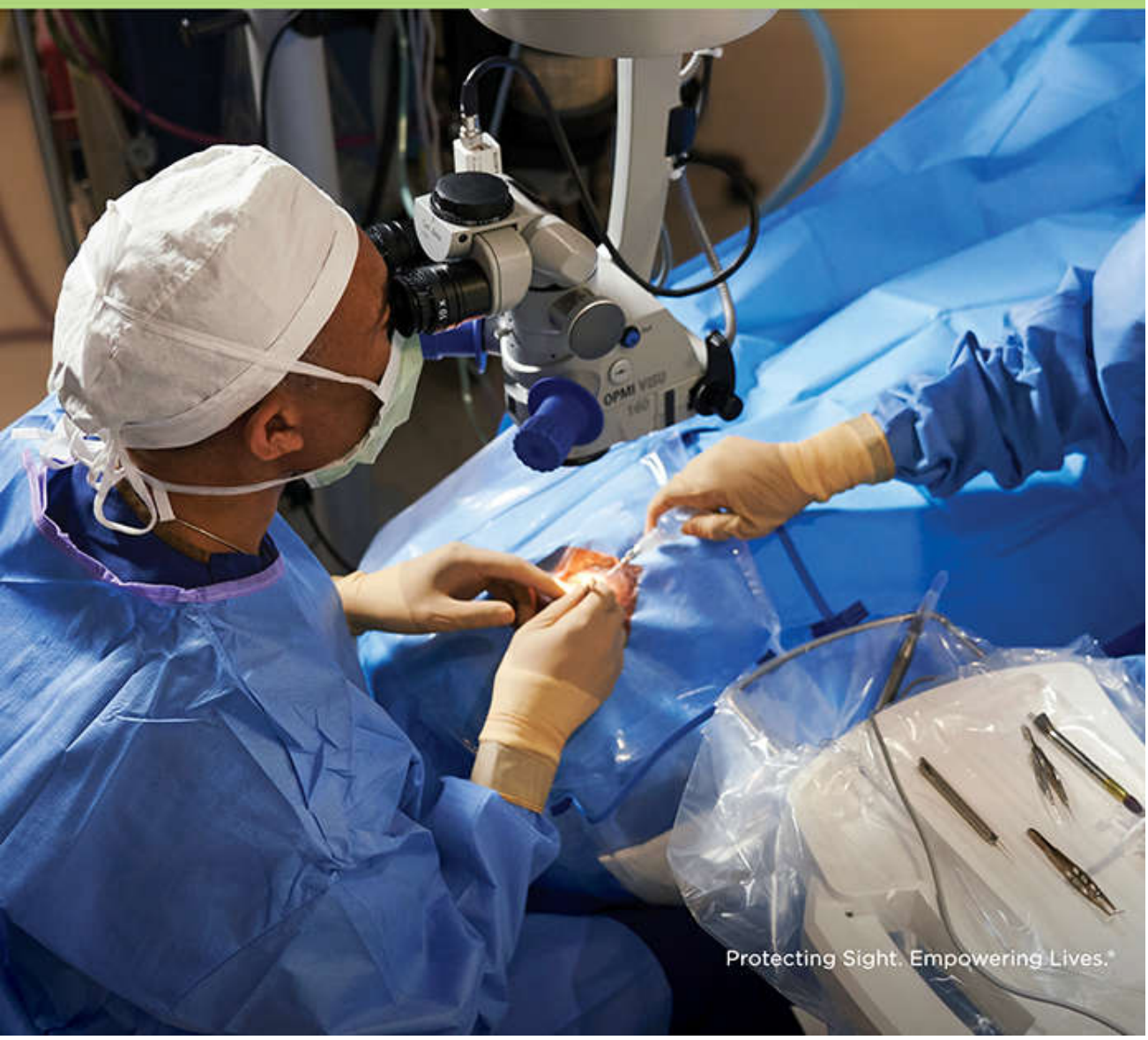
AMERICAN ACADEMY
OF OPHTHALMOLOGY®

Fourth Edition

Ayman Naseri, MD
Executive Editor

Basic Principles of Ophthalmic Surgery



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Basic Principles of Ophthalmic Surgery

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Protecting Sight. Empowering Lives.®

American Academy of Ophthalmology

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Foreword

How do you teach surgery? How do you learn surgery? We surgeons have vivid memories of events in our surgical learning path—the first time we scrubbed in as medical students, the first time we sutured a laceration, or the first time we touched a beating heart—and many, many more.

As ophthalmologists, we remember the first successful cataract surgery and the patient's vision the next day—and we remember our first serious intraoperative complication and the steps we took to manage it. We likely all shared a similar surgical learning process in residency training as we built on our general medical and surgical experience, sequentially adding knowledge, specific manual maneuvers, and procedural components through a combination of didactics, surgical "wet laboratories," observation, and supervised patient experience. Then, under supervision, we assembled it all into the complete package as primary surgeons.

Is that the best way to learn surgery? Ultimately, no. In an ideal system, ophthalmic surgical simulation technology will soon allow us to gain not only technical proficiency but also experience in intraoperative decision making and complication management. When surgeons in training then perform their "first cases" as primary surgeons, they will do so having had important near-real-life experience. The process will benefit surgeons in training and patients alike.

But surgery is much, much more than the technical performance of a set of skill components. A well-constructed set of surgical learning objectives must involve many subjects, including the biomechanics of wound construction and healing, instrument design, surgical materials (such as sutures and irrigation fluids), and sterility and infection control. It should include patient selection, the informed consent processes, medical ethics, postoperative management, and complication avoidance and management, among other topics.

For ophthalmology, surgery is a core and a complex competency, and education in this complex subject remains a process equally daunting for teacher and student alike. Anything that can facilitate the process benefits future patients. *Basic Principles of Ophthalmic Surgery,* together with the Academy's companion volume, *Basic Techniques of Ophthalmic Surgery,* packages many of the key elements of the surgical process and environment into an invaluable adjunct to the learning program for residents.

Simulators, texts, and videos are only imperfect tools in this educational process. But they can better prepare us to meet its challenges. There is one other critical component to surgical education—the experienced operative teacher and mentor who sits (or stands) at our sides and guides us through the exciting, exacting, and at times stressful process of altering living human tissue. This volume, with both text and video, reflects the commitment and talents of some of those incredible ophthalmic educators who have shepherded the earlier editions.

As surgeons we have a profound obligation to our patients. They honor us by trusting to us their sight and sometimes their lives. This text acknowledges the scope and complexity of that obligation.

David W. Parke II, MD
Chief Executive Officer
American Academy of Ophthalmology

Preface

Many years ago when the American Academy of Ophthalmology began development of *Basic Principles of Ophthalmic Surgery,* respected educators immediately recognized the need for a comprehensive resource to aid in navigating the surgical learning curve experienced by all ophthalmology residents. Led by Dr. Anthony Arnold in its inaugural edition and by Dr. Thomas Oetting in the second edition, this book shares the collective knowledge and experience of passionate surgical educators accumulated over thousands of hours of professional dedication. The hope is that residents and educators from around the corner and around the world can benefit from this text in traversing among the most challenging aspects of residency training: the interface between the patient and the novice surgeon.

This edition is divided into 4 major sections: Evaluation and Preparation, Surgical Logistics, Intraoperative Considerations, and Postoperative Considerations. All chapters have been updated where appropriate, with particular revisions made to the chapters on ergonomics, intraocular fluids, patient safety issues, and postoperative management.

To all of the authors of this book, we are grateful for your generous contributions of time, effort, and expertise, and offer thanks on behalf of many future generations of ophthalmologists. I am also personally grateful for the support of Susan Malloy and Amanda Fernandez for their patience and guidance in creating this edition.

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PART I

Evaluation and Preparation

CHAPTER 1

Patient Selection

Maria M. Aaron, MD

The performance of surgery involves much more than the procedure itself. The beginning surgeon often focuses on the successful completion of the technical procedure—merely getting from point A to point B—without complications. Successful surgery, however, also requires careful patient selection, preoperative evaluation, and postoperative care. This chapter focuses on issues of patient selection, including criteria for surgical intervention; factors affecting surgical risk; ethical considerations, including informed consent and advertising; and the implications of the surgeon's experience.

Criteria for Surgical Intervention

Surgeons must carefully assess patients' concerns and expectations of surgery. Upon reviewing the clinical pathology, they must determine if a surgical procedure will accomplish the desired outcome. For example, the patient with mild to moderate macular degeneration who undergoes cataract extraction might expect 20/20 visual acuity as a result, since for some patients this is the outcome of the procedure. The surgeon must communicate a reasonable expectation of more limited visual acuity for this patient, though. Moreover, a patient with severe macular degeneration and a dense posterior capsule opacity may not benefit at all from a YAG capsulotomy, which is often necessary after cataract extraction, and therefore the laser procedure is not justified.

In addition to understanding the patient's expectations, the surgeon must carefully review the clinical findings in order to accurately assess risk, evaluate whether surgery is justified, and clearly communicate the risk-benefit ratio to the patient. Careful clinical evaluation may reveal coexisting disease that could increase the risks of surgery. For example, a patient who has a moderate degree of corneal endothelial guttata who is undergoing phacoemulsification for a dense brunescent lens has the added risk of corneal decompensation. Table 1-1 lists common coexisting findings to consider when evaluating patients for cataract surgery. While the implications of such abnormalities may vary depending upon the clinical situation and the experience of the surgeon, preoperative examination should include their consideration in every case.

Table 1-1 Common Concerns to Consider Before Cataract Surgery

Condition	Risk
History	
Previous trauma	Zonular weakness, capsular damage, or iris abnormalities
General physical condition	
Congestive heart failure	Inability to lie supine
Current or prior use of an alpha-blocker	Intraoperative floppy iris syndrome
Dementia	Altered response to anesthesia, movement during procedure
Severe spine/neck disease	Inability to lie supine
Anterior segment	
Abnormally deep anterior chamber	Difficulty with surgical maneuvers
Abnormally shallow anterior chamber	Limited working space, corneal or iris injury
Corneal scars	Poor visualization
Endothelial guttata	Corneal decompensation
Exposure keratopathy	Corneal decompensation
Glaucoma	Spike in intraocular pressure
History of iritis or inflammatory condition	Severe postoperative inflammation
Mature cataract or poor red reflex	Need for capsular stain and poor visualization of capsulorrhexis
Phacodonesis	Zonular weakness
Poor pupil dilation	Need for pupil expansion device, challenging nuclear removal, iris prolapse
Prior trabeculectomy	Failure of filter
Pseudoexfoliation	Poor dilation, zonular weakness
Posterior segment	
Diabetic retinopathy	Progression of disease
High myopia	Retinal detachment
Macular degeneration	Need for retinal evaluation/treatment, limited visual potential
Other macular pathology	Guarded visual outcome
Previous pars plana vitrectomy	Loss of vitreous support, capsular rupture

Factors That Affect Surgical Risk

Ophthalmic surgical procedures are often performed on elderly patients who require careful medical evaluation to prevent surgical or systemic complications. While patients' ages do not necessarily correlate with their physical and mental status, older patients often have concomitant medical conditions that require multiple medications. Proper preoperative medical assessment allows for safe selection of surgical candidates and helps ensure a smooth operation and course of treatment in those who proceed to surgery.

Preoperative medical evaluation, either a brief survey by the surgeon or a detailed assessment by a medical specialist, depending on the clinical situation, allows for careful

selection of those patients who can safely undergo surgery and identification of those who either require medical care before surgery or cannot safely proceed. The examiner should take a thorough history, which should include questions about medications, allergies, bleeding disorders, and prior surgical procedures, during the preoperative assessment. When evaluating a patient for cataract surgery, the surgeon should inquire about past or current use of alpha-blocking agents such as tamsulosin (Flomax), silodosin (Rapaflo), or terazosin (Hytrin), as use of these agents increases the risk of the intraoperative floppy iris syndrome (IFIS). The surgeon should also pay careful attention to a patient's use of products that contain aspirin and other medications that may cause bleeding, including warfarin sodium (Coumadin), heparin, and nonsteroidal anti-inflammatory drugs (NSAIDs) as well as some of the newer anticoagulants—rivaroxaban (Xarelto), dabigatran (Pradaxa), apixaban (Eliquis), enoxaparin (Lovenox)—and herbal therapies such as Ginkgo biloba, garlic, and ginger. Many patients are unaware that some of these drugs and supplements may cause bleeding and therefore do not report them unless specifically questioned.

Anticoagulants are of particular concern when eyelid, periorbital or orbital procedures, and some glaucoma procedures are being considered. In patients who require oral anticoagulants for prevention of stroke and transient ischemic attack, suspension of these agents carries risks, and so consultation with the patient's physician and alternative anesthesia should be considered. Systemic conditions that may require special evaluation or therapy before surgery include cardiac disease, hypertension, pulmonary disease, and diabetes mellitus. Implications of anesthesia may be a concern with children and patients with altered mental status.

Cardiac Disease

Patients with cardiac disease should be evaluated for any recent ischemic events, arrhythmias, or congestive heart failure (CHF). Patients with severe CHF may have difficulty lying supine for the duration of the procedure and may require intensive therapy to optimize cardiac status before surgery. If a patient is unstable or if the surgeon has any degree of uncertainty about his or her cardiac stability, the cardiologist or primary care provider should evaluate and clear the patient before performance of the ophthalmic procedure.

Hypertension

Arterial blood pressure control is essential for patients undergoing ophthalmic surgery, as uncontrolled pressure increases risk of cardiovascular complications. Patients with a systolic blood pressure over 180 mm Hg or a diastolic blood pressure over 100 mm Hg should be evaluated and treated before the performance of an elective procedure, particularly if local anesthetic injection is planned.

Postural Limitations

Proper positioning of the patient for surgical or laser procedures is essential for uncomplicated, successful surgery. The majority of intraoperative procedures require the patient to be in the supine position; however, positioning of patients with severe kyphosis, cerebral

palsy, myotonic dystrophy, or obesity may present challenges. These patients may also be difficult to position for office procedures at the slit lamp. Adjusting the operating table and/or chair, rotating the surgical microscope or laser apparatus, altering the surgical/laser approach, and using pillows, sheets, foam, and so on, are effective techniques for minimizing discomfort for patients and surgeons.

Pulmonary Disease

Patients with severe chronic obstructive pulmonary disease or asthma will need clearance from their pulmonologist or primary care physician before elective surgery. Optimization of pulmonary function reduces cardiopulmonary risks of anesthesia. Uncontrolled cough increases risk of complications in intraocular surgery, in both intraoperative and postoperative periods; patients with this condition require careful screening and management before consideration for surgery.

Diabetes Mellitus

Optimal control of diabetes mellitus may reduce risks of general anesthesia and postoperative infection. Patients with uncontrolled diabetes mellitus should be evaluated and have their treatment managed by a medical specialist before elective ophthalmic surgery.

Children

Children who have a family history of unexplained morbidity in association with anesthesia should be suspected of having a predisposition to malignant hyperthermia, a rare genetic disorder of the skeletal muscle metabolism. Any such question should be addressed by the patient's medical and anesthesia teams before surgery. Chapter 13 reviews symptoms of malignant hyperthermia; early recognition and action may be lifesaving.

Altered Mental Status

Patients with altered mental function present specific problems in understanding surgical procedure and postoperative conditions and so may be unable to cooperate for surgery under local anesthesia. These patients require the participation of a family member in the preoperative, operative, and postoperative states. Additional consideration regarding the choice of anesthesia (eg, general or local) is also necessary for these patients.

Ocular Conditions

Specific ocular conditions should also be taken into account to ensure proper preparation for surgery. Many are listed in Table 1-1, and some require special consideration, particularly severe dry eye when lid procedures, refractive surgery, or other corneal or intraocular surgeries are being considered. Most commonly, dry eye worsens following surgery because of damage to the epithelial cells, the cutting of corneal nerves, or the prolonged use of drops containing preservatives that cause corneal toxicity. Ideally, dry eye symptoms should be treated preoperatively and treatment continued in the postoperative period for several months.

Corneal diseases

Epithelial, stromal, and endothelial disease can all complicate cataract surgery either by obscuring proper visualization during the procedure or by contributing to postoperative corneal edema. If possible, corneal diseases should be addressed prior to or during cataract surgery in order to provide the best possible surgical outcomes.

Iris abnormalities

Any conditions causing poor pupillary dilation (eg, pseudoexfoliation, posterior synechiae) or use of a medication causing IFIS should be noted preoperatively so that they can be addressed, helping to prevent difficulty with nucleus removal or iris prolapse. Specifically, surgeons should inquire about the use of systemic alpha-blockers for the treatment of urinary tract symptoms associated with benign prostate hypertrophy. Treatment options to consider include iris retractors, pupil expansion rings, and viscoelastic agents that mechanically hold the pupil in position.

Lens concerns

Extremely dense nuclei, a subluxated lens, or phacodonesis can create challenges during cataract surgery. Proper planning regarding technique (ie, conversion to extracapsular cataract surgery, a posterior approach to cataract removal, placement of a capsular tension ring) can prevent intraoperative complications.

Ethical Considerations

Informed Consent

Chapters 2 and 4 review details of the informed consent process. Regarding patient selection, however, the following issues apply to the discussion of informed consent:

1. The surgeon has the responsibility to determine whether a patient is able to understand the nature of a procedure and its potential risks, and then to make an autonomous decision whether to proceed. If the patient is unable to do so, or if uncertainty exists about a patient's competence to make this decision, elective surgery should be deferred pending clarification of the issue (possibly with legal consultation). In some circumstances, a surrogate may make the decision.
2. Patients have the right to make their own decisions regarding medical treatment, and they may contribute to the process of selection for surgery. For example, a moderate nuclear cataract in a patient with 20/50 visual acuity may or may not require surgery. An airline pilot might desire that the cataract be removed, whereas an elderly person may feel comfortable continuing daily life with 20/50 visual acuity.
3. The patient has the right to know if a resident in training, supervised by an experienced faculty, will be the primary surgeon for a portion of or for the entirety of a procedure. This must be made explicit during the consent process. Patient selection must take into account those who are uncomfortable with this situation so that alternate planning for surgical care can be made.

Advertising

The fundamental principle in medical advertising is that communications to the public must be accurate. Individuals who engage in false advertising may be subject to punishment under state and federal laws, but physicians must also be aware of the rules outlined by state medical boards as well as by the American Medical Association's and the American Academy of Ophthalmology's ethics codes. Before the twentieth century, advertising for patient recruitment was prohibited because it was considered "derogatory to the dignity of the profession to resort to public advertisements"; however, in 1977 it became unlawful for physicians to restrict advertising. With the recent development of numerous refractive surgical procedures, the ethical concepts of advertising must be thoroughly considered. Care must be taken to portray all aspects of surgery accurately, without misleading the public, and to avoid claims of superiority or exclusivity that promote a physician's business rather than a patient's best interest. Similarly, one must avoid any patient education program or referral process that utilizes coercion to encourage surgery or limit patient options for surgical referral.

Implications of the Surgeon's Experience

A surgeon is responsible for assessing whether he or she has attained the level of experience required to perform specific surgical procedures. In residency training, the attending faculty generally sets guidelines and monitors them, with more complex or difficult cases being assigned to senior residents with greater surgical experience. Thus, the patient selection process includes assigning certain categories of surgical candidates to residents at the appropriate level of training. For example, for cataract surgery, patients with characteristics that may present challenges at surgery (eg, patients who are monocular, have poor pupil dilation, poor visualization due to corneal disease, phacodonesis, or high myopia), or patients who have selected premium intraocular implants (IOLs) or have chosen laser-assisted cataract surgery are often paired with experienced surgeons. Similarly, patients who require surgery to be completed in the shortest time possible (eg, those whose ability to cooperate is limited due to altered mental status, or those with severe medical problems that limit tolerance for prolonged procedures) are usually assigned to the more experienced surgeons.

This principle also holds after the completion of residency training, as surgical technology advances and new techniques become available. Patients who are candidates for new techniques must be selected according to the expertise of the surgeon.

Key Points

- A thorough preoperative medical evaluation is essential in appropriate patient selection.
- Patients with cardiac disease, hypertension, postural limitations, pulmonary disease, or diabetes mellitus may require special evaluation or therapy before surgery. Issues to do with anesthesia may be a concern with children and people with altered mental status.

- Appropriate patient selection includes:
  - ensuring that indications for surgical intervention are appropriate and that the risk-benefit ratio is satisfactory
  - carefully assessing medical risk factors and ensuring that the patient's general medical status is optimized prior to surgery
  - ascertaining that the patient understands and agrees to the indications, risks, benefits, and alternatives for surgery by obtaining full informed consent
  - avoidance of coercion in proceeding with surgery
  - ensuring that the proposed surgical procedure is one for which the surgeon has adequate training and experience

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Self-Assessment Test

1. Medications that may increase the risk of bleeding include which of the following? (Choose all that apply.)
   a. Ginkgo biloba
   b. nonsteroidal anti-inflammatory drugs
   c. rivaroxaban (Xarelto)
   d. all of the above
2. List at least 3 features that a preoperative medical evaluation should address.
3. The decision to recommend cataract surgery includes consideration of which of the following factors? (Choose all that apply.)
   a. coexistent macular disease
   b. patient's visual requirements
   c. coexistent corneal disease
   d. family history of macular degeneration

For preferred responses to these questions, see Appendix A.

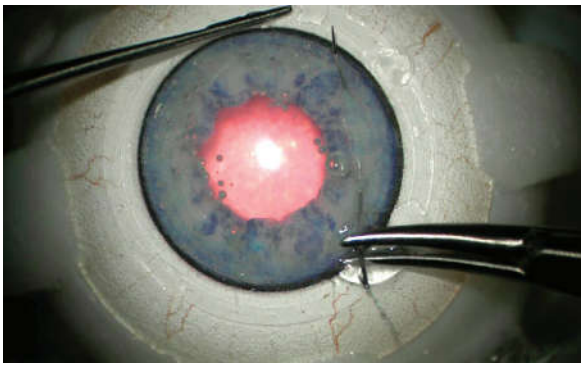


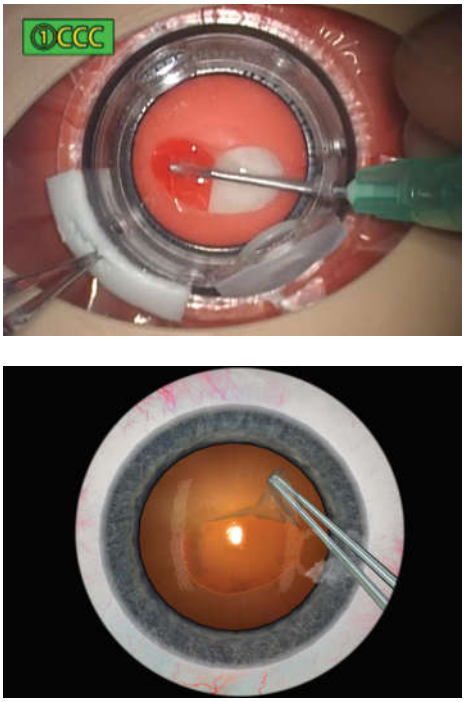
Figure 5-3 Bioniko model for iris suturing. *(Courtesy of Bioniko Models.)*

Figure 5-4 Kitaro WetLab Kit. *(Courtesy of FCI Ophthalmics.)*

While no comparative studies of the utility of these different models have been published, many programs utilize these simulation devices to ease residents' transitions to the operating room. Surgical practice is most beneficial when a simulation method with reasonable fidelity is incorporated into a well-planned surgical curriculum and when experienced faculty members are available for teaching, evaluation, and feedback.

Extraocular Simulation

Cadaveric human and animal tissues are also used for extraocular surgical simulation, including strabismus surgery and oculoplastic surgery. Cadaveric human tissue is more representative of human living tissue but also more difficult to obtain. Animal tissue such as pigs' feet and chicken breasts can be used for suturing practice, as can grapes and bananas. Suturing models made of synthetic materials are commercially available from several companies (Fig 5-6). There are also commercially available strabismus surgery training models that allow for realistic simulation of horizontal and vertical muscle strabismus surgery.



A

B

Figure 5-5 Simulation of continuous curvilinear capsulorrhexis. **A,** Kitaro training system. **B,** Eyesi system. *(Part A courtesy of FCI Ophthalmics and Frontier Medical; Part B courtesy of VRmagic.)*

Figure 5-6 Example of a suturing model for practicing advanced flaps and grafts in additional to basic suturing procedures. *(Courtesy of SimSkin.)*

Figure 5-7 Eyesi surgical platform equipped with a cataract interface. *(Courtesy of VRmagic.)*

Virtual Reality

Virtual reality (VR) surgical training is a computer-generated 3-dimensional surgical environment that allows interaction between the surgeon and a simulated surgical environment through visual and tactile feedback. Advances in technology have allowed virtual reality ophthalmic surgical simulators to become increasingly realistic. The major disadvantage of VR simulators is the high cost—along with a lack of comparative data to show that these high-cost investments have advantages over other simulation models.

The most widely studied and commercially available VR surgical simulator in ophthalmology is the Eyesi surgical simulator (VRmagic); it includes a surgical platform that can be equipped for cataract and vitreoretinal surgical training modules (Fig 5-7). The platform includes an artificial eye, patient head, stereoscopic microscope, adjustable table, and foot pedals. Instruments are inserted into the artificial eye, allowing virtual reality simulation of the steps taken in ophthalmic surgery. The cataract surgery modules allow