquer' technique8 for hard nuclei, and the 'chip and flip' technique for soft nuclei.9 An OMS (Optical Micro Systems) device was used for phacoemulsification in all cases. Capsular dialysis, or rupture, was handled as discussed below. After irrigation/aspiration, the corneal aspect of the scleral tunnel was expanded to 5·1 mm with a keratome; this is routinely followed by insertion of an intraocular lens (Kabi Pharmacia 809P). After removal of the viscoelastic, the self sealing incision was closed by injection of BSS through the paracentesis. The external lips of the tunnel were not routinely sutured. Closure of the conjunctival wound was by a single injection of BSS into the conjunctival stroma at the wound site.

Results
Not surprisingly, this study confirmed that capsular tears are more common than capsular dialyses – with incidences

### Table 1 Background ocular pathology present in our study group

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optic atrophy*</td>
<td>1</td>
</tr>
<tr>
<td>Arteritic anterior ischaemic optic neuropathy*</td>
<td>1</td>
</tr>
<tr>
<td>Primary angle closure glaucoma</td>
<td>2 (1 patient)</td>
</tr>
<tr>
<td>Oculocutaneous albinism*</td>
<td>2 (1 patient)</td>
</tr>
<tr>
<td>Dry macular degeneration</td>
<td>2</td>
</tr>
<tr>
<td>Disciform macular degeneration*</td>
<td>1</td>
</tr>
<tr>
<td>Myopia</td>
<td></td>
</tr>
<tr>
<td>&lt;6 Dioptres</td>
<td>2</td>
</tr>
<tr>
<td>&gt;6 Dioptres</td>
<td>1</td>
</tr>
<tr>
<td>Pseudoexfoliation</td>
<td>3 (2 patients)</td>
</tr>
</tbody>
</table>

*Pre-existing cause for suboptimal visual acuity.

### Table 2 The incidence of capsular disruption type, and the intraoperative stage at which disruption occurred

<table>
<thead>
<tr>
<th>Incidence of capsular disruption type (%)</th>
<th>Stage at which disruption occurred</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialysis – 6 cases (14%)</td>
<td>Nuclear phacoemulsification</td>
<td>3</td>
</tr>
<tr>
<td>Irrigation/aspiration</td>
<td>IOL manipulation</td>
<td>1</td>
</tr>
<tr>
<td>Tear – 37 cases (86%)</td>
<td>Nuclear phacoemulsification</td>
<td>18</td>
</tr>
<tr>
<td>Irrigation/aspiration</td>
<td>Other</td>
<td>4</td>
</tr>
<tr>
<td>Capsule polish</td>
<td>IOL manipulation</td>
<td>1</td>
</tr>
<tr>
<td>Not documented</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

IOL=Intraocular lens.
of 37 cases (86%) and six cases (14%) respectively. A complete overview of the details relating to the timing and to the incidence of each type of capsular disruption (dialysis or tear) is given in Table 2. It is worthwhile, however, to emphasise the point that the nuclear phacoemulsification stage is the most dangerous stage of the procedure, as the highest proportion of posterior capsular tears and dialyses occur during this stage.

A sheet’s glide was necessary in 9% of cases to allow continued phacoemulsification of the nucleus fragment in the presence of a capsular tear.

Anterior vitrectomy was necessary in 44% of cases. This was either a dry vitrectomy or a low flow bimanual vitrectomy.

In 25% of cases, endcapsular placement of an IOL was possible, sulcus fixation was achieved in 56% of cases: Table 3 outlines the details relating to IOL location. During the initial procedure, 7% of cases did not have an IOL inserted. The figure for anterior chamber lenses (AC IOL), represents the total of primary and secondary AC IOL implantations. All secondary IOL insertions carried out in this series consisted of insertion of an AC IOL.

In 56% of cases it was felt necessary to suture the scleral tunnel. This was always the case if an anterior vitrectomy was performed; however, normally in uncomplicated surgery no sutures are used.

Raised intraocular pressure in the immediate postoperative period occurred in 39% of cases; there was no case which resulted in chronic glaucoma.

Complications relating to lenticular debris arose in 13 cases (30%) (see Table 4), 10 cases had small amounts of residual soft lens matter in the anterior chamber, which either resorbed or became quiescent; two cases had soft lens matter in the vitreous, and one case had prolapse of the nucleus into the vitreous cavity. Associated with this latter case was concomitant vitreous presentation in the anterior chamber, the surgeon performed a dry anterior vitrectomy, sufficient to remove all vitreous anterior to the iris-lens/capsular diaphragm. This was followed by a low flow irrigation/aspiration of the residual intercapsular lens material. There remained, however, insufficient capsular support for sulcus or endcapsular fixation of an IOL. The scleral tunnel was then closed with 10/0 nylon. The surgeon’s intention was to proceed the following day to do a pars plana vitrectomy and fragmatome removal of the nuclear fragment, combined with insertion of an AC IOL. The patient was, however, reluctant to have further surgery and so our only course was to continue to monitor the patient. Apart from raised intraocular pressure on the first postoperative day, no further problems arose. To this day the eye remains quiet, with no evidence of retinal breaks, glaucoma, or cystoid macular oedema. Corrected by a contact lens, the visual acuity is 6/9.

Retinal complications occurred in three cases (7%) – there were two eyes with retinal detachment, and one eye with a horseshoe tear. The former were treated by three port pars plana vitrectomy and scleral buckling (6/12 and 6/18 were the respective visual outcomes) and the latter with focal argon photocoagulation.

Table 5 details the range of visual acuities obtained. In our series 60% of cases associated with posterior capsular disruption achieved a visual acuity of 6/9 or better, and 79% of cases obtained a final visual acuity of 6/18 or better.

The outcome of the fellow eye with regard to capsular disruption during phacoemulsification was examined. Forty per cent of patients in our study had an unoperated fellow eye, while 60% had bilateral phacoemulsification surgery (although not necessarily in the study period). Of this 60%, 65% had uncomplicated surgery, but 35% had capsular disruption (either a tear or dialysis).

Discussion

Capsular disruption during cataract surgery has become a problem since IOL insertion has evolved to become the ideal correction of aphakia. Various groups have looked at IOL insertion after extracapsular surgery complicated by capsular disruption, be it with an AC IOL,10–15 or with a posterior chamber (PC) IOL.14–16 There are, however, few reports217 in the literature on the long term outcome and criteria for intraocular lens implantation in phacoemulsification surgery complicated by capsular disruption. Our analysis of 43 cases of capsular disruption (either from a capsular tear or dialysis) will highlight the contributing factors to capsular disruption, management of the vitreous, criteria for IOL placement and discuss the postoperative complications which can ensue.

Most surprisingly our study showed that general anaesthesia seems to be an aggravating factor for capsular disruption. Perhaps the higher incidence of general versus local anaesthesia (58% and 42% respectively) in this series was related to attempts to 1) optimise patient cooperation, and 2) minimise the positive vitreous pressures effects seen with peribulbar anaesthesia. Although cases considered difficult – for example, pseudoxefoliation or traumatic cataract, might have undergone general anaesthesia from the surgeon’s preference, we feel patient preference was overall a more likely explanation for the higher incidence of general anaesthesia, as peribulbar anaesthesia is the norm in our unit for phacoemulsification surgery. The prevalence of general versus local anaesthesia as a contributing factor in capsular disruption associated with phacoemulsification is not quantified by other authors. In Claoué and Steele’s series,18 which consisted primarily of extracapsular surgical cases associated with vitreous loss, general anaesthesia was found to be more important as a risk factor (88%) than in our series. However, the authors did not comment on this. All things considered, it is our opinion that general anaesthesia is not an aggravating factor for capsular disruption, and the higher percentage of cases performed under general anaesthesia in this series is related to 1) the surgeon’s concern about the complexity
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Table 6 Overview of the cases in which zonular dialysis occurred

<table>
<thead>
<tr>
<th>Case</th>
<th>Dialysis</th>
<th>Background</th>
<th>IOL status after primary procedure</th>
<th>Anterior vitrectomy</th>
<th>Eventual visual acuity (after 1st or 2nd procedure)</th>
<th>Secondary procedure/type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt;6 clock hours</td>
<td>Oculocutaneous albinism</td>
<td>Aphakic</td>
<td>No</td>
<td>6/36</td>
<td>Yes/AC IOL</td>
</tr>
<tr>
<td>2</td>
<td>Some nasal and temporal zonular loss</td>
<td>Oculocutaneous albinism</td>
<td>Endocapsular</td>
<td>Dry</td>
<td>6/18</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>5-7 o'clock</td>
<td>Myopia (&lt;6 dioptres)</td>
<td>AC IOL</td>
<td>Low flow</td>
<td>6/24</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Inferior</td>
<td></td>
<td>Sulcus</td>
<td>No</td>
<td>6/12</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>360°</td>
<td>Pseudoexfoliation</td>
<td>AC IOL</td>
<td>No</td>
<td>6/6</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>360°</td>
<td>Pseudoexfoliation</td>
<td>Aphakic</td>
<td>Dry</td>
<td>6/12</td>
<td>Yes/AC IOL</td>
</tr>
</tbody>
</table>

AC IOL = anterior chamber intraocular lens.

of a particular case, and (2) patient specific factors – for example, nervousness, tremor, etc.

Our study showed capsular tears to be more common (86% of cases) than dialyses (14% of cases). Osher and Cioni2 and Gimbel17 did not consider the outcome in their series of cases in which dialysis was the aetiology of the capsular disruption. Table 6 gives an overview of each case in which capsular dialysis was encountered. One individual with oculocutaneous albinism had bilateral dialysis during phacoemulsification. The association of zonular dialysis during phacoemulsification with albinism has not been previously noted in the literature. The reason that dialysis should have occurred in this patient is not apparent, as no preoperative phacoedemone was noted and there was no previous history of trauma. In cases 5 and 6 both patients (with pseudoexfoliation) had complete disinsertion of the capsular bag. Of note (see Table 6), was the suboptimal IOL location in cases of dialysis, with only two cases achieving a posterior chamber fixated IOL. On consideration of the group (with dialysis) as a whole, the poor visual outcome is quite apparent, only one individual (17%) achieving 6/9 or better visual acuity. This contrasts strongly with the fact that 70% of those getting a capsular tear had a visual acuity of 6/9 or better.

The ideal location for the IOL when faced with zonular dialysis is controversial. Endocapsular fixation is felt by some authors18 19 to be safer, as support for the IOL is not sought directly from the zonules, and migration of the IOL is less likely, as the IOL is secured in the capsular bag. Ciliary sulcus implantation is advocated in several articles,4 15 20 particularly if the dialysis is less than 6 clock hours in extent. The ideal IOL for endocapsular fixation when dialysis has occurred, is one with a large optic and C loops. The IOL should be inserted by pressure on the superior haptic rather than by dialling. The large optic will lessen the risk of glare should decentration occur, while the C-shaped haptics will more uniformly distribute pressure over the zonular–capsular interface than J-shaped haptics.

Concerning the stage of surgery, and the relative hazard of capsular disruption, our series suggests that nuclear phacoemulsification is the stage most likely to be associated with dialyses or posterior capsular tears; 50% of dialyses and 49% of tears occurred in this stage. This figure corresponds with that of Osher and Cioni’s series,2 which also had nuclear phacoemulsification as the stage most commonly associated with capsular tears. Gimbel in his series,17 however, had the irrigation/aspiration stage as the most hazardous stage, followed by the nuclear phacoemulsification stage. Capsular tears during nuclear phacoemulsification may be the result of sculpting too deeply, or to the creation of tears by the sharp edges of hard nuclear segments formed during the nucleofractis technique. Table 2 highlights the incidence of capsular disruption occurring during other stages of surgery.

In the event of a tear occurring while nuclear material remains, the residual nucleus can be more easily removed by phacoemulsification if a Sheet’s glide is placed between the nucleus and the underlying cushion of cortex in a viscoelastic medium. The glide also prevents further nuclear material from reaching the vitreous, and to some extent may tamponade the vitreous. When the Sheet’s glide is in place, irrigation is minimised to prevent hydration of the vitreous. Although not previously described in the literature, a Sheet’s glide is considered to be a useful adjunct by the authors when faced with residual nuclear material and a capsular tear; it was used in 9% of the cases in our series.

Anterior vitrectomy was carried out in 44% of our cases.

Vitrectomy was not deemed necessary if the anterior hyaloid face was intact behind the tear or dialysis. If vitreous presented anterior to the capsular disruption, an anterior vitrectomy was carried out, either a low flow bimanual type or a dry vitrectomy with viscoelastic – that is, all efforts were made to prevent vitreous hydration and thus further prolapse. Subsequent to the vitrectomy, residual lens matter can be removed by phacoemulsification over a Sheet’s glide if the material is nuclear, or by low flow irrigation/aspiration if cortical lens matter remains. The goals are to minimise vitreous hydration and anterior–posterior displacement of the zonular–capsular diaphragm (both of which can precipitate further vitreous prolapse); minimal instrumentation and constancy of the anterior chamber depth help to achieve the latter goal.

Probably one of the most difficult decisions to make when capsular disruption occurs is whether or not to implant an IOL. In our series (see Table 3), three cases did not receive an IOL during the primary procedure; of these, two had a capsular dialysis. In the first (see case 1, Table 6) there was insufficient zonular support for a PC IOL; in the second (see case 6, Table 6) the capsular bag was totally aspirated, this latter patient had pseudoexfoliation. Both these cases subsequently had an AC IOL implanted as a secondary procedure. The third case, which resulted in aphakia, was a patient with a posterior capsular tear associated with migration of the nucleus into the vitreous cavity. This case of the ‘dropped’ nucleus was the only case in our series which ended up as being aphakic. Notwithstanding the patient’s reluctance, our intention had been to combine insertion of a flexible open loop AC IOL with pars plana vitrectomy and fragmatome removal of the nuclear fragment. As already stated, this patient’s visual acuity is 6/9, but in the long term lens induced inflammation, secondary glaucoma, and cystoid macular oedema may occur. Two interesting questions arise from this case: (1) what course should the phacosurgeon undertake when faced with a ‘dropped’ nucleus, and (2) what is the usefulness or validity of using a scleral or iris sutured PC IOL, as opposed to an AC IOL, when insufficient capsular support exists for the more traditional methods of PC IOL fixation? The former question is important, especially given the increased incidence of posteriorly dislocated lens fragments since the advent of phacoemulsification.21 22 A review of the current literature23 24 would suggest quite strongly that no attempts should be made by the phacosurgeons to retrieve a lens fragment from the vitreous cavity using ‘scoops, cryoprobes, saline streams’, viscoelastics, or a phacoemulsifier as these are associated

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with a high rate of retinal tears. It is, however, important to do an anterior cortical clean up and an anterior vitrectomy if vitreous prolapse occurs. Concerning IOL insertion, this is feasible unless the dislocated lens fragment is particularly dense (that is fragmatome removal would then be impossible) thus making removal of the lens material via the limbus a necessity. Postoperatively, topical and even systemic steroids may be required to dampen the inflammatory response. Prompt referral to a vitreoretinal surgeon is of paramount importance. The majority of authors\textsuperscript{23 25} would suggest early removal of the nuclear fragment with a combined vitrectomy/fragmatome approach as being the best course, citing reduced rates of corneal decompensation, cystoid macular oedema, and secondary glaucoma. Interestingly, most authors\textsuperscript{21 24 25} do recognise the fact that nuclear lens material in the vitreous (particularly if small in size) may remain inert with retention of good visual acuity. The study of Gilland et al\textsuperscript{21} however, examined the outcome of conservative management versus surgical removal of the lens fragment, and this study suggests that the long term visual acuity was better and the incidence of complications less in the operated group. As to the second issue raised, we feel that to some extent this debate is much more applicable to cases where a corneal graft is in situ (or where very severe endothelial disease is present), and inadequate capsular support exists for capsule supported fixation. For these latter cases, the study by Schein et al\textsuperscript{26} would suggest that insertion of an iris sutured PC IOL may be the best option, but as stated in a recent article by Olson,\textsuperscript{27} even for cases associated with penetrating keratoplasty, no clear guidelines regarding the ideal IOL type or location exist and long term data, particularly important in these cases, are not available. We are of the opinion, therefore, that for eyes which have inadequate capsular support for a PC IOL (after phacoemulsification) AC IOL insertion is a very reasonable means to correct aphakia.

Four cases in our series had a primary insertion of an AC IOL when insufficient capsular or zonular support remained for fixation of a PC IOL. The decision to implant in the sulcus, or to use the bag, is governed by several factors; the disruption type (tear or dialysis) and the extent of the dialysis, or extent of the tear. As has been mentioned above, the ideal location for an IOL when faced with dialysis is endocapsular. If a posterior capsular tear is small or circular endocapsular fixation is possible, but if adequate zonular support is present, ciliary sulcus fixation remains an option, even if the tear is too large to allow endocapsular placement. One must still, however, balance the advantages of sulcus fixation with the threat of posterior migration or decentration of the IOL. In our series anterior chamber fixation was avoided if possible, based on our own and others\textsuperscript{10 28 29} dissatisfaction with AC IOL seqeulae.

Fifty six per cent of cases had 10/0 nylon sutures used to close the section site. This was, of course, mandatory when an AC IOL was inserted. All cases in which an anterior vitrectomy was warranted had the scleral tunnel closed with 10/0 nylon. This was felt to be advantageous given the risk of a high postoperative intraocular pressure and the risk of vitreous wick syndrome.

Table 4 lists the postoperative side effects seen in this series. The raised intraocular pressure on the first postoperative day was felt to be the result of several factors: (1) increased instrumentaiton; (2) the increased amount of viscoelastie used and the fact that it was sometimes not aspirated at the end of the procedure; (3) the fact that residual soft lens matter was present in the anterior chamber (47% of cases with raised intraocular pressure had soft lens matter in the anterior chamber) or in the vitreous; (4) the fact that anterior vitrectomy had been carried out (41% of cases with raised intraocular pressure had an anterior vitrectomy). In our series no patient developed raised intraocular pressure which persisted outside the immediate postoperative period. Other complications seen postoperatively included two cases of retinal detachment and one case of a horseshoe tear. No case in our series had documented clinically significant cystoid macular oedema, and it was felt unjustifiable to perform fluorescein angiography for study purposes only. Gimbel\textsuperscript{17} does not mention postoperative cystoid macular oedema in his series, and Osher and Cionni\textsuperscript{2} report only one case of clinically significant cystoid macular oedema. Chambliss\textsuperscript{30} reported the incidence of clinically significant cystoid macular oedema as 7-6% in phacoemulsification cases complicated by posterior capsular disruption.

As can be seen from Table 5, the visual prognosis after complicated phacoemulsification surgery can be very good - 60% of patients' corrected visual acuity was 6/9 or better and 79% of patients had a visual acuity of 6/18 or better. This compares favourably with 77% and close to 100% of cases seeing 20/40 or better in Gimbel's\textsuperscript{17} and Osher and Cionni's\textsuperscript{2} respective series. We do feel, however, that the more anatomical position of the lens (in the bag or sulcus) will, in several years time, prove to be more satisfactory with regard to the fine visual acuity. This is in contrast with eyes receiving an AC IOL, whose ultimate visual potential may be compromised by late onset pseudophakic glaucoma, bullous keratopathy, and cystoid macular oedema. The reports of Spiegelman et al\textsuperscript{14} and Claeue and Steele\textsuperscript{16} both affirm the poorer long term visual prognosis of eyes with AC IOLs compared with eyes with PC IOLs in extracapsular surgery complicated by capsular disruption.

In our study, 60% of the patients had their fellow eye operated on; of these, 35% were complicated by a posterior capsular tear or dialysis. We do feel, therefore, that it is particularly important that the surgeon considers this fact when planning to undertake phacoemulsification surgery on the second eye of a patient who had complicated surgery in the first eye. Our findings contrast with Osher and Cionni's series,\textsuperscript{2} which failed to show an incidence of capsular disruption in the fellow eye (39% of cases in their series had the fellow eye operated on). This variation between series may be attributable to differing case selection.

Conclusion

Posterior capsular disruption is a very important intraoperative complication but current techniques permit endocapsular or sulcus fixation of the IOL in a high percentages of cases. Furthermore, good visual acuity and minimal long term complications ensue. Surgery on the fellow eye of a patient who has already had a posterior capsular disruption is associated with an appreciable risk (35%) of posterior capsular tear or dialysis in the second eye.

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Effects of posterior capsular disruption on the outcome of phacoemulsification surgery


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