Achieving Excellence in Cataract Surgery
A Step-by-Step Approach

Edited by
D. Michael Colvard, MD, FACS
Clinical Professor of Ophthalmology
Doheny Eye Institute
Keck School of Medicine
University of Southern California
Los Angeles, CA
Medical Director of Colvard Eye Center
Encino, CA
Dedication

To Drs. Richard Kratz and Thomas Mazzocco,
whose unwavering commitment to innovation, instruction, and patient care
has benefited all of ophthalmology, and in turn helped each of us to be better physicians.
# Contents

*Dedication* ............................................................................................................................................................ iii

*Acknowledgments* .................................................................................................................................................. vii

*About the Editor* .................................................................................................................................................... ix

*Contributors* .......................................................................................................................................................... xi

*Preface* .................................................................................................................................................................... xiii

*Foreword by Peter J. McDonnell, MD* ................................................................................................................... xvii

*Introduction* ........................................................................................................................................................... xix

Chapter 1: Local Anesthesia for Cataract Surgery ................................................................. 1

  *Rom Kandavel, MD*

Chapter 2: Incisions ........................................................................................................................................... 11

  *D. Michael Colvard, MD, FACS*

Chapter 3: Capsulorrhexis .............................................................................................................................. 19

  *Howard V. Gimbel, MD, MPH, FACS, FRCSC*

Chapter 4: Hydrodissection and Hydrodelineation .................................................................................... 27

  *I. Howard Fine, MD, Richard S. Hoffman, MD, and Mark Packer, MD, FACS*

Chapter 5: Phaco Techniques

  Part A: Disassembling the Nucleus—An Overview .................................................................................. 33

    *D. Michael Colvard, MD, FACS*

  Part B: Divide and Conquer ......................................................................................................................... 35

    *D. Michael Colvard, MD, FACS*

  Part C: Phaco Chop Techniques .................................................................................................................. 38

    *David F. Chang, MD*

  Part D: Bimanual Vertical Chop Technique .............................................................................................. 49

    *Mark Packer, MD, FACS, I. Howard Fine, MD, and Richard S. Hoffman, MD*

Chapter 6: Managing the Broken Posterior Capsule ............................................................................... 53

  *David F. Chang, MD*

Chapter 7: Management of the Small Pupil ......................................................................................... 59

  *Robert H. Osher, MD, and James M. Osher, MD*

Chapter 8: The Phaco Machine: Understanding the Equipment to Take Advantage .................. 67

  of Contemporary Phaco Techniques

  *William J. Fishkind, MD, FACS*
Few calls are dreaded more than the one that 17 of my colleagues received last year. That call was mine, asking each of them if they would be kind enough to write a chapter for a new textbook. Early in one's career, one might reasonably imagine that it would be flattering to be asked this. Certainly the invitation implies a certain level of recognition and esteem, but this request presented to an overworked surgeon whose reputation is already well established is, in all honesty, seldom welcomed. Writing a chapter for a new textbook is hard work with little upside. The effort occupies hours of what little “free” time the surgeon may have, he or she is guaranteed to be paid absolutely nothing, and, for the most part, all of the effort is lost in anonymity. One’s name on a list of contributors—that’s about it.

So why did all 17 of these people agree to take on this project? I would like to think some of it was out of friendship. I am certain that this played a small role, but the major motivation, I think, is that everyone believed in the project and wanted to be a part of it. This is a textbook written specifically for residents in training and young ophthalmologists who want to become better cataract surgeons. Every one of the contributors was at one time a young cataract surgeon, hoping to become a better one. Every one of us was once helped by teachers and mentors to whom we will always be grateful. Every one of us wants to give back a little and honor those who helped us by passing forward what we have learned. I think it’s as simple as that.

I want to express my deepest gratitude to each one of the selfless physicians who worked so hard to make this text the great success that it is. And my special thanks goes out to the hardy few who went the extra mile—those who not only accepted the burden but truly seemed to relish it. To Howard Fine, who helped tremendously with the early planning of the text (including choosing the title); to Mark Packer and David Chang, who actually volunteered to do more work than I asked of them; and to Richard Hoffman, who did a spectacular job, both in the text and in the video supplement, painstakingly itemizing the loading and insertion techniques of all the major IOLs in use today.

My gratitude and thanks also goes out to Debra Toulson and Jennifer Cahill of SLACK Incorporated, both for their patience in putting up with me over the past 6 months and for their expert and conscientious efforts which have allowed this text to become a reality.
About the Editor

D. Michael Colvard, MD, FACS, was born in Atlanta and completed a combined undergraduate-MD program at Emory University, where he was Phi Beta Kappa and Alpha Omega Alpha. He completed a residency in ophthalmology at the Mayo Clinic in 1978 and an anterior segment fellowship with Richard P. Kratz, MD, in 1979.

Dr. Colvard is presently in private practice in Encino, California, where he specializes in lens-based surgery. He has been on the clinical staff at the Doheny Eye Institute since 1981. He received the Honor Award from the American Academy of Ophthalmology in 1994 and has been selected as one of America's Top Ophthalmologists and one of America's Top Doctors.

Dr. Colvard has published widely in the ophthalmic literature and is the new technology editor for Review of Ophthalmology. He has been the medical monitor for a number of Food and Drug Administration clinical studies involving new intraocular lens technologies and presently serves as the medical monitor and consultant to several ophthalmic companies. He holds a number of patents for ophthalmic devices and was the developer of the Colvard Pupillometer, a device widely used in refractive surgery around the world.

In addition, Dr. Colvard is the founder and medical director of the Friends of Vision Foundation, an organization supporting medical charities in third-world countries, and is on the Board of Directors of SEE International. He has been active as a volunteer cataract surgeon in underdeveloped countries the past 20 years.
Contributors

Robert H. Osher, MD (Chapter 7)
Professor of Ophthalmology
University of Cincinnati
College of Medicine
Medical Director Emeritus
Cincinnati Eye Institute

Mark Packer, MD, FACS (Chapters 4, 5, 9, 10)
Clinical Associate Professor of Ophthalmology
Casey Eye Institute
Oregon Health & Science University
Portland, OR
Drs. Fine, Hoffman & Packer, LLC
Eugene, OR

Patrick J. Riedel, MD (Chapter 14)
Partner, Minnesota Eye Consultants, PA
Assistant Clinical Professor of Ophthalmology
University of Minnesota
Attending Surgeon
Phillips Eye Institute
Minneapolis, MN

Thomas W. Samuelson, MD (Chapter 14)
Attending Surgeon
Minnesota Eye Consultants
Phillips Eye Institute
Adjunct Associate Professor
University of Minnesota
Minneapolis, MN

H. John Shammas, MD (Chapter 16)
Clinical Professor of Ophthalmology
Keck School of Medicine
University of Southern California
Los Angeles, CA
Medical Director
Shammas Eye Medical Center
Lynwood, CA

Renée Solomon, MD (Chapter 16)
Cornea, External Disease, Refractive Surgery
Specialist
Private Practice
New York, NY
I realize that you have opened this text to learn phacoemulsification and that you are anxious to get on with it. Yet something compels me to ask you to slow down, if only for a moment. Before we hurry ahead, I need to tell you where we came from and how we got to the place we are today.

When I was a resident, the best that ophthalmology had to offer a cataract patient was a bloody operation, a painful eye, and a lifetime of aphakia. We operated with loops, not microscopes, and made a 180-degree incision while an assistant surgeon held a silk retraction suture placed through the cornea. The cornea was folded back on itself, allowing the surgeon to place a cryoprobe on the surface of the cataract. A large ice ball formed, the zonules were “gently” broken, and the entire lens, capsule and all, was delivered. If no vitreous followed the lens, we congratulated ourselves and proceeded to quibble about how many sutures were needed. Should we use five or seven? The suture material was so large the knots could not be buried.

In the 1960s and much of the 1970s, this intra capsular cataract extraction was hailed as the “perfect” procedure by experts of the day. Countless lectures were given, describing seemingly important refinements in this procedure, and there was general agreement, especially in academic institutions, that cataract surgery had reached its ultimate zenith. Those with ideas to the contrary were not welcomed. Most unwelcomed of all was Charles Kelman.

Kelman came upon the idea of phacoemulsification while sitting in a dental chair, having his teeth cleaned. It occurred to him that the same ultrasonic energy used to remove tartar could be used to remove the nucleus of a cataractous lens.

Kelman’s first phacoemulsification instruments were clumsy and difficult to use. Techniques for performing phaco were in their infancy, and the early complication rates, including “dropped nucleus” and corneal decompensation, were very high. There were at that time no effective instruments or techniques for retrieving the nucleus from the vitreous cavity, and eyes with retained nuclear material often progressed to phthisis. To help prevent this terrible complication, Kelman advocated subluxing the nucleus into the anterior chamber.

In the early machines, the fluidics was very primitive, and high levels of ultrasonic energy were needed to emulsify the nucleus. The role of the endothelium in corneal health was poorly understood, and viscoelastic materials had yet to be developed. Eyes undergoing phacoemulsification in those days were frequently “lost” due to corneal decompensation, and Kelman’s new method for cataract surgery was rejected by virtually everyone. Kelman was seen as reckless by most surgeons and was personally reviled by many. To his assistance came a handful of surgeons who saw both the potential of Kelman’s ideas and the necessity of developing safer techniques for the new procedure.

Most ophthalmologists of that era operated with only one hand. With intracapsular surgery only one hand is needed to engage the nucleus and lift it out of the anterior chamber. Richard Kratz was one of the first surgeons to realize that phacoemulsification needed a new and innovative approach, a “bimanual technique.” He understood the need to control the nucleus to prevent complications. Kratz devised techniques for tipping the proximal aspect nucleus out of the capsular bag and bringing it into the iris plane. This was accomplished by introducing a second instrument through a side port incision. Held in this position, the nucleus could be emulsified with less risk of damage to the posterior capsule and less trauma to the corneal endothelium. The “bimanual approach” was quickly adopted by “early adapters” in the mid-1970s. By the late 1970s and early 1980s, hundreds of surgeons came to learn the new technique for phacoemulsification from Kratz. They returned to their practices to perform phacoemulsification with greater safety, and, gradually, the procedure began to become more popular.

Monumental improvements in intraocular lens (IOL) technology were beginning to occur simultaneously with the advances in phacoemulsification techniques. Efforts to combine anterior chamber and iris-supported IOLs with intracapsular surgery had proven largely unsuccessful. The introduction of the posterior chamber IOL by Steve Shearing in 1977 led to a revival in extracapsular surgery. In the 1950s, extracapsular surgery had been abandoned in favor of intracapsular surgery because of problems of retained cortex and postoperative inflammation. With the advent of the
operating microscope and improvements in hand-held aspiration-irrigation systems, standard extracapsular surgery became much “cleaner.” This reduction in postoperative inflammation with the new standard extracapsular methods and the maintenance of a posterior capsule that provided support for Shearing’s new posterior chamber IOL suddenly made extracapsular surgery much more appealing to surgeons.

Shearing’s innovation was a change that made a huge difference in ophthalmology. Cataract surgery skyrocketed in popularity with the introduction of the posterior chamber IOL. Like phacoemulsification, posterior chamber lenses were initially rejected by many as inherently dangerous. The great fear was that posterior chamber IOLs would ultimately float in the vitreous cavity, but as positive experience with the new lenses increased and long-term success became established, this new IOL technology was universally embraced.

By the mid-1980s, there were two camps of posterior chamber lens users: those who performed standard extracapsular surgery and inserted the lenses through an 8- to 11-mm incision, and those who performed phacoemulsification and then enlarged the phaco incision to 6 mm in order to implant the IOL. All IOLs at this time were made of polymethylmethacrylate (PMMA). Conventional extracapsular surgeons in the mid-1980s were very much in the majority. They saw little advantage in adopting phacoemulsification with all of its inherent difficulties and challenges as long as the incision needed to be enlarged for IOL insertion.

Thomas Mazzocco changed this. The “Mazzocco Taco,” a plate-shaped IOL made of silicone, was the first IOL designed to be rolled and inserted through an incision smaller than 6 mm. Many surgeons believed only in the sanctity of PMMA and doubted that a foldable material such as silicone would remain biologically inert or that it would remain clear over the course of time. Fortunately, the detractors, once again, were wrong. With the eventual development of a foldable IOL that could be placed through an unenlarged 3-mm phaco incision, the advantages of small incision surgery were finally realized.

The foundations were now in place for the steady evolution in materials and techniques that have made phacoemulsification one of the safest and most elegant procedures in medicine today.

David Miller and Roger Stegmann introduced sodium hyaluronate to ophthalmology in the late 1970s and over the past three decades continuous improvements in ophthalmic viscoelastic devices have added greatly to the safety of cataract surgery.

Topical anesthesia was reintroduced to modern cataract surgery by Richard Fichman in the late 1990s and, to the surprise of most ophthalmologists, both retrobulbar and peribulbar injections of anesthetics were found to be largely unnecessary with the new surgical techniques.

Innovations by Michael McFarland, Paul Ernest, and Howard Fine in incision construction have allowed us to design better, stronger incisions, some of which no longer require sutures.

The can opener capsulotomy, the age-old mainstay of extracapsular surgery, was replaced by Howard Gimbel and Thomas Neuhann with the continuous curvilinear capsulotomy in the early 1990s. This innovation resulted in greater stability of the capsular bag during phacoemulsification and improved the centration of IOLs postoperatively, but its introduction led to other challenges. The nucleus of a dense cataract could no longer be tipped easily into the pupillary plane for emulsification. New techniques had to be developed for disassembling the nucleus within the capsular bag. Howard Gimbel and John Shepherd developed “divide and conquer” techniques in the early 1990s, followed soon by Kunihiro Nagahara who introduced the first of the many chopping techniques now used widely by surgeons all over the world. These techniques, which all require the ability to move the nucleus within the capsular bag without placing undue stress on the zonular support of the capsule, were made possible by the development of hydrodissection and hyrodelineation techniques pioneered by Aziz Anis and Howard Fine.

IOL technology has continued to advance with lens edge configurations that delay the onset of capsular opacification and lens optics that improve the quality of vision through aspheric design. Capsular tension rings now reduce the risks of capsular destabilization during our most challenging cases.

Last, but certainly not least, phacoemulsification technology has constantly improved with innovations in fluidics, power control, and duty cycles. These improvements in phacoemulsification provide the surgeon with a level of control and safety that even Charles Kelman could not have imagined. What comes next? What will be the direction of change that makes surgery safer, easier, more reliable, and more efficient?

Thirty-five years ago, it would have been impossible for any one person to guess where the collective genius of a generation of eye surgeons was about to take us. No one knew then what the future would bring, and no one knows now. Only one thing is certain. Those of
you who are just beginning to learn phacoemulsification today will be part of that future. You are the next generation of innovators. Your challenge is to resist the notion that everything worthwhile has been discovered, that all the obstacles have been surmounted, and that there is nothing left to do. You are our future and there will be much left for you to do.

REFERENCES

This excellent text serves an important need in furthering the "science" of cataract surgery. The history of progress in surgery, in general, contrasts in many ways with the rest of medicine. The initial "barber surgeons" of England were looked down upon by the elitist and self-declared medical intellectuals who called themselves physicians. In contrast to the perception of surgery as a crude assault on the body, the tools of the physicians included observation, dietary manipulation, pharmacologic therapy, and scientific study. Surgeons learned their crafts via apprenticeships and accumulated anecdotal experience, but "medicine" was a science.

This legacy persisted for quite a while. Prospective, randomized, controlled clinical trials became routine in the evaluation of new proposed medical therapies. But rarely was this methodology embraced by surgeons, who would declare preeminence of their own surgical techniques after reporting small case series in which no control group was included. In the United States, a group of ophthalmologists actually sued in an effort to prevent the National Institutes of Health from carrying out a prospective study of one eye operation.

Early in my own career, it was common to hear interesting expressions from surgeons such as “in my hands.” In at least some cases, this was a mechanism for explaining away a lack of replication of claimed outcomes by other surgeons or medical centers. I have witnessed surgeon innovators ridiculing surgeons in the audience who described complications after trying the new surgical procedure, complications that the innovator claimed could never occur. “Perhaps you should go back and repeat your residency if you cannot perform a simple operation,” said one guest lecturer to a skilled local ophthalmic surgeon in California who did not see the same uniformly wonderful results in his patients. With the passage of time, it has become clear to me that in every case the observant practitioner was correct, and the indignant surgeon-innovator was too personally invested in his or her work to be objective.

Fortunately the field has evolved, and the term surgical science is no longer an oxymoron. Prospective controlled trials comparing surgical interventions and devices are no longer rare, and the claims from the podium of charismatic surgical “thought leaders” are no longer routinely accepted as valid substitutes for objective data.

At the same time, our society is tasking surgeons in general and ophthalmologists in particular with figuring out how to do more surgery, with better outcomes and at lower costs. The looming demographic tidal wave of the baby boomer generation has led ophthalmic manpower studies to predict a 30% undersupply of ophthalmologists within a decade or two in the United States. The prevalence of cataracts and other age-related eye diseases will increase dramatically; the number of ophthalmic surgeons will not change appreciably. Not content to simply see our profession deal with this volume, our society demands that we reduce the cost of this care, improve the results (eg, eliminate the need for corrective eye wear for distance, near, and intermediate vision postoperatively after cataract surgery), and reduce the risks of endophthalmitis and other complications. In short, ophthalmic surgeons will need to do more with less.

We are also asked to change how we transform new ophthalmology residents into capable surgeons. The apprenticeship model of “see one, do one, teach one” is being replaced by a more rigorous approach of communicating the underlying scientific principles of surgery, breakdown of multistep procedures into their component parts, and “certification” of trainees as having mastered each of these steps. Pedagogical scientists tell us that this will accelerate the progress of new surgeons, more quickly identify strengths and weaknesses of budding surgeons so that deficiencies can be quickly corrected, reduce the likelihood of complications during the early part of the learning curve, and ensure society that the new surgeons we train possess the required competencies.
This text reflects the positive trends in how we are coming to embrace the science of ophthalmic surgery. The physics that drives our cataract surgical instruments, the detailed exploration of techniques for each step of the procedure, the optics of vision correction, and the outcomes data that speak to the quality of our interventions are all beautifully illustrated. I believe this will prove a valuable resource for beginning surgeons who will want to immerse themselves in the details of surgical technique before performing those techniques on their first patients, as well as for more experienced surgeons looking to continuously improve the outcomes for their patients.

Peter J. McDonnell, MD
Director of The Wilmer Eye Institute
Johns Hopkins University School of Medicine
Baltimore, MD
Introduction

Modern cataract surgery is one of medicine’s finest achievements. No procedure today is more gentle, safe, and successful; more important to the quality of life and well-being of patients; or more beneficial to society as whole than is phacoemulsification. The procedure is also a marvel to behold. It is an art form, and, once learned well, it is a joy to perform.

In the hands of a skilled surgeon, phacoemulsification is a masterful ballet of efficiency and grace. Each precise and carefully practiced step leads fluidly to the next. For a number of years, I have had the pleasure of training a wonderful group of young resident surgeons in phacoemulsification. This experience as a teacher and my own 30 years as a phaco surgeon have taught me the value of understanding phacoemulsification as a series of thoughtfully considered steps. Each step of phacoemulsification must be understood thoroughly, learned perfectly, and practiced repeatedly before the procedure can be executed with consistent proficiency.

Phacoemulsification is unforgiving. If there is a stumble on any one step, the next step becomes more difficult and things begin to go badly. When each sequential step is performed well, however, the procedure seems to glide effortlessly and a magical thing occurs. The surgeon’s hands create something that is not only good but lovely to behold.

More than a dozen of the world’s finest surgeons have come together in this text to help you learn to perform phacoemulsification at its highest level. Each has chosen one or more aspects of the procedure and has carefully analyzed the steps that are critical to the successful performance of that part of the surgery. Whenever it is useful, the authors have also provided narrated video footage that illustrates the key instructional points made in the text. This complete video reference should prove to be an invaluable resource as you learn to achieve excellence phacoemulsification.