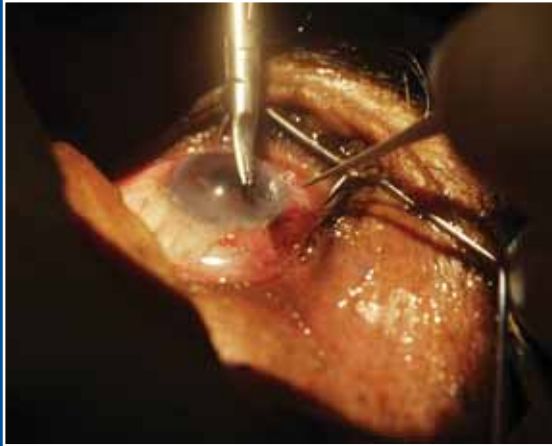




**CATARACT SURGERY COMPLICATIONS 1**

**COURSE CODE: C-11440**

# Intraoperative complications



Louise Stainer BSc (Hons)

Cataract surgery is the most commonly performed operation worldwide.<sup>1</sup> Technological progress has enabled major advances in this procedure. However, as with any surgery there are inherent risks, some of which are related to the increased complexity of the operation. There are four main forms of cataract extraction surgery: intracapsular (ICCE), extracapsular (ECCE), phacoemulsification (PHACO) and manual small incision (MSICS). This article is the first of three that identifies the more common complications that occur intraoperatively during phacoemulsification and intraocular lens (IOL) implantation. Future articles will describe the early and late post-operative complications that may occur.

At the beginning of the twentieth century ICCE was the main method of lens removal used. This involved creating a large 180° limbal incision and removing the lens together with the capsule by breaking the zonular ligaments. Vitreous loss, haemorrhage, chronic cystoid macular oedema (CMO) and high astigmatism were complications often associated with this technique. Post-operatively the patient generally spent a week in hospital with their head immobilised to allow recovery. Subsequently they were prescribed thick aphakic spectacles and had to contend with their associated disadvantages.<sup>2</sup> As technology progressed, the option of inserting an IOL into the anterior chamber (anterior chamber IOL) following ICCE became available. It can be carried out rapidly (in five minutes) by surgeons experienced in the technique and avoids the potential development of lens capsule opacification and the subsequent need for intervention.<sup>3</sup>

ECCE became more popular after the

Second World War. It involves a smaller limbal incision followed by an incision in the anterior lens capsule (capsulotomy) through which the lens is removed. This procedure reduced the risk of vitreous loss. A posterior IOL could then be placed into the capsular bag. However, remaining undetected cortical material that was not removed, for example due to the surgeon's poor view, could result in severe post-operative inflammation and significant posterior capsular opacification (PCO).

Over the last 20 years phacoemulsification has become the method of choice. The incisions required are smaller (about 3-4mm) so the risk of decompression of the eye is avoided, making the procedure safer. The time for recovery, the stabilisation of the post-operative refraction and the amount of induced astigmatism in the refraction is less. However, the technique itself is more complicated, requiring extensive training and manual dexterity.

## Anaesthesia-related complications

Various methods of anaesthesia can be used prior to surgery. Retrobulbar anaesthesia is performed by injecting the anaesthetic drug into the muscle cone of the eye. An alternative is peribulbar anaesthesia (PBA) during which the needle is introduced into the extraconal space. Sub-tenon anaesthesia involves injecting the anaesthetic into the subtenon space. Patient movement is common during any of these methods of anaesthesia. This may result in globe perforation or an orbital haemorrhage if the needle perforates the orbital arteries or vortex veins.

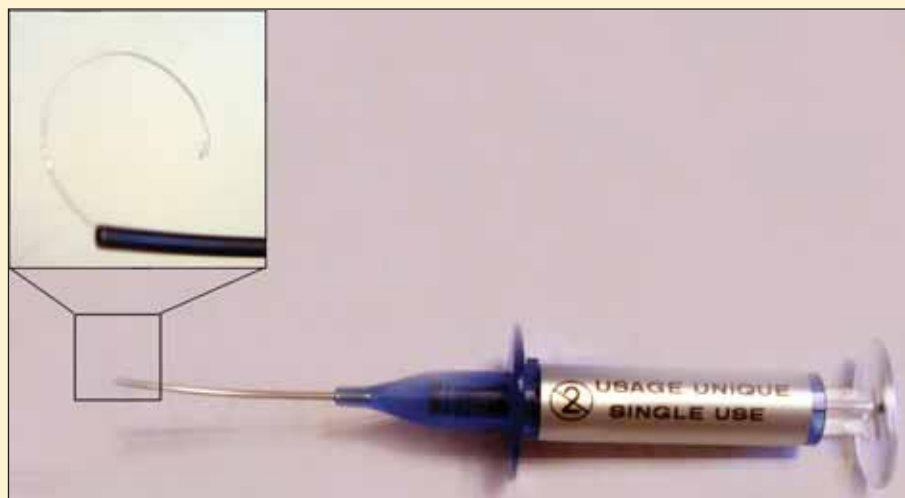
Management depends on the severity of the haemorrhage. If the intraocular pressure (IOP) is raised, this may be managed with glaucoma medication. In rare cases the elevation of IOP may be enough to threaten vision. If this occurs together with progressive proptosis and tightening of the lids, the retinal arterioles are assessed for blood flow

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➔ **Figure 1**

An injectable capsular tension ring

and pulsation. If the retinal arteriolar pressure is compromised, urgent decompression of the eye is necessary via the lids or periorbital space.

General anaesthetic is rarely used for cataract surgery and although the potential complications described above are avoided, there are numerous other possible major complications that must be considered. There is the risk of increased mortality and morbidity especially if the patient is elderly and has co-existing systemic disease. Cardiac and respiratory function may be significantly depressed in these individuals by anaesthesia. There is also a delay in recovery from general anaesthesia. Therefore, general anaesthetic is generally avoided if possible but may be useful for paediatric cases and patients who may have uncontrollable neurological movements.

During application of anaesthesia, steps can be taken to reduce the risk of patient movement. With the patient's consent, an assistant can hold the patient's head gently but firmly to reduce movement during the injection. Movement due to discomfort can be alleviated with suitable ventilation, which often reassures and calms the patient, whilst pillows can be used to position the patient. Patients should be fully informed to put them at ease. It may be advisable to rebook the operation slot for patients with a significant chest infection, to reduce

the risk of movement due to coughing and the spread of infection.

In the UK the use of topical or intracameral anaesthesia (the use of anaesthetic irrigation at any step of surgery) for cataract surgery has increased from 4.1% in 1996 to 20.9% in 2003,<sup>4</sup> as this technique avoids the complications previously described. Although this method of anaesthesia doesn't result in global akinesia if the surgeon is experienced, it has been shown that there is no increased risk in intra-operative complications.<sup>5,6</sup> In fact the presence of full ocular motility can be helpful because the globe remains on-axis as the patient looks towards the fixation light of the operating microscope, or elsewhere if needed.

### **Surgery-related complications**

Successful draping methods enable the eyelashes to be isolated which minimises the development of infectious endophthalmitis. Proper hand washing, the subconjunctival injection of antibiotics<sup>7, 8</sup> and the intracameral injection of cefuroxime<sup>9</sup> at the end of surgery can also be carried out to reduce the risk of post-operative endophthalmitis. In addition, any patient with blepharitis should be given instructions regarding lid and lash cleaning pre-operatively, in order to minimise the risk of infection occurring post-operatively. Drapes are also positioned to allow maximum

exposure and visualisation of the surgical field and to minimise interference with any instrumentation.

### **Incisions**

There are a number of potential complications that can occur when the incisions are made. Incisions that are too large allow flattening of the anterior chamber during irrigation, aspiration, and the phacoemulsification process and this in turn increases the probability of iris prolapse occurring. Iris prolapse causes pupillary distortion which has a cosmetic impact and also makes it more difficult to introduce surgical instruments into the anterior chamber, increasing the risk of other complications. Iris prolapse can also have other causes such as the patient coughing.

If the incision is too large then it can be reduced with sutures. If iris prolapse occurs, the surgeon then aspirates fluid from the anterior chamber via a second incision site, in order to reduce the IOP. The iris is then repositioned. Failing this, a small peripheral iridectomy is performed at the prolapse site to help equalise the pressure in the anterior and posterior chambers. A miotic agent may then be injected into the anterior chamber to help reposition the iris and sutures applied to secure the wound and prevent re-occurrence if necessary.

Tight incisions increase the risk of tearing Descemet's membrane. Such tears can have numerous affects post-operatively, which will be described in future articles. A detachment or tear of Descemet's membrane is caused by improper insertion of an instrument through the incision so that it passes between Descemet's membrane and the stroma causing the break. If the tear is small it can be left alone or pressure applied to its posterior edge, to allow repositioning. Larger tears are generally repositioned using a small bubble of air or viscoelastic agent, either alone or in combination with sutures, until healing occurs. If there is a complete detachment of Descemet's membrane, which is extremely rare, half of the anterior chamber needs to be filled by injection with a heavy gas



such as hexafluoride to hold the membrane in place. In some cases, corneal transplantation is required.

Tight incisions can also cause excessive eye movement as a result of the manipulation of intraocular surgical instruments. This may increase the likelihood of thermal injury occurring. If the incision is properly positioned however, there should be a reduction of post-operative astigmatism. An irregular or jagged incision or loose sutures may result in post-operative leakage. A well-apposed watertight wound is required to promote adequate wound healing.

### Capsulorrhexis

The aim of anterior capsulectomy or capsulorrhexis (rhesis) is to create a continuous central and curvilinear opening in the anterior lens capsule. The shape of incision helps to maximise its strength and stability.<sup>10</sup> It should also allow efficient removal of the lens but be small enough so that there is fixation of the lens implant to the inside of the capsule. This helps to reduce the incidence of PCO post-operatively. However, if it is too small the phacoemulsifier tip has to be manoeuvred within a tight space, which makes it difficult to emulsify the peripheral lens regions. Also it increases the risk of causing a tear in the corneal endothelium or the capsular bag.

A small rhesis can increase the difficulty of IOL insertion into the capsular bag. It can also lead to contraction of the anterior capsule (capsular phimosis) with dislocation of the implant or a reduction in the effective optical zone of the IOL; the latter will cause visual disturbances post-operatively.<sup>11</sup> These can include glare symptoms and possibly a reduction in visual acuity (VA). If the rhesis is too large this can mean that it extends beyond the edge of most IOL optic zones and again the patient may experience glare post-operatively. Also, if a large rhesis tears, the anterior zonule insertions may be disrupted.

### Phacoemulsification

Hydrodissection is the process of separating the cortical material from

the capsular bag. The nucleus is then separated from the cortex by a similar method called hydrodelineation. Fortunately complications during these procedures are rare. The nucleus can then be removed by a combination of ultrasound energy (phacoemulsification) and mechanical fracturing. Numerous complications may potentially occur during phacoemulsification.

The phacoemulsifier power provides the energy to break up and emulsify the cataract using ultrasonic vibrations. Aspiration involves using fluid flow to bring the resultant lens material fragments to the tip. This works in combination with a vacuum, which exists when the tip is occluded by these fragments; the result is a suction action which allows the fragments to be removed via the tip.

If the phacoemulsifier power is too high, the excess energy is transformed into heat. This can damage the nearby corneal endothelium causing endothelial dysfunction and corneal oedema. By modulating the energy into micro-pulses and micro-bursts, this can be minimized whilst efficient nucleus removal is still maintained. The cortex is then removed in a similar manner. Finally, any anterior capsular tags are removed. These are flaps that may be present if the rhesis is not continuous; if left they may encroach on the visual axis. The posterior capsule is then polished to remove any remaining cortical layers.

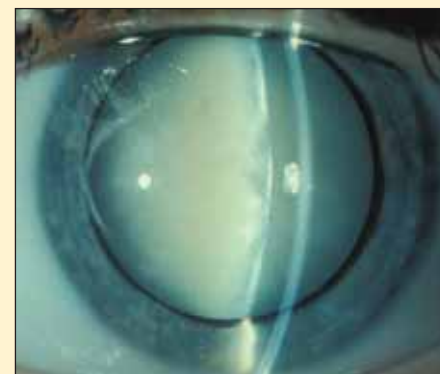
Posterior capsular tears most commonly occur during this stage but can also occur during other stages of phacoemulsification.<sup>12</sup> Even a small tear may result in vitreo-retinal traction, which can cause a retinal tear or detachment. If a small tear occurs near the end of the phacoemulsification procedure, and there is no vitreous prolapse into the anterior chamber, it may be possible to continue. The patient should then be informed and warned of symptoms of retinal detachment and the action to take if these occur. A peripheral retinal examination is then performed at a suitable time post-operatively to rule out any retinal breaks. The risk of endophthalmitis is also significantly

increased following a posterior capsular tear. This is because the tear allows bacteria direct access to the vitreous, which acts as a substrate for growth; any prophylactic treatment given is likely to be less effective.<sup>13</sup> Endophthalmitis will be discussed in greater depth in the next article.

### Anterior segment

There is also the potential for anterior capsular tears to occur throughout the surgical procedure. A recent study showed that half of such tears extended through the posterior capsule.<sup>14</sup> The rhesis or surgical technique can be modified to try to prevent this from occurring.

If vitreous gel leaks into the anterior chamber (vitreous loss) this will be indicated by various changes in the anterior eye. The anterior chamber will suddenly deepen as hydrated vitreous prolapses into the anterior chamber and forces the iris posteriorly. The pupil will also become distorted, independent of the presence of any surgical instruments in the eye, because there is traction transmitted through vitreous strands. These strands may also be visible in the anterior chamber. If phacoemulsification is still in process this should be stopped and the probe withdrawn as carefully as possible to minimise further vitreous traction. A viscoelastic substance may be injected into the anterior chamber at this stage, as the phacoemulsification probe is withdrawn, to reduce vitreous prolapse and to stabilise any



➔ **Figure 2**

A white cataract (courtesy of Professor Jon Gibson, Aston University)



remaining lens fragments.<sup>15</sup> The prolapsed vitreous then has to be removed (vitrectomy). It may not be possible to complete the cataract removal and IOL implantation safely at this stage, and this may have to be carried out at a later date when it is appropriate.

Posterior capsular tears may be converted into a posterior rhexis, by altering the shape into a curve; this will stop it from increasing in size. However, nuclear fragments may fall behind the posterior capsule into the vitreous following a posterior capsule tear (dropped nucleus) and if these fragments are left in the vitreous, their significant antigenic properties could result in a severe inflammatory reaction.<sup>16</sup> This can result in complications such as corneal decompensation, inflammation, glaucoma<sup>17</sup> and CMO.<sup>18</sup> However if removal is attempted anteriorly without pars plana vitrectomy, this can result in excessive vitreous traction, which may result in giant retinal tears and even retinal detachment. In addition the fragments may also be moved further into the vitreous.

Therefore if the cataract surgeon is not specialised in posterior segment surgery, a management plan should be arranged with local vitreo-retinal specialists.

Opinions regarding the timing of lens fragment removal are mixed. Immediate pars plana vitrectomy can prevent or stop the occurrence of secondary glaucoma<sup>19</sup> but if the lens fragments are left for two to three weeks they become softer and easier to remove.<sup>20</sup> However, if the removal is performed any later than this the visual outcome tends to be poor as a result of the above complications.

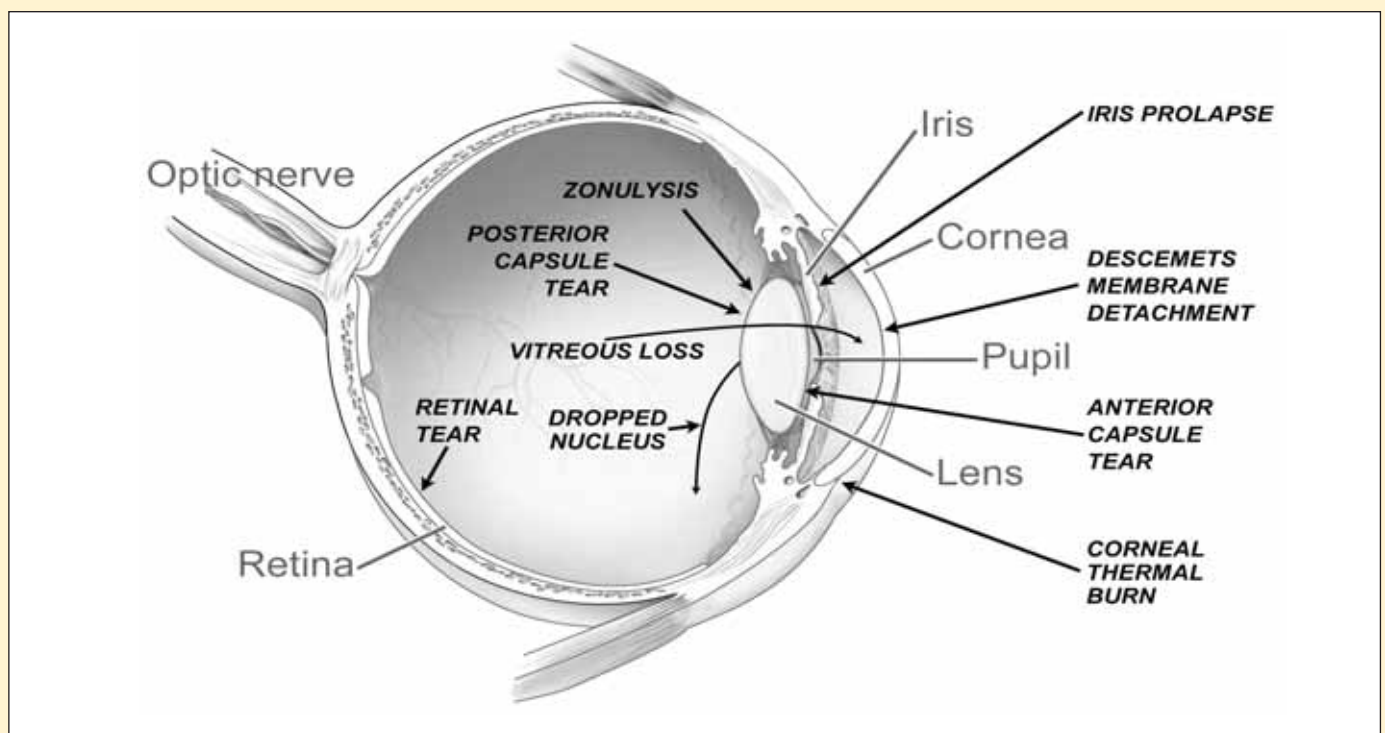
#### Posterior capsular tears

There are other types of posterior capsular tears in addition to the commonest caused by surgical complications. Posterior capsule tears can also be pre-existing (congenital or traumatic) or spontaneous. Congenital tears occur during pregnancy as a result of an intra-uterine insult which affects the posterior capsule epithelium during the development of the embryonic nucleus. Penetrating injury and blunt ocular trauma may also

result in posterior capsule tears that may be detected only during surgery. The characteristics of penetrating trauma tears depend on the time period between the trauma occurring and the cataract surgery. Tears that occurred a long time before the surgery will have thickened margins that have fibrosed in an attempt to heal the injury. The size of the tear is not affected by irrigation during aspiration of the lens fragments.<sup>21</sup> In contrast, tears associated with recent penetrating trauma have thin, transparent margins and behave in a similar manner to intra-surgical tears. Irrigation and aspiration can cause such tears to rapidly enlarge increasing the risk of vitreous prolapse and dropped nucleus.

#### Zonular weakness

There is also an increased risk of capsular tears, vitreous loss and lens material retention in patients with weak lens zonules. This weakness is associated with a number of conditions including pseudoexfoliation, traumatic lens displacement, hypermature cataract and systemic tissue diseases such as Marfans Syndrome.<sup>22</sup> It may be



➔ **Figure 3**

Summary of potential intra-operative cataract surgery complications (adapted from the National Eye Institute<sup>34</sup>)



indicated by the presence of a subluxated lens, phacodonesis (increased mobility of the lens) or iridodonesis (increased mobility or tremulousness of the iris). A shallow anterior chamber of less than 2.5mm is highly suspicious of significant anterior chamber weakness in cases of pseudoexfoliation.<sup>23</sup> Lens zonule weakness can also occur as a result of damage of the zonules during surgery. Previously, cases of severe zonular compromise required ECCE, ICCE or pars plana lensectomy, a procedure which involves the removal of the entire lens within the pupillary area (the anterior capsule, anterior cortex, nucleus, posterior cortex, and posterior capsule).

In the 1990s devices called capsular tension rings (CTRs) (See Figure 1, page 23) began to be used in mild cases of segmental zonulysis or generalized zonular weakness. These capsular support devices have a diameter that is slightly greater than the capsular bag. They work by exerting a centrifugal force at the capsular equator after they have been placed inside the capsule. This redistributes tension from the weakened zonules equally over the others. This stabilises the whole structure, expands the capsular bag and makes the posterior capsule more taut. This helps prevent phimosis of the capsule which means that Nd:YAG capsulotomy can be carried out if PCO occurs in the future. CTRs have also been shown to reduce the incidence of PCO post-operatively.<sup>24</sup> A modified design of the CTR has been created for use in more extensive or progressive cases if zonular instability. It contains eyelets, which allows it to be sutured to the wall of the eye.<sup>25</sup>

## Visualisation

Performing an optimum capsulorrhexis in cases where there is a poor or absent red retinal reflex can be especially difficult due to poor visualisation; retroillumination of the fundus is necessary to see the edges of the rhexis. Such cases include mature or white cataracts (See Figure 2, page 25), vitreous opacity or corneal haze. Visibility of the anterior capsular edge can be improved in these scenarios by

the use of various capsular dyes including Trypan Blue, Indocyanine Green (ICG), Gentian Violet, fluorescein and autologous blood.<sup>26</sup> Trypan blue is one of the most commonly used capsular dyes.<sup>27</sup> This is marketed as Vision Blue (DORC International, Zuidland, The Netherlands) and is approved by the US Food and Drug Administration (FDA) for use as an adjunct to cataract surgery. It causes a more intense staining than other dyes and lasts longer, typically throughout the whole procedure, making visualisation easier. It is also less expensive as only a small amount is required.

The surgeon's visibility can also be poor due to the patient having a small non-dilating pupil. This could increase the risk of complications such as retained lens material and vitreous loss occurring. There are several methods commonly used to counter this. Mechanical stretching is the cheapest, quickest method. Iris hooks allow more iris stability but if the hooks are positioned or removed incorrectly this may result in iris prolapse or iridodialysis. An alternative to iris hooks are ring expanders which expand the pupil circumferentially. These are more expensive, but once in position provide the additional benefit of pupil margin protection and minimal iris trauma.

## Ophthalmic viscosurgical devices (OVDs)

OVDs are chemically non-active solutions that were originally used to maintain space inside the eye during surgery. They also prevent corneal endothelial cell trauma through contact with the IOL or surgical instrumentation, as well as dispersing heat generated by phacoemulsification. An ideal OVD should be easy to inject into the anterior chamber and remain there throughout the surgical procedure. It should allow the surgeon to have good visualisation whilst operating and be easily removable after the procedure since any OVD remaining in the anterior chamber may block the trabecular meshwork and cause an

increased post-operative IOP.<sup>28</sup>

Previously, OVDs could be divided into two broad categories: dispersives and cohesives. Dispersive OVDs tend to be short molecular chain compounds with low viscosity and molecular mass meaning that aspiration needs to be carried out for longer to ensure complete removal. The cohesive property of an OVD is a measure of the polymers ability to remain linked together and move collectively. Cohesive OVDs are therefore made up of long polymer chains with a high molecular mass and viscosity value. This makes them easier to remove and therefore this type of OVD is typically used for space maintenance and to expand the capsular bag for IOL insertion.

Newer OVDs known as "viscoadaptive compounds" have since been introduced. The behaviour of these compounds varies from cohesive to dispersive depending on the rate of fluid flow around them. At low flow rates these compounds have similar properties to cohesive structures and vice-versa. This means that they are able to successfully maintain space in the anterior chamber and provide tissue stabilisation at low flow rates as well as remaining in the eye during phacoemulsification when the flow rate is high. An example of this type of OVD is Healon 5 (Abbott Medical Optics, Santa Ana, CA, USA).

OVDs have been successfully used to make cataract surgery easier in patients with a condition known as intraoperative floppy iris syndrome (IFIS). IFIS is commonly seen in individuals who have been prescribed  $\alpha 1$  adrenergic receptor antagonists such as tamsulosin for the treatment of benign enlargement of the prostate. This drug improves lower urinary tract flow by relaxing smooth muscle in the prostate and neck of the bladder but it also inhibits the iris dilator smooth muscle. IFIS was first described in 2005 as a clinical triad observed during cataract surgery, which included undulation and billowing of the iris stroma in response to normal intraocular fluid currents, a tendency for the iris stroma to become floppy





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and prolapse towards the surgical incision site, and progressive intra-operative pupillary constriction, despite the use of standard dilating agents.<sup>29</sup> A spectrum of cases have been observed ranging from mild to severe, though it is difficult to predict the severity in advance of the individual's cataract surgery.

There are a number of potential complications that can result during cataract surgery in this group of patients. These include an increased risk of posterior capsule rupture, loss of vitreous, iris prolapse, capsulorrhexis tear, iridodialysis and anterior chamber haemorrhage.<sup>30</sup> Several modifications may be made to the surgical process to minimise the probability of such events occurring. These include the use of alternative pharmacological dilating agents. Phenylephrine and epinephrine ( $\alpha$ 1A-adrenergic receptor agonists) administered intracamerally (directly into the anterior chamber) allows maximum stimulation of the  $\alpha$ 1A-adrenergic receptors. This approach has been shown to cause additional pupillary dilation in patients with IFIS as well as preventing iris prolapse and billowing.<sup>31</sup> In mild and moderate cases, Healon 5 may be injected into the anterior chamber to help maintain pupillary mydriasis and to prevent iris prolapse towards the incisions. Low aspiration flow and vacuum settings are necessary to prolong the time that Healon 5 remains in the anterior chamber and to reduce the need for repeat injections. However, if the patient's cataract is dense and high vacuum setting are necessary, this modification would not be suitable. In more severe cases, pupillary ring expanders and iris retractors may be used in conjunction with OVDs to minimize the risk of complications.<sup>32</sup>

IFIS has been found to occur even when patients discontinued use of  $\alpha$ 1 antagonist medication for years prior to cataract surgery.<sup>33</sup> Therefore, in any patient about to undergo cataract surgery, it is important to determine whether they are currently or have previously been prescribed this type of medication. This enables measures to then be taken during surgery to reduce the risk of complications.

## Conclusion

This article has illustrated the potential complications that can occur during cataract surgery. Some of these are summarised in Figure 3 (See page 26). A thorough pre-operative consultation with a detailed assessment including determination of the patient's full medical history enables a management plan to be devised with regards to their surgery. Surgical modifications may need to be made depending on the patient's state of health including concurrent ocular conditions, medications and allergies. Their ocular anatomy also needs to be taken into account. Additional steps may be needed in the case of a patient with miotic pupils, for example, such as the use of mechanical stretchers or ring expanders, which need to be arranged before surgery commences. The utilisation of such a plan can reduce the risk of many complications from occurring. Another important aspect is good communication with the patient so that they understand what they are undertaking and the potential risks involved. At Aston University Day Hospital, the surgeon discusses the risks and benefits of the surgery with the patient pre-operatively and the patient is able to call if they have any queries or concerns. There is also an out of hours on-call service available for the patient post-operatively should they require it.

## About the author

Louise Stainer is an optometrist at Aston University Day Hospital. She is currently involved in the pre-and post-operative care of cataract and refractive surgery patients and research into macular degeneration. Ms Stainer has previously worked at Kidderminster Hospital in the paediatric eye unit and has taught the ophthalmic section of the guide dog mobility instructor's (GDMI) diploma and Masters courses (affiliated with Southampton University) at the Guide Dogs for the Blind. She also works in private optometric practice.

## References

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## Module questions

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Please note, there is only one correct answer. Enter online or by the form provided

**An answer return form is included in this issue. It should be completed and returned to CET initiatives (c-11440) OT, Ten Alps plc, 9 Savoy Street, London WC2E 7HR by July 21 2009**

- What is currently the commonest type of cataract surgery performed in the UK?
  - Extracapsular cataract extraction (ECCE)
  - Intracapsular cataract extraction (ICCE)
  - Phacoemulsification (PHACO)
  - None of the above
- Which of the following methods of anaesthesia can be used prior to cataract surgery?
  - General anaesthetic
  - Retrobulbar anaesthetic
  - Topical anaesthetic
  - All of the above
- Which of the following methods of anaesthesia does not affect eye movements?
  - General anaesthetic
  - Retrobulbar anaesthetic
  - Topical anaesthetic
  - All of the above
- Vitreous loss can be characterized by all of the following EXCEPT:
  - Distorted pupil
  - Shallow anterior chamber
  - Vitreous prolapse into the anterior chamber
  - Iris movement posteriorly
- Dropped nucleus, if left in the vitreous, does NOT cause which of the following?
  - Cystoid macula oedema (CMO)
  - Glaucoma
  - Corneal decompensation
  - Retinal detachment
- Weak lens zonules are associated with which of the following conditions?
  - Hypermature cataract
  - Pseudoexfoliation
  - Traumatic zonulysis
  - All of the above
- Intra-operative Floppy Iris Syndrome (IFIS) may be observed in patients taking which type of medication?
  - $\alpha$ 1 antagonists
  - $\alpha$ 2 antagonists
  - $\beta$ 1 antagonists
  - $\beta$ 2 antagonists
- Which of the following is not a complication of Intra-operative Floppy Iris Syndrome (IFIS)?
  - Iris prolapse
  - Retinal detachment
  - Iridodialysis
  - Capsulorrhexis tear
- Which of the following is TRUE? The ideal Ophthalmic Viscosurgical Device (OVD) should:
  - Be easy to inject into the anterior chamber
  - Be retained in the anterior chamber after the cataract surgery procedure
  - Hinder visualization of the capsulorrhexis
  - All of the above
- Which of the following are advantages of phacoemulsification over other methods of cataract extraction?
  - Shorter recovery time
  - Smaller incisions
  - Less induced astigmatism
  - All of the above
- Capsular opacification is NOT a complication of which cataract surgery procedure?
  - Extracapsular cataract extraction (ECCE)
  - Intracapsular cataract extraction (ICCE)
  - Phacoemulsification (PHACO)
  - Manual small incision cataract surgery (MSICS)
- Which of the following is NOT an operative complication of cataract surgery?
  - Thermal corneal burn
  - Vitreous loss
  - Posterior capsular thickening
  - Descemet's membrane detachment

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