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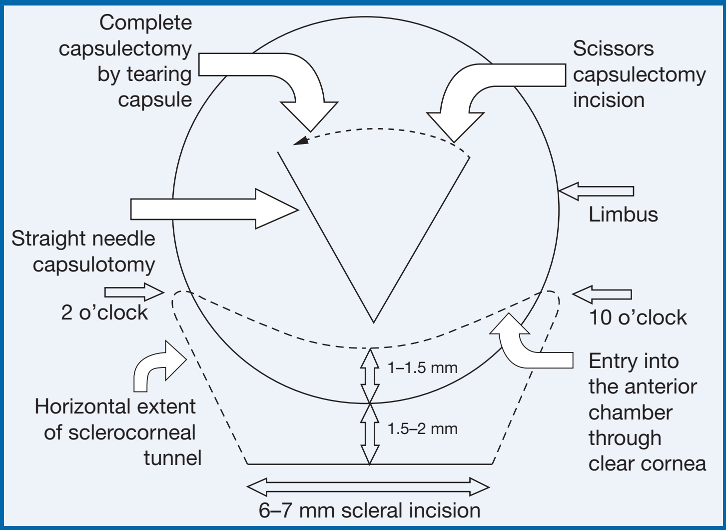

Cataract Surgery in the Developing World

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Learning Objectives

Upon completion of this module, the reader should be able to:

- Describe the manual small-incision cataract surgery (MSICS) technique
- Discuss the potential complications and expected outcomes of MSICS compared to other surgical techniques
- Outline the keys to delivering high-volume surgery in the developing world

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Introduction

Over the past 2 decades, innovations and advances in phacoemulsification have helped to improve surgical outcomes for millions of patients, with fewer complications and faster visual rehabilitation. However, the high cost associated with this technology limits its use throughout the developing world, where the majority of cataract-blind people live (Figure 1). The need to provide high-quality, low-cost cataract surgery to underserved patients in underdeveloped countries has fostered innovations in sutureless, non-phaco surgical techniques and novel refinements in the delivery of surgical services.

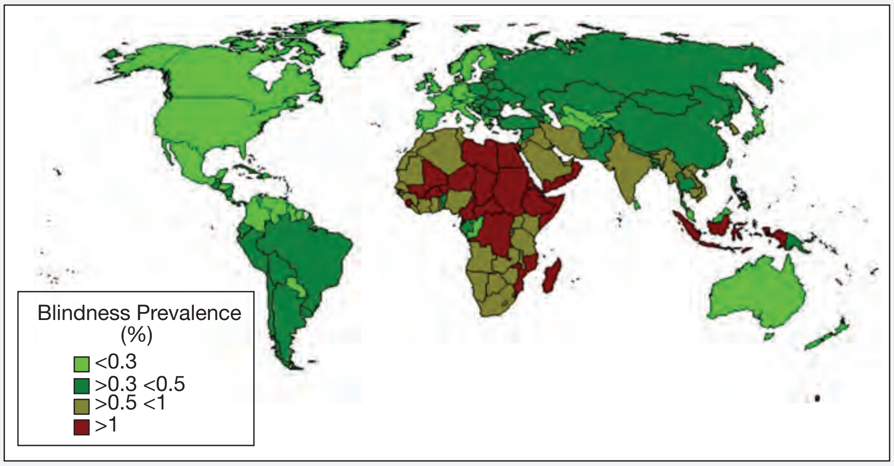

Figure 1 Prevalence of blindness. (Reprinted with permission from the World Health Organization, www.who.int/blindness/data_maps/blindness.jpg.)

In fact, ultra-efficient delivery systems, sustainable economic strategy, and indigenous production of consumables have made high-quality, 5-minute cataract surgeries available throughout the developing world for $20 USD. This sutureless non-phaco technique, termed *manual small-incision cataract surgery* (MSICS), provides excellent results for even the most advanced and challenging cataracts. This module outlines the provision of high-volume cataract surgery and reviews the surgical techniques used throughout the developing world.

Scope of the Problem

Cataract is the leading cause of blindness (defined as visual acuity less than 20/400) worldwide and is responsible for approximately 50% of blindness in the developing world, affecting nearly 20 million people (Figure 2). In response to this crisis, in 1999 the International Agency for the Prevention of Blindness and the World Health Organization collaborated to launch the "Vision 2020: The Right to Sight" initiative. Its mission is to develop the infrastructure, personnel, and economic strategy necessary for sustainable provision of high-quality cataract surgical services throughout the underdeveloped world. At the onset of the initiative, the number of individuals blinded by cataracts was projected to double by the year 2020 without significant improvements in global eye care delivery.

Over the past decade, significant progress has been made in both the quantity and quality of cataract surgery provided in the developing world. For example, the cataract surgery rate (operated cataracts per million population per year) in India and Nepal has reached a stable prevalence level, and 98% of cataract surgeries are performed using high-quality IOLs (Figure 3).

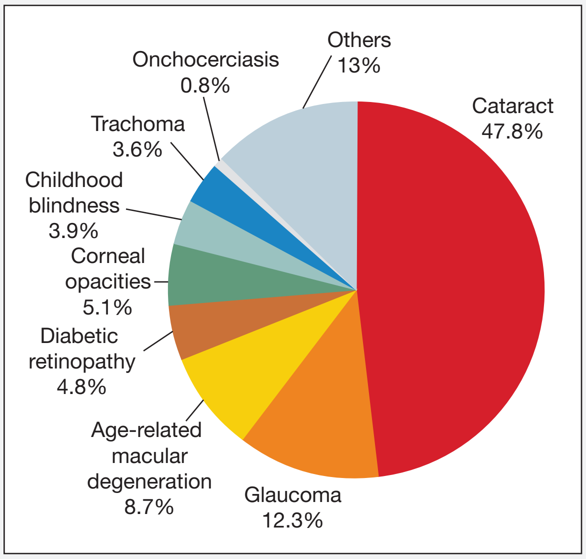

Figure 2 Global causes of blindness due to eye disease. (Reprinted, with permission, from Resnikoff S, Pascolini D, Etya'ale D, et al. Policy and practice: global data on visual impairment in the year 2002. *Bull World Health Organ.* 2004;82:849.

Patient Selection and Preoperative Management

Preoperative management begins with the surgeon examining patients who have been prescreened for vision and relative afferent pupillary defects by ophthalmic assistants. Priority is given to patients who are bilaterally blind from advanced cataracts. However, multiple

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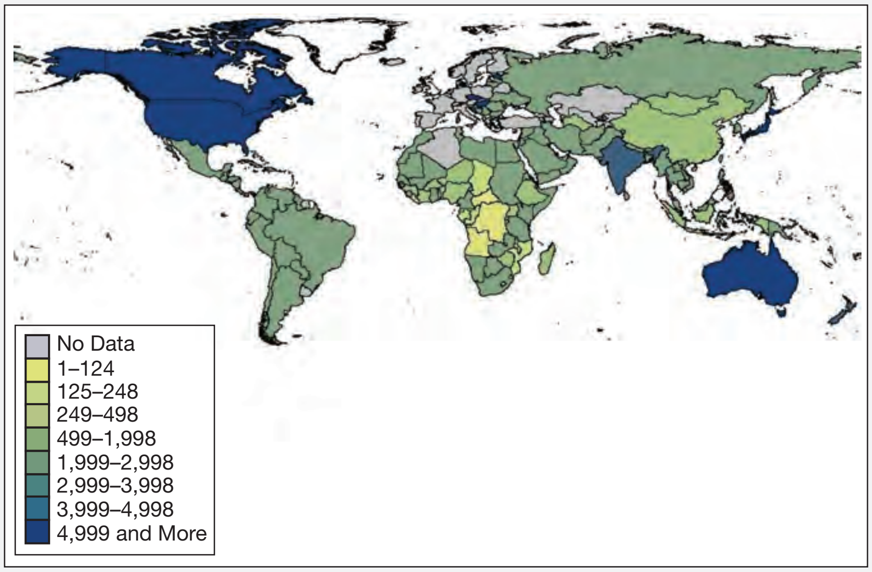

Figure 3 2006 global cataract surgical rates. The volume of surgery is per million in the population. (Reprinted with permission from the World Health Organization, www.who.int/blindness/CSR2006.jpg.)

studies have demonstrated the additional benefits of cataract surgery on the fellow eye, and surgery on the second eye is also performed when possible. Many patients in the developing world have mature cataracts with no view to the posterior pole. Prior to surgery, these patients should undergo B-scan ultrasonography, when available, at the time of their biometry measurements.

Before the patient is brought into the operative room, the eye is prepped with 5% povidone-iodine (Betadine) solution and a peribulbar block is administered by an ophthalmic assistant or anesthetic technician, after which a Betadine-soaked gauze is placed over the eye. Once the patient is brought to the operating table, the surgeon or assistant performs a final prep with instillation of a small amount of Betadine into the fornix.

Delivery of High-Volume Surgery

The importance of successfully delivering high-volume surgery in the setting of the developing world cannot be emphasized enough. High-volume surgery not only allows the provision of surgery to more individuals, it significantly lowers the unit cost of each procedure due to economy of scale. To maximize efficiency in the operating room, turnover time should be minimized and multiple instrument sets should be available for each operating surgeon. With proper division of labor, sufficient support staff, and sufficient number of surgical instrument sets, the turnover time between cataract surgeries should be under 3 minutes. Table 1 summarizes instruments necessary for the procedure.

Different strategies are employed to maximize efficiency and patient flow. At Aravind Eye Hospital (India), for example, the operating room is set up with 2 parallel tables, each supplied with 2 equipment trays and 1 microscope. Two scrub nurses are assigned to each table. In this setting, the surgeon takes a table-to-table approach: as surgery is proceeding on table 1, the assistant moves a patient to table 2 and prepares the patient and the instruments for surgery. As the surgeon finishes at table 1, surgery begins at table 2 on the pre-prepped patient while the patient from table 1 is removed. A new patient is then brought to table 1 and prepared for surgery. Using this technique, the typical turnover time between cases is less than 1 minute.

Table 1. Instruments Necessary for Manual Small-Incision Cataract Surgery

1 mL syringe	Needle driver
25–27 gauge needle	Simcoe irrigation/aspiration cannula
27 gauge cannula	Sinskey hook
3 ml syringe	Superior rectus forceps
4-0 silk	Toothed forceps (0.12 or 0.3)
5% povidone-iodine (Betadine)	Tying forceps
Bevel-up crescent blade	Vannas scissors
Cautery (low-temp or wet-field)	Viscoelastic
Gauze pads	Westcott scissors
Dish for gauze pads	
Eyelid speculum	
Keratome	

At Tilganga Institute of Ophthalmology (Nepal), each surgeon uses a single table. A scrub nurse and scrub aide assist the surgeon and prepare the instruments and sterilized drapes to be used for the next case. As soon as the surgeon finishes with a case, a third operating assistant escorts the patient to the postoperative recovery room while another patient, who has already been given a peribulbar block, is brought to the table. Using this technique, surgeries take place in rapid and smooth succession, with a typical turnover time of 1 to 2 minutes between surgical cases.

Manual Small-Incision Cataract Surgery

It is well established that the combination of continuous curvilinear capsulorrhexis, phacoemulsification, and in-the-bag placement of an intraocular lens (IOL) is the standard of care in industrialized nations. However, the high cost of purchasing and maintaining a phaco machine, the dependence on unreliable amenities, and the limited availability of appropriate training for technicians and surgeons are significant obstacles currently limiting the widespread use of this technique in the developing world. Fortunately, the MSICS technique offers a high-quality, cost-effective surgical alternative to phacoemulsification.

First described by Blumenthal in 1994, MSICS has since received significant international attention, particularly throughout Asia and Africa, as an inexpensive, low-technology, high-quality alternative to phacoemulsification. MSICS is similar to extracapsular cataract extraction (ECCE) in that it involves removal of an intact crystalline lens from the eye while maintaining the integrity of the posterior capsule. However, in contrast to traditional ECCE, in MSICS the lens is delivered through a 6 to 7 mm wedge-shaped, multiplanar, self-sealing sclerocorneal tunnel large enough to allow removal of the nucleus and insertion of a rigid posterior chamber intraocular lens (Figure 4).

Scleral Tunnel

MSICS can be performed from a superior or temporal approach. When a superior tunnel is performed, a superior rectus bridle suture may facilitate globe positioning intraoperatively.

Superior wound construction is less technically challenging for the beginning surgeon; however, for more experienced surgeons, the temporal approach is preferred because it induces less astigmatism (0.5 to 1.0 diopters) compared to the superior approach and tends to counteract the pre-existing against-the-rule astigmatism that is commonly present in elderly patients with visually significant cataracts. The temporal approach also improves working space by eliminating the anatomic crowding associated with a prominent brow or deep sockets.

A fornix-based conjunctival flap of 7 to 8 mm is created. Following dissection of Tenon's capsule away from the scleral bed, light cautery is applied. A 33% to 50% depth external scleral groove of approximately 6 to 7 mm in width is made 1.5 to 2 mm posterior to the limbus using a crescent blade, side-port blade, or 20-gauge needle. The incision should be tangential to the limbus or frown-shaped to minimize surgically induced astigmatism and ensure sutureless wound closure (Figure 4).

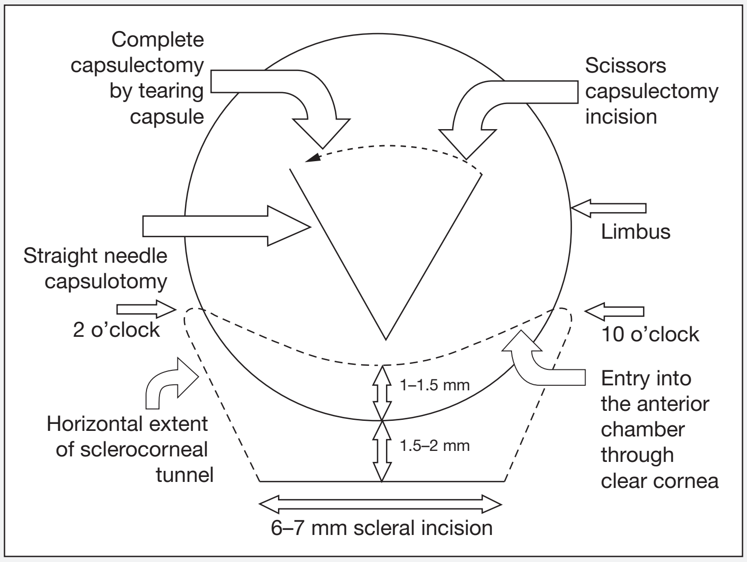

Figure 4 Small incision cataract surgery diagram. (Reprinted from Ruit S, Paudyal G, Gurung R, et al. An innovation in developing world cataract surgery: sutureless extracapsular cataract extraction with intraocular lens implantation. *Clin Experiment Ophthalmol.* 2000;28:274–279, © 2000, with permission from John Wiley and Sons.)

A bevel-up crescent blade is used to advance the tunnel anteriorly and parallel to the surface of the eye. The tunnel should be uniform in thickness, follow a single dissection plane, and extend approximately 1.5 mm into the clear cornea along the entire width of the incision. It is important that the dissection is of sufficient depth and carried anterior in a plane parallel to the ocular surface to avoid early entry into the anterior chamber, creation of buttonhole tears, and tearing of the wound edges. The inner aspect of the tunnel should extend peripheral to the limbus, creating a trapezoidal tunnel (Figure 4). At this point, the anterior chamber has not been entered.

ONLINE VIDEO:
Sclerocorneal Tunnel, 02 min 15 sec

Side-Port Entry

Creation of a side port at this point is optional, but it may be useful for injection of viscoelastic and capsular staining agents, performing a capsulotomy, aspirating cortex and viscoelastic (especially in cases with iris prolapse), and adjusting the intraocular pressure at the end of surgery.

ONLINE VIDEO:
Side-Port Incision, 01 min 27 sec

Capsulotomy

Several different capsulotomy techniques are possible with the MSICS technique. Continuous curvilinear capsulorrhexis (CCC) may provide optimal IOL positioning but can be difficult in the setting of large mature, hypermature, or Morgagnian cataracts and in the setting or poor surgical visibility due to corneal scars, pterygium, and suboptimal operating microscopes. These are all common circumstances when operating in the developing world. The triangular capsulotomy and can-opener capsulotomy can be particularly useful in these suboptimal surgical settings, especially when capsular staining techniques are not available.

If the surgeon uses a CCC, the capsulotomy can be performed either before or after completion of the internal corneal incision. However, if the CCC is performed after creation of the internal incision, it is usually necessary to use viscoelastic to maintain the anterior chamber depth. The capsulotomy should have a minimum diameter of 5.5 to 6 mm, depending on the size and maturity of the nucleus. If the diameter of the CCC is less than 5.5 to 6 mm, it is prudent to make several relaxing incisions in the capsulotomy to facilitate prolapse of the nucleus into the anterior chamber. Capsular staining is helpful in the setting of white, dense brown, or black cataracts.

If the surgeon uses a triangular capsulotomy, this step should be performed prior to creation of the internal corneal incision and entry into the anterior chamber. A straight 25- to 27-gauge needle attached to a 1 mL syringe filled with balanced saline solution (BSS) is advanced in the scleral tunnel just anterior to the limbus, angled parallel to the iris plane, and advanced into the anterior chamber. The bevel tip of the needle is used to make a linear cut from 4 o'clock to 12 o'clock and then from 8 o'clock to 12 o'clock so that the incisions meet at 12 o'clock (Figure 4). Thus, a triangular or V-shaped flap of anterior lens capsule is created with its base still attached. The apex of the V should be oriented toward the surgeon and the base of the capsulotomy away from the surgeon (Figures 4, 5). Each point of the triangle

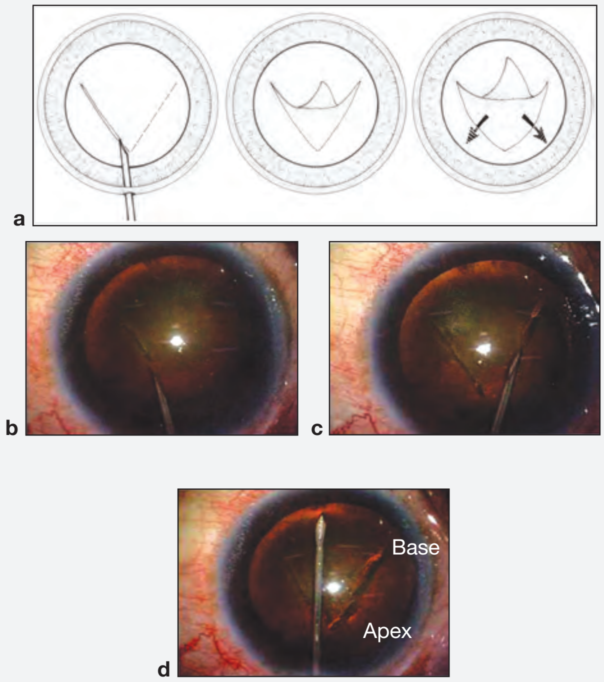

Figure 5 Triangular capsulotomy. **a.** Illustration of the creation of a triangular capsulotomy. Left image: First, 2 capsular incisions are made with a 27-gauge needle, demarcated by a dotted line, and joined to create a V-shaped window in the anterior lens capsule. Center image: The capsular window is then created by peeling the apex of the capsulotomy distally with the tip of the needle. Right image: The capsular bag is freed from the underlying lens cortex by injection of balanced saline solution. Intraoperative photographs illustrating the first (**b**) and second (**c**) anterior lens capsular incisions created with a 27-gauge needle. **d.** Intraoperative photograph illustrating the creation of the capsular window by peeling the apex of the capsulotomy distally. (Reprinted, with permission, from Tabin G. Small incision cataract surgery in underdeveloped countries. In: Steinert RF, ed. *Cataract Surgery.* 3rd ed. New York, NY: Elsevier; 2010:128.)

should be approximately 3 mm from the center of the pupil. Next, the apex is lifted with the tip of the needle and peeled away from the surgeon. This confirms the capsulotomy incisions are complete.

ONLINE VIDEO:
Capsulotomy, 01 min 58 sec

Internal Corneal Incision

Advancing a sharp angled keratome into the anterior chamber at the anterior edge of the corneal dissection completes the corneal tunnel. The tip of the keratome is advanced to the anterior edge of the internal wound, and the heel of the keratome is raised until the blade becomes parallel to the iris plane. The keratome is then advanced anteriorly and extended along the length of the incision, with care taken to maintain a single plane.

Hydrodissection

Hydrodissection can be performed using a 27-gauge bent-tip cannula attached to a syringe filled with BSS or by using an irrigation and aspiration cannula. In cases of can-opener or triangular capsulotomy, gentle hydrodissection is performed to avoid capsular stress and capsular tears. The nucleus should be freely mobile within the capsular bag at the end of a successful hydrodissection. In the setting of a white or hypermature cataract, hydrodissection may not be necessary as the lens is freely mobile within the capsule.

Prolapse of Nucleus Into the Anterior Chamber

Hydroprolapse With CCC. Often, when the initial hydrodissection is performed, a pole of the nucleus will prolapse into the anterior chamber along with the fluid wave. At the site of this prolapse, injection of viscoelastic posterior to the nucleus will further prolapse the nucleus. A Sinskey hook can be used to rotate the lens and complete the prolapse.

Prolapse With Triangular or Can-Opener Capsulotomy. Prolapse of the lens in this setting is achieved using hydrostatic and gentle mechanical pressure. Irrigating under the displaced triangular capsule flap, as well as under the temporal and nasal edges of the flap, with a flowing Simcoe cannula will mobilize the lens nucleus and delaminate the lens components. The nucleus is then gently directed away from the tunnel incision within the capsular bag. Gentle downward pressure applied at the limbus within the tunnel incision using the tip of the Simcoe cannula will prolapse the edge of the nucleus anterior to the iris. The irrigating cannula is then used to completely prolapse the nucleus into the anterior chamber, through a combination of hydrostatic pressure and mechanical rotation.

Nucleus Extraction

Once the nucleus is prolapsed into the anterior chamber, viscoelastic is injected anterior and posterior to the nucleus to protect the endothelium and posterior capsule. The nucleus can be extracted through the tunnel using one of the following techniques. In each technique, passing an instrument around the nucleus must be performed carefully to avoid damaging the corneal endothelium and posterior lens capsule.

Simcoe Extraction Technique. Following injection of viscoelastic anterior and then posterior to the nucleus, a vigorously flowing Simcoe cannula is passed posterior to the nucleus until the tip is fully visible beyond the distal pole of the nucleus, anterior to the iris. A toothed forceps is used to gently rotate the eye away from the external wound. The accumulating irrigation fluid from the cannula will engage the nucleus into the internal mouth of the sclerocorneal tunnel. Hydrostatic pressure and slow retraction of the cannula will promote migration of the nucleus through the sclerocorneal tunnel. Gentle downward pressure on the posterior lip of the wound using the heel of the cannula and gentle retraction of the cannula will complete delivery of the nucleus (Figure 6). If the surgeon has difficulty in delivering the nucleus, the wound should be lengthened using a keratome blade to avoid damaging the endothelium.

Phacosandwich Technique. In this technique, a Sinskey hook is used in addition to the irrigating vectis or Simcoe cannula. Once the nucleus is prolapsed into the anterior chamber, a protective layer viscoelastic should be placed anterior and posterior to the lens to protect the endothelium and posterior capsule. The vectis or cannula is then placed beneath the nucleus, and a Sinskey hook is carefully introduced and placed on top of the nucleus, sandwiching it between the vectis and the Sinskey hook. The tip of the Sinskey hook is placed beyond the central portion of the lens. With the Sinskey hook in the dominant hand and vectis in the other, the surgeon sandwiches and extracts the nucleus, again using gentle downward pressure on the posterior lip of the wound.

Irrigating Vectis Technique. This technique uses a combination of mechanical and hydrostatic forces to deliver the nucleus. A good superior rectus bridle suture is necessary for this technique. The bridle suture is held

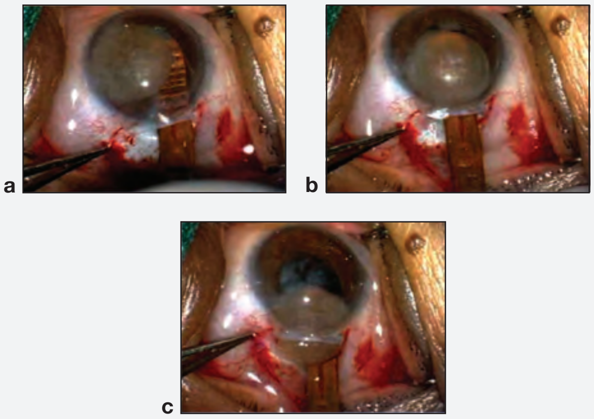

Figure 6 Extraction of the nucleus from the anterior chamber. Intraoperative photographs of a flowing Simcoe cannula aiding delivery of the lens nucleus from the anterior chamber. **a.** The tip of the cannula is passed posterior to the nucleus beyond the distal pole and the eye is gently rotated downward with toothed forceps. **b.** Accumulating irrigation fluid from the cannula beyond the distal pole of the nucleus engages the nucleus into the internal mouth of the sclerocorneal tunnel. **c.** Hydrostatic pressure plus gentle lifting and retraction with the lip of the cannula aides the nucleus into the tunnel and the nucleus is delivered through the external foramen of the tunnel with gentle downward pressure from the heel of the Simcoe cannula. (Reprinted, with permission, from Tabin G. Small incision cataract surgery in underdeveloped countries. In: Steinert RF, ed. *Cataract Surgery.* 3rd ed. New York, NY: Elsevier; 2010:129.)

loosely in the left hand. After checking the patency of the ports, the surgeon inserts an irrigating vectis concave side up under the nucleus but anterior to the iris. As the superior rectus bridle suture is pulled tight, the irrigating vectis is slowly withdrawn without irrigating, until the superior pole of the nucleus is engaged in the tunnel. Gentle irrigation is then performed and the vectis is slowly withdrawn while placing gentle downward pressure on the posterior scleral lip. The force of irrigation should be carefully reduced when the maximum diameter of the nucleus just crosses the inner lip of the tunnel. Excessive hydrostatic pressure can result in forceful expulsion of the nucleus and other intraocular contents. If the wound is placed temporally, the lateral rectus bridal suture will not provide sufficient traction and traction on the nasal conjunctiva by the assistant may be necessary to aid in nucleus extraction.

Phacofracture Technique. This technique of manual nuclear fragmentation is used for removing a large nucleus through a small (4 to 5 mm) incision. Following prolapse of the nucleus into the anterior chamber and injection of viscoelastic above and below the nucleus, a bisector or trisector instrument is used to section the nucleus. The vectis is inserted posterior to the lens. Steady and constant downward pressure with the bisector or the trisector, and gentle lifting pressure with the irrigating vectis, will split the nucleus. The split entities can be removed one by one using the irrigating vectis.

Fishhook Technique. In this technique, a 30-gauge disposable needle is bent in the form of a fishhook and used in the nucleus extraction. After a thorough hydrodissection or hydrodelineation, the superior pole of the nucleus is brought into the anterior chamber, and viscoelastic is injected anterior and posterior to the nucleus. The modified 30-gauge needle is introduced into the anterior chamber sideways to prevent endothelial injury. It is then maneuvered behind the nucleus to hook the undersurface, distal pole of the nucleus. Viscoelastic should be reinjected posteriorly if there is difficulty in positioning the fishhook. Once the nucleus is hooked, it is delivered using gentle downward pressure on the posterior lip of the tunnel. The nucleus is thus delivered without performing extensive maneuvering in the anterior chamber.

ONLINE VIDEO:
Nucleus Delivery Into the Anterior Chamber, 01 min 59 sec

ONLINE VIDEO:
Nucleus Delivery From the Anterior Chamber, 02 min 00 sec

ONLINE VIDEO:
Small Pupil Techniques, 01 min 14 sec

Epinucleus Removal, Cortex Aspiration, and IOL Implantation

After the extraction of nucleus from the anterior chamber, a mixture of epinucleus, cortex and viscoelastic remains in the anterior chamber and capsular bag. The Simcoe cannula is used in standard fashion to remove all nuclear and cortical debris from the anterior chamber and capsular bag. If the surgeon experiences iris prolapse and difficulty in maintaining the anterior chamber, aspiration should be continued through the side-port incision, or the wound may be temporarily shortened by placing single suture in the wound.

Next, viscoelastic is injected to inflate the capsular bag and a rigid, single-piece polymethylmethacrylate (PMMA) IOL is inserted into the capsular bag. Alternatively, the IOL can be inserted after filling the anterior chamber and capsular bag with air.

In the setting of a triangular capsulotomy, the apex of the capsulotomy tear should be folded away from the surgeon. The capsular flap typically assumes this configuration upon injection of viscoelastic or air into the anterior chamber and capsular bag. The leading haptic of the IOL is passed into the capsular bag, behind the base of the triangular capsulotomy. The folded anterior capsule flap at the base of the triangular capsulotomy serves as an easily identifiable landmark and facilitates in-the-bag IOL placement. The trailing haptic is then passed into the capsular bag.

If a triangular capsulotomy was performed, the anterior capsular flap is removed to prevent obscuration of the visual axis. A small incision is made in the anterior capsule at the edge of the base of the triangular flap with fine Vannas scissors. During this step, the anterior chamber should be maintained with viscoelastic or an irrigating Simcoe cannula. The capsular flap is then engaged with aspiration near the incision site, and the tear is propagated across the base of the flap and removed from the anterior chamber. This step should always be performed after insertion of the IOL.

ONLINE VIDEO:
Cortical Cleanup and IOL Insertion, 3 min 38 sec

Wound Closure

At the end of the procedure, the wounds should be watertight. If the sclerocorneal tunnel is properly constructed, the wound will be self-sealing, with no need for sutures. In cases of superior tunnel, a single interrupted 10-0 nylon suture can help minimize surgically induced astigmatism, although its effects are temporary. If the wound construction is suboptimal, the wound should be secured with one or more sutures. Cautery or a single conjunctival suture can be used to replace the conjunctiva over the incision site. Proper coverage of the incision site with conjunctiva may decrease the risk of postoperative infection. Subconjunctival antibiotics and steroids are routinely provided to decrease postoperative inflammation and infection.

Avoiding Potential Complications

Each stage of the procedure is associated with a particular set of potential complications.

Wound Construction. Common errors in wound construction include a tunnel that is too shallow, resulting in buttonhole tears, or too deep, resulting in premature entry into the anterior chamber. If the tunnel is too shallow, or a buttonhole tear appears, we recommend either redirecting the blade angle to slightly deepen the tunnel or beginning a new, deeper tunnel away from the primary tunnel.

Nucleus Delivery. To facilitate nucleus delivery, it is important to make sure the wound is sized according to the size of the nucleus. If the wound is too small, the surgeon will struggle to deliver the nucleus and risks significantly damaging the corneal endothelium. When the nucleus cannot be delivered out of the wound, simply replace the nucleus and use the keratome blade and toothed forceps to enlarge the wound. Wounds of 7.5 mm are sometimes necessary to deliver large cataracts. Despite their size, these larger wounds will reliably self-seal if constructed properly. Additionally, the tendency of beginning surgeons is to lift the nucleus when delivering the cataract out of the wound, unknowingly causing significant endothelial damage. This can be avoided with gentle downward pressure with the heel of the irrigating vectis or cannula at the external lip of the wound during nucleus delivery.

Cortical Cleanup. Particularly in the setting of a can-opener or a triangular capsulotomy, removal of cortical material needs to be performed gently and carefully. With manual aspiration, it is easy for the inexperienced surgeon to unknowingly aspirate a capsular tag and cause a posterior capsular tear. Therefore, excess care and attention should be given to this stage of the procedure.

IOL Implantation. Particularly in the setting of triangular capsulotomy, it is imperative to ensure proper IOL placement. Improper sulcus placement of the IOL can result in undesired refractive results, and pigment dispersion. Therefore, during IOL insertion, it is important to ensure that the leading haptic is placed under the anterior capsule. Equally important is the placement of the trailing haptic in the capsular bag.

Comparison of Outcomes

Traditionally, removal of the lens nucleus using ECCE involves a large 8 to 12 mm limbal incision requiring several sutures for proper wound closure. The need for suture placement results in longer operative times, high levels of postoperative astigmatism, more frequent postoperative office visits for suture removal, and slower visual rehabilitation compared to MSICS. Many studies have shown that MSICS, compared to ECCE, results in higher surgical volume, faster visual rehabilitation, fewer postoperative visits, significantly less postoperative astigmatism, and improved uncorrected visual acuity.

Phacoemulsification techniques are considered the gold standard for cataract extraction in industrialized nations. Undoubtedly, phacoemulsification is significantly more expensive than intracapsular cataract extraction (ICCE), ECCE, or MSICS. Added to the large capital expense of the equipment are the per-case costs of necessary consumables (phacoemulsification tips, foldable lenses, and tubing) and ongoing maintenance. Therefore, phacoemulsification remains cost-prohibitive in most of the developing world.

Cost aside, how do outcomes with phacoemulsification compare with MSICS? Three randomized controlled studies have measured and compared patient outcomes in phacoemulsification and MSICS in the developing world. All of these studies have reported similar uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) ≥20/60 with either technique at 6 weeks (2 studies) and 6 months (1 study) postoperatively.

A recent randomized prospective study from Nepal evaluated 6-month outcomes of 108 patients undergoing phacoemulsification or MSICS for the treatment of advanced cataracts (average visual acuity ≤20/300). In this study, the techniques demonstrated equal rates of UCVA ≥20/60 and BCVA ≥20/60 at 6 months (Figures 7 and 8). The patients undergoing phacoemulsification had significantly more postoperative day 1 corneal edema, resulting in worse postoperative day 1 UCVA. However, no significant difference in corneal endothelial cell loss has been demonstrated between the techniques at 6 weeks. Additionally, this study demonstrated slightly higher rates of UCVA ≥20/30 and BCVA ≥20/20 in the phacoemulsification group at 6 months. In the Nepal study setting, phacoemulsification was less efficient, requiring 15.5 minutes compared to 9 minutes for MSICS. Of note, at 6 months, the rate of posterior capsular opacity was significantly higher in the MSICS group compared to the phacoemulsification group. Although this finding did not result in significantly worse BCVA or UCVA between the groups, further follow-up is necessary to determine the long-term visual significance of this finding. Finally, complication rates, including postoperative endophthalmitis, have been shown to be similar between the procedures in multiple comparative and independent studies.

In summary, at 6 months, the BCVA and UCVA ≥20/60 were similar between phacoemulsification and MSICS groups. However, MSICS was more efficient and economical and resulted in faster visual rehabilitation compared to phacoemulsification in the treating of advanced cataracts in the developing world.

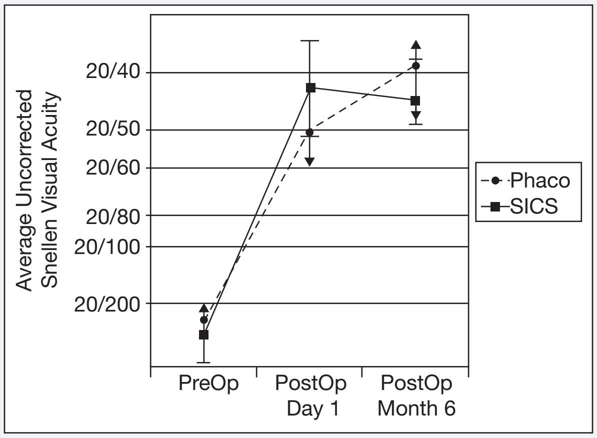

Figure 7 Mean uncorrected visual acuity for the phacoemulsification (dashed line) and manual sutureless small incision extracapsular cataract surgery (SICS) groups. Vision recorded at preoperative testing (PreOp) and postoperative (PostOp) day 1 and month 6. Error bars denote 95% confidence interval. (Reprinted from Ruit S, Tabin G, Chang D, et al. A prospective randomized clinical trial of phacoemulsification vs manual sutureless small-incision extracapsular cataract surgery in Nepal. *Am J Ophthalmol.* 2007;143:35, © 2007, with permission from Elsevier).

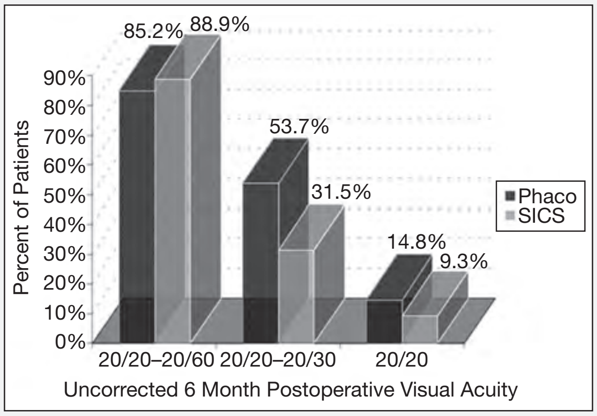

Figure 8 Uncorrected visual acuity by functional level at six months after operation. Stratified into groups with visual acuity of 20/20, better than or equal to 20/30, and better than or equal to 20/60 in the phacoemulsification group (Phaco; black) vs the manual sutureless small-incision extracapsular cataract surgery (SICS; gray) group. (Reprinted from Ruit S, Tabin G, Chang D, et al. A prospective randomized clinical trial of phacoemulsification vs manual sutureless small-incision extracapsular cataract surgery in Nepal. *Am J Ophthalmol.* 2007;143:35, © 2007, with permission from Elsevier.)

Table 2. Cataract Surgical Trends in Nepal, 1994–2008

YEAR	TOTAL CATARACT OPERATIONS	ICCE/ECCE, NO IOL[a]	ICCE WITH ACIOL[b]	ECCE WITH PCIOL[c]	MSICS WITH PCIOL[d]	PHACOEMULSIFICATION
1994	37,500	75%	7.5%	17.5%	0%	0%
1996	40,500	47%	4.5%	48.5%	0%	0%
1998	55,500	21%	2%	46%	31%	0%
2000	85,000	8%	1.50%	32.50%	57%	1.0%
2002	120,000	4%	0.75%	29%	65%	1.25%
2004	149,000	3%	0.9%	20%	72%	4%
2006	159,500	1.25%	0.5%	17%	69.25%	12%
2008	168,500	0.5%	0.5%	9%	67%	23%

[a]Intracapsular cataract extraction/extracapsular cataract extraction, no intraocular lens
[b]Intracapsular cataract extraction with anterior chamber intraocular lens
[c]Extracapsular cataract extraction with posterior chamber intraocular lens
[d]Manual small-incision cataract surgery with posterior chamber intraocular lens

Phacoemulsification in the Developing World

Phacoemulsification is increasingly being used in the developing world (Table 2), especially at large tertiary care centers and teaching hospitals in metropolitan areas, where such a procedure is economically feasible.

Multiple explanations are available for this phenomenon. Access to technology is improving, as phacoemulsification equipment is increasingly being donated or available to physicians at a justifiable cost. Also, access to the necessary consumables, including viscoelastic and foldable hydrophilic lenses, has increased significantly due to local production. Such local production has also driven down the price of the procedure to an affordable level, making phacoemulsification economically feasible in many developing nations. As patients become educated regarding their treatment options, demand for state-of-the-art cataract surgery increases and patients are willing to pay a premium price for this technique. As a result, institutionalization of phacoemulsification becomes important from a cost-recovery perspective. Finally, physicians in these institutions strive to acquire the necessary skills to provide state-of-the-art surgical options similar to those available in industrialized nations.

Conclusion

Ten years after the launch of the "Vision 2020: The Right to Sight" initiative, those working to eradicate preventable cataract blindness are gaining ground. (For more information, visit www.vision2020.org.) The development, implementation, and sustainability of high-volume, high-quality, low-cost cataract surgery have been demonstrated in some of the world's poorest regions. These successful models can be replicated through coordinated efforts in countries where economic factors prevent implementation of more expensive and time-consuming cataract surgery delivery systems. Through the collaborative and continued efforts of government and nongovernment organizations, using the techniques discussed in this module and already proven in many regions of the world, the lofty goal of eliminating cataract blindness can be achieved in our lifetime.

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Clinicians' Corner

Clinicians' Corner provides additional viewpoints on the subject covered in this issue of *Focal Points*. Consultants have been invited by the Editorial Review Board to respond to questions posed by the Academy's Practicing Ophthalmologists Advisory Committee for Education. While the advisory committee reviews the modules, consultants respond without reading the module or one another's responses. –*Ed.*

1. Given the different techniques used predominantly in the developing world, such as manual small-incision cataract surgery (MSICS) rather than phacoemulsification, how can phaco-trained surgeons in industrialized nations interact and aid ophthalmologists in the developing world?

Dr. Brown: Certainly the phaco surgeon should be familiar with MSICS techniques before performing surgery. Courses are available through Surgical Eye Expeditions International (www.seeintl.org), the American Academy of Ophthalmology (www.aao.org), and the American Society of Cataract and Refractive Surgery (www.ascrs.org). Phaco-trained surgeons in industrialized nations can inform and educate colleagues in the developing world about phacoemulsification cataract surgery. Considerations include financial factors (cost of the machine and the availability and cost of tubing), importance of trained technical staff and phaco training courses, the long learning curve, availability of a retina surgeon, patient selection, and possible complications and their management. Patients with a rock hard nucleus, seen in much of the developing world, are not prime candidates for phaco.

Dr. Shah: In the developing world, one setting is urban and the second involves camps in rural areas. In urban areas phacoemulsification is the norm. In camp-based settings the volumes are huge, which justifies MSICS. Phaco-trained surgeons in an urban setting would likely do phacoemulsification rather than MSICS. The problem would arise when volumes are huge in a rural setting where either they can do conventional extracapsular cataract extraction or jump to MSICS (where I feel the learning curve is very short). So, in summary, the phaco-trained surgeon would benefit from learning MSICS for use in rural-based settings.

2. How are intraoperative complications, such as dropped nuclear material and vitreous loss, addressed in the setting of cataract surgery in the developing world?

Dr. Brown: Intraoperative complications demand good surgical judgment. Fortunately, dropped nucleus in MSICS is not common. If it does occur it is frequently best left alone. Fishing for a lost nuclear fragment often leads to more serious complications. Vitreous loss is handled in the traditional way of carefully using sponges and scissors in removing vitreous from the wound, anterior chamber, and iris. Some clinics may have a vitreous cutter available. An anterior IOL is put in place.

Dr. Shah: In an urban setting, I would refer the patient to a vitreoretinal surgeon who would take the surgery forward. In a rural setting where a vitreoretinal surgeon is difficult to find, the patient can be referred to the nearest city for a nuclear drop. For vitreous loss without nuclear drop, it would be better to put in a sulcus-based IOL if your capsulorrhexis is intact and manually cut the vitreous using Weck ophthalmic sponges. I would also consider employing a scleral-fixated IOL as I feel it is better to put in the IOL than to leave the patient aphakic.

3. Describe your preoperative evaluation and postoperative management of MSICS. Who provides these services?

Dr. Brown: Preliminary preoperative screening of patients is frequently done by the local ophthalmologist. This should include a general health assessment and an ocular evaluation. The visiting surgeon examines each patient to determine the appropriate surgical management.

Postoperative examination by the operating surgeon the day following surgery is important to identify any problems that need to be addressed before the patient is discharged. Subsequent postoperative exams and follow-up are undertaken by the local ophthalmologist.

Dr. Shah: A complete eye examination would include slit-lamp evaluation for the grade of cataract, intraocular pressure, conjunctival sac patency, posterior segment evaluation of the retinal status, and B-scan ultrasonography in patients with mature cataracts. I would also order investigations such as complete blood count, blood glucose, urinalysis, and an electrocardiogram. Previous history of any illness is documented. Finally, A-scan ultrasonography for measurement of axial length and IOL power calculation is done.

Postoperative management includes examination on day 1, day 3, and then after 15 days. The patient is started on systemic antibiotics and analgesics, steroid–antibiotic eyedrops, and nonsteroidal anti-inflammatory eyedrops, which are eventually taped off. In an urban setting, the operating surgeon or the resident provide these services. In a rural setting the operating surgeon and later on the local eye surgeon would follow up and provide the services.

4. How do you handle IOL calculations in MSICS in the developing world?

Dr. Brown: A-scan machines and keratometers for IOL calculation are sometimes available at clinics or brought by the visiting team. If these are not available, IOL calculation is approximated based on the patient's visual history. Generally IOL powers between 18 and 22 diopters are used.

Dr. Shah: In an urban setting, the calculations would be done by using the water immersion A-scan technique. Holladay or SRK-II formula K readings would be automated and applied. In a rural setting, calculations would be done by using an A-scan probe, applying the SRK-II formula, and using a manual keratometer to obtain K readings.

5. When should the phaco-trained surgeon consider MSICS surgery instead of extracapsular cataract extraction?

Dr. Brown: MSICS offers a number of advantages compared to extracapsular cataract extraction. MSICS is safer, results in less astigmatism and less bleeding, and does not require stitches. There are fewer complications. Phaco surgeons should be familiar with MSICS techniques before attempting the surgery.

Dr. Shah: The phaco-trained surgeon should consider MSICS in the following conditions: pseudoexfoliation, calcified cataract, brown/black cataract, hypermature Morgagnian cataract, subluxated cataract, and in certain traumatic cases where lens is dislocated in the anterior chamber.

6. What are your considerations for a temporal approach versus a superior approach for MSICS?

Dr. Brown: The superior approach offers some protection from the upper eyelid covering the wound. Deep-set eyes with over-hanging brow may make this approach difficult. Generally the surgeon should use the technique with which he or she is most familiar.

Dr. Shah: I always prefer a superotemporal approach for MSICS as the astigmatism is least in this approach and it is easier because you have the brow to support your hand, which is not so in the temporal approach. A temporal incision is exposed to the atmosphere as compared to superior incisions that are covered by the eyelid.

7. What is the rate of posterior capsular opacification with MSICS and how is this addressed? Do you perform primary posterior capsulotomies in selected situations?

Dr. Brown: Accurate figures on the rate of posterior capsular opacification (PCO) after MSICS in the developing world are scanty at best. Careful cortical cleanup, posterior capsular polishing, and choice of IOLs known to reduce the incidence of PCO may help. YAG laser capsulotomy is ideal but not available in many clinics. Primary posterior capsulotomies are performed if there is calcification, clouding or opacity of the posterior capsule.

Dr. Shah: I believe the rate of posterior capsular opacification is equal between MSICS and phacoemulsification. Normally such patients undergo YAG capsulotomy, but if the capsule has become hard and you cannot use the YAG technique, then you need to do a surgical capsulectomy. I do perform primary capsulotomies but only in the pediatric age group.

8. What are the primary sources of funding for cataract surgical care in underdeveloped countries?

Dr. Brown: The cost of providing cataract surgical care is spread across a broad base. Sources of funding include nongovernment organizations that recruit, organize, and deploy surgical teams; volunteer doctors and nurses who pay their own travel expenses and donate their professional services; the host country that provides in-country transportation, food, and lodging for the visiting team for the duration of the surgery clinic; and government social service agencies and local hospitals that cooperate in support of the clinic. Additional sources of funding include donations from international service clubs (such as Lions and Rotary) that provide financial support; ophthalmic industries that supply in-kind donations of consumable supplies, IOLs, medications, and operative packs; and visiting teams that transport surgical equipment (microscopes, instruments sets, sterilizers, and lasers) needed to augment local circumstances to conduct the cataract clinics.

Dr. Shah: In an urban setting, the patients pay or, if they are insured, then the insurance company covers the costs. In a rural setting, typically the funding is through charitable organizations and non-governmental organizations. The government helps in certain cases by providing consumables for the surgery.

9. How do you handle patients with coexisting glaucoma and cataracts in this setting?

Dr. Brown: Severity of glaucoma, visual field loss, size of cataract, and preoperative IOP will help determine surgical management. Since removing the cataract will lower the IOP in many cases, most surgeons do not do combined procedures. Postoperative IOP will determine if further surgery is an option for the patient.

Dr. Shah: In an urban setting, I would do phacoemulsification with trabeculectomy or deep sclerectomy with mitomycin. In a rural setting, I would do superior MSICS along with trabeculectomy by raising the flap at the end of the incision and cutting the meshwork from that end. I would also put a 10-0 suture at that end.

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Suggested Reading

Brian G, Taylor H. Cataract blindness—challenges for the 21st century. *Bull World Health Organ.* 2001;79:249–256.

Chang MA, Congdon NG, Baker SK, Bloem MW, Savage H, Sommer A. The surgical management of cataract: barriers, best practices, and outcomes. *Int Ophthalmol.* 2008;28:247–260.

Foster A. Cataract and "Vision 2020—the right to sight" initiative. *Br J Ophthalmol.* 2001;85:635–637.

Frick KD, Foster A. The magnitude and cost of global blindness: an increasing problem that can be alleviated. *Am J Ophthalmol.* 2003;135:471–476.

Gogate P, Deshpande M, Nirmalan PK. Why do phacoemulsification? Manual small-incision cataract surgery is almost as effective, but less expensive. *Ophthalmology.* 2007;114:965–968.

Gogate PM, Kulkarni SR, Krishnaiah S, et al. Safety and efficacy of phacoemulsification compared with manual small-incision cataract surgery by randomized controlled clinical trial. *Ophthalmology.* 2005;112:869–874.

Lewallen S, Courtright P. Blindness in Africa: present situation and future needs. *Br J Ophthalmol.* 2001;85:897–903.

Resnikoff S, Pascolini D, Etya'ale D, et al. Policy and practice: global data on visual impairment in the year 2002. *Bull World Health Organ.* 2004;82:849.

Riaz Y, Mehta JS, Wormald R, et al. Surgical interventions for age-related cataract. *Cochrane Database Syst Rev.* 2006;Oct 18:CD001323.

Ruit S, Tabin G, Chang D, et al. A prospective randomized clinical trial of phacoemulsification vs manual sutureless small-incision extracapsular cataract surgery in Nepal. *Am J Ophthalmol.* 2007;143:32–38.

Ruit S, Tabin GC, Wykoff CC. *Fighting Global Blindness: Improving World Vision Through Cataract Elimination.* Washington, DC: American Public Health Association; 2006.

Ruit S, Tabin GC, Nissman SA, Paudyal G, Gurung R. Low-cost high-volume extracapsular cataract extraction with posterior chamber intraocular lens implantation in Nepal. *Ophthalmology.* 1999;106:1887–1892.

Tabin G, Chen M, Espandar L. Cataract surgery for the developing world. *Curr Opin Ophthalmol.* 2008;19:55–59.

Yorston D, Abiose A. Cataract blindness—the African perspective. 2001. *Bull World Health Organ.* 2001;79:249–256.

Related Academy Materials

Khanna RC. Blumenthal manual small-incision cataract surgery in hypermature cataract: alternative technique for the developing world. Video. http://aao.scientificposters.com/vodONE.cfm?id=V08&yr=2006. Accessed June 21, 2011.

Raju LV, Ghanta M, Raju VK. Techniques for manual small-incision extracapsular cataract extraction. Current Insight. http://one.aao.org/ce/news/currentinsight/detail.aspx?cid=ea87e277-d336-4a8b-a0cb-2a2a359c90a9. Accessed June 21, 2011.

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