Modern techniques can significantly reduce endothelial cell loss after cataract surgery

Phaco Technology

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Rolbeer N H Einselechn in Stockholm

To RSO N Al phaco and the soft-shell technique are among the means available to surgeons for reducing endothelial cell loss to a minimum after cataract procedures, said Rudy Nuijts MD, University Hospital, Maastricht, The Netherlands.

At every stage of a cataract procedure the surgeon has options that can optimise corneal endothelial safety. The relevant parameters include the machines, materials, and techniques used, and patient characteristics such as stage of the cataract, age of the patient, and the presence of corneal disease, Dr Nuijts told the XXV Congress of the ESCRS.

In the published literature endothelial cell loss after cataract surgery ranges from four per cent, in some of the shorter term studies, up to 25 per cent in the only study published to date with a follow-up of 10 years (Bourne et al Ophthalmology 1994; 101:1014). That study involved patients who underwent ECCE without ODVs.

Dr Nuijts said while it is phacoemulsification and ODVs that have made modern cataract surgery possible, phacoemulsification does not afford any greater endothelial safety than ECCE, as the older technique is currently performed.

He cited a prospective randomised study that compared endothelial cell loss after phacoemulsification with ECCE in 500 patients and showed no difference between the two treatment groups (Bourne, Ophthalmology 2004; 111:679). The mean cell loss was around 10 per cent after one year in both groups although the phacoemulsification group actually had a higher rate of cell loss in hard cataracts (18.9 per cent vs. 11.8 per cent). The factors associated with higher amounts of cell loss in the study included hard cataract, age, capsule break and vitreous loss.

Power modulation improves results

In phacoemulsification procedures the most important predictor of corneal clarity in the early postoperative period is the amount of ultrasound energy used, Dr Nuijts noted. For this reason all of the major platforms now use power modulation to reduce the amount of phaco power necessary, either by varying the duty cycle and pulse energy or by varying the pulse intervals with microburst techniques.

More recently torsional phacoemulsification has become available in the form of the OZil torsional handpiece (Alcon). The new technology uses the rotational motion of the phaco tip to shear and emulsify the lens, instead of the purely longitudinal motion of a conventional phaco tip. Since the torsional phaco tip does not repel the surface it is acting on, the nucleus does not need to be constantly followed throughout the procedure. In this way, the technology may improve the efficiency of the surgery and reduce endothelial trauma.

In a randomised study that compared torsional and conventional phacoemulsification, less ultrasound was necessary for all grades of cataract with torsional ultrasound. Moreover, torsional ultrasound provided a faster visual recovery and resulted in significantly less endothelial cell loss, at 12.5 per cent, compared to 19.1 per cent with conventional ultrasound (Lu et al, JCRS 2007; 33:287).

Irrigating solutions

As regards the materials used in cataract surgery, Dr Nuijts said that the irrigating solution should resemble the natural constituents of the aqueous. The composition of the irrigating solution is more important to endothelial cell survival than is the duration of irrigation.

He noted that standard BSS and Ringer’s solution lack two key constituents of the aqueous necessary for minimising endothelial trauma. Namely, bicarbonate, which is the natural buffer in the eye, and glucose, which is an energy source for the cells. Furthermore, Ringer’s solution has a significantly lower pH and osmolarity than aqueous.

Fortified BSS (BSS Plus, Alcon), in contrast, contains bicarbonate, glucose and glutathione at levels close to those of the aqueous. It also has a more similar pH and osmolarity. BSS Plus may therefore improve corneal safety in cases with compromised corneas or prolonged surgery.

Clinical Studies supporting that view include a study carried out by Antonia Joussen MD and associates (Joussen et al, JCRS 2000; 26:392) where corneal thickness after cataract surgery increased by 4.2 per cent with Ringer’s solution, compared to only 1.9 per cent with BSS Plus. However, in another prospective randomised study there was no difference in acute postoperative corneal swelling and corneal cell loss at three months whether Ocucoat (Bausch and Lomb) Ringer’s solution or Viscoat (Alcon) and BSS Plus was used, he noted (Kiss et al, JCRS 2003; 29:733).

Another aspect of phacoemulsification that has a bearing on endothelial cell loss is the sterilisation of equipment. Small gauge cannulas can retain toxic detergents and cleaners. These toxins can induce toxic endothelial cell destruction and profound corneal oedema. Furthermore, viscoelastics may potentiate retention of toxic substances in canulas.

“O one should consider restricting the use of reusable instruments, be aware of complications that arise from cleaning and sterilisation and follow recommended cleaning procedures,” Dr Nuijts emphasised.

Phaco and Endothelial Cell Loss

Coaxial vs Biaxial

<table>
<thead>
<tr>
<th>No. Eyes</th>
<th>Endothelial Cell Loss at 3 mos (%)</th>
<th>Coaxial</th>
<th>Biaxial</th>
</tr>
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<tbody>
<tr>
<td>Crema 2007</td>
<td>60</td>
<td>4.7±0.1</td>
<td>4.5±0.1</td>
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<tr>
<td>Cavallini 2007</td>
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<td>10.1±11.7</td>
<td>11.9±15.2</td>
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<tr>
<td>Menucci 2006</td>
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<td>6.5</td>
<td>6.3</td>
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<tr>
<td>Kurz 2006</td>
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<td>4.7±0.1</td>
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</tr>
<tr>
<td>Kharasman 2006</td>
<td>68</td>
<td>3±0.2</td>
<td>6.2±0.1</td>
</tr>
<tr>
<td>Abo 2005</td>
<td>100</td>
<td>11.7±16.0</td>
<td>7.4±3.2</td>
</tr>
</tbody>
</table>

No difference in EC loss between coaxial and biaxial phaco Range of EC loss between 5-12% for both techniques

EC Loss and TECD

Toxic Endothelial Cell Destruction

- Profound corneal oedema < 24 hours after surgery
- Causes
  - Topical antiseptic solutions
  - Intracocular medications
  - Preservatives
  - Detergents
  - Sterilization procedures

Torsional vs Conventional US Mode

- Randomized study of torsional vs conventional US
- Torsional:
  - Lower level of US time and energy
  - Faster visual recovery
  - Less endothelial cell loss

Liu, JCRS 2007: 33:287


Courtesy of Rudy Nuijts MD
OVDs and soft-shell technique

The ophthalmic viscosurgical devices used in cataract procedures can also influence the risk of acute endothelial cell loss. For example, low viscosity dispersive OVDs provide protection against air-bubble damage during phacoemulsification because they adhere to corneal endothelium.

However, low viscosity dispersive OVDs are not as good at maintaining anterior chamber depth and stability as cohesive OVDs and are also harder to remove from the eye at the end of surgery. For this reason Steven Arshinoff MD in 1999 proposed his soft-shell technique, which combines dispersive OVDs with cohesive OVDs to facilitate the surgery and enhance the safety of cataract procedures, particularly as regards the endothelium.

In the soft-shell technique, the surgeon first injects the dispersive OVD and then injects a cohesive OVD underneath it until the dispersive OVD forms a protective coating on the corneal endothelium. During phacoemulsification, the phaco probe rapidly aspirates the high viscosity cohesive but leaves the dispersive OVD behind.

Following cataract removal, loosely filling the capsular bag and anterior chamber with a high viscosity cohesive OVD stabilises the anterior chamber while the injection of a dispersive OVD into the centre of the pupillary space provides a lower viscosity zone through which to move the IOL. The dispersive OVD is also then easier to remove at the end of surgery because it is fully encapsulated in a high viscosity cohesive.

In a study involving 57 patients with hard cataracts (Emery-Little classification grade 3 or higher), corneal endothelial cell loss after phacoemulsification was only 6.4 per cent with the soft-shell technique using Viscoat and Healon (AMO), compared to 16.3 per cent using Healon alone (p=0.0003). There was also a transient increase in corneal thickness at day one after using Healon alone, while corneal thickness remained stable after using the soft-shell technique (Miyata, JCRS 2002; 28:1546-1550).

Another study involving 230 cataract patients yielded similar findings. It showed that in eyes with cataracts LOC CCS grade 4 endothelial cell loss was only 12.2 per cent using the soft shell technique with Viscoat and Hyal-2000 (LG Life sciences India), compared to around 20 per cent or more using Viscoat, Provisc (Alcon) or Hyal-2000 alone (Kim, JCRS 2004;30:2366).

More recently a viscoadaptive OVD, Healon 5 (AMO) has become available which has both cohesive and dispersive characteristics. The OVD has the good retention and corneal protective properties of lower viscosity dispersive OVDs and the good anterior chamber maintenance of high viscosity cohesives. It is also administered with one single syringe. However, published studies have yielded contradictory results regarding the endothelial cell protection provided by the viscoadaptive OVD. In one prospective randomised study involving 74 eyes, endothelial cell loss was significantly less after cataract surgery with Healon 5 (6.2 per cent) than after surgery with Viscoat (15.4 per cent) (Holzer et al, JCRS 2001; 27:213). But in another randomised study involving 157 eyes, there was no significant difference regarding endothelial cell loss between procedures with Healon 5 or Healon (Oshika et al, JCRS 2004; 30:357).

Surgical manoeuvres may play role

The size and site of the incision may also influence endothelial cell loss. One study showed slightly less cell loss with 3.5mm clear corneal incision than with a 5.0mm clear corneal incision (Dick, JCRS 1996; 22:63). Another study showed less endothelial cell loss with a 5.5mm scleral tunnel incision than with 3.5mm clear corneal incision (Beltrame et al, JCRS 2002; 28:118). A third study showed no difference between temporal and superior corneoscleral tunnel incisions (Walkow et al, JCRS 2000; 26:727).

“Advanced phaco technology appears better for endothelial cell protection in hard cataracts and soft-shell technique and fortified BSS may have a greater protective effect in hard cataracts and corneas at risk of decompensation”

“Scleral tunnel incisions may be preferable in patients at risk for endothelial damage,” Dr Nuijts suggested.

As regards nuclear fractioning technique only one of several studies showed a difference between the chop and divide and conquer techniques, with cell loss rates at three months of 4.7 per cent and 13.8 per cent, respectively (Pizzolot, 1996). The remaining studies had comparable cell loss rates in both groups, ranging from seven per cent to 10 per cent.

Similarly, a number of studies have failed to show a significant difference between endothelial cell loss occurring after coaxial and biaxial phaco, with the mean rates of cell loss ranging from around five per cent to 12 per cent for both techniques.

Certain coexisting ocular diseases, such as cornea guttata and Fuchs’ dystrophy, may also predispose patients to endothelial cell loss following cataract surgery. In those cases it is important to ask the patient if they have a diurnal shift in vision. In addition, when examining the patient under the slit-lamp, surgeons should look for epithelial oedema and stromal folds. They should also grade the density of the cataract and discuss the risk of corneal decompensation with the patient. A soft-shell technique is recommended in such cases, Dr Nuijts added.

As regards Fuchs’ dystrophy, current guidelines recommend initial triple procedures (combining phacoemulsification, lens replacement and penetrating keratoplasty) in eyes with pre-operative corneal thickness greater than 600 µm. However, the results of a recent study (Seltzman et al, Ophthalmology 2005; 112:441) suggest that the risk of corneal decompensation only increases slightly at that thickness. A thickness of 640 µm might therefore be a better cut-off point for performing keratoplasty, the study’s authors suggested.

“Cataract surgery in Fuchs’ patients can be done successfully when a good pre-operative risk analysis is performed. Advanced phaco technology appears better for endothelial cell protection in hard cataracts and soft-shell technique and fortified BSS may have a greater protective effect in hard cataracts and corneas at risk of decompensation,” Dr Nuijts summarised.