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Refractive Surgery Atlas

Surgical Techniques and Complications

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To all my fellows who constantly inspire me through their boundless curiosity and thirst for knowledge.

—Samir A. Melki

To my teachers at Boston Vision. To my parents Ahmad and Sahar, whose love and guidance have shaped me into the person I am today. To my beloved wife Lulwa, whose unwavering support and encouragement have fueled my passion for writing. And to my precious daughter Yasma, who is the inspiration behind every word written in this book.

—Wassef Chanbour

To my wife Allison who helped put me through medical school, raise our children, and is the keystone to our family.

—Jason Brenner

Foreword

With gratitude and great admiration, I am honored to introduce the outstanding work of the *Refractive Surgery Atlas: Surgical Techniques and Complications* by Samir Melki, MD, PhD, Wassef Chanbour, MD, and Jason Brenner, MD. This comprehensive book is a testament to the remarkable progress achieved in refractive surgery, providing a guide to surgical techniques while addressing the complexities and challenges of managing potential complications.

Refractive surgery has undergone tremendous advancements, revolutionizing how we correct vision and liberating countless individuals from dependence on corrective lenses. The advent of laser vision correction has been remarkable, driven by the relentless pursuit of safety and efficiency. Moreover, refractive surgery is on the path to being considered a specialty of medicine with ophthalmology as a prerequisite, as defined by the World College of Refractive Surgery and Visual Sciences (www.wcrsvs.org).

Within these pages, esteemed experts in the field have meticulously documented and curated an extensive collection of surgical techniques, ensuring readers acquire the knowledge and skills required to navigate the intricate world of refractive surgery. This atlas is a comprehensive guide for experienced surgeons and aspiring ophthalmologists and provides valuable insights for researchers and scholars interested in this rapidly evolving field. One of the distinguishing features of this atlas is its unwavering focus on the understanding of complications. While refractive surgery offers immense benefits, it is not without risks. Recognizing this, the authors have dedicated significant attention to preventing and managing potential complications arising during or after surgical interventions. By shedding light on the nuances of difficulties, they empower practitioners to approach these challenges confidently, ensuring the highest level of patient care and safety.

I sincerely appreciate the authors and contributors who have dedicated their time, knowledge, and passion to creating this remarkable atlas. Their unwavering commitment to advancing the field of refractive surgery is evident in every chapter, making this volume an indispensable resource that will undoubtedly shape the future of ophthalmic surgery.

I am honored to contribute to this work by describing a case of iatrogenic ectasia after SMILE. This was the first (and still the only) case of ectasia that I generated after laser vision correction. Paradoxically, I dedicate my research to preventing such complex and unfortunate complications. Nevertheless, the lessons learned using the "black-box thinking" mindset have been fundamentally relevant for my evolution as a refractive surgeon-scientist. I recommend this work and invite you to the learning journey through the *Refractive Surgery Atlas: Surgical Techniques and Complications*. May this atlas inspire and empower you to provide the best possible care for your patients.

The Federal University of the State of Rio de Janeiro
International Society of Refractive Surgery (ISRS) Renato Ambrósio Jr
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Preface

The *Refractive Surgery Atlas* starts with an introduction that provides an overview of the most commonly used refractive surgical techniques. The subsequent chapters delve into the intraoperative and postoperative complications that can arise from LASIK and PRK surgeries, combining detailed descriptions of potential complications with strategies for preventing and treating them.

In addition to LASIK and PRK, *Refractive Surgery Atlas* also covers other types of refractive surgeries, such as phakic intraocular lenses, SMILE, and incisional surgeries. Each surgery is discussed in detail, with explanations on their indications and their potential risks and benefits.

One of the unique features of this book is the case-based approach used to present normal and abnormal changes encountered during and following refractive surgeries.

Overall, *Refractive Surgery Atlas* is an essential resource for anyone interested in refractive surgery. Whether you're a surgeon, an optometrist, a medical student, or a resident, this book provides comprehensive information that will help you identify potential complications and make the right decisions to manage them.

Boston, MA, USA — Samir A. Melki
Boston, MA, USA — Jason Brenner
Minneapolis, MN, USA — Wassef Chanbour

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Editors and Contributors

About the Editors

Samir A. Melki, MD, PhD is the founder and director of the Boston Vision and Boston Eye Group. He is also a clinical instructor at Harvard Medical School and assistant in ophthalmology at the Massachusetts Eye and Ear Infirmary. He was medical director for ophthalmology at the UK Specialist Hospitals. He completed his ophthalmology residency at Georgetown University Hospital, where he was elected as chief resident. This was followed by a fellowship in Corneal and Refractive Surgery at the Massachusetts Eye and Ear Infirmary, where he served as chief fellow. His areas of interest include refractive surgery, complex cataract surgery, and ocular surface reconstruction.

Jason Brenner, MD started his education at Lafayette College where he obtained a Bachelor of Science in biology with a minor in medical ethics. After his undergrad, he attended medical school at George Washington University School of Medicine in Washington, D.C. He then completed his residency training at Temple University Hospital in Philadelphia, where he was also chief resident.

He is a board-certified ophthalmologist, specializing in cornea, refractive, and anterior segment surgery. He did his fellowship under the supervision of Dr. Melki, at the Boston Eye Group and is currently one of the primary refractive surgeons at Boston Vision. He is also an associate staff at Beth Israel Deaconess Medical Center in Boston. As a cornea specialist, his primary interests are LASIK, Visian ICL surgery, femtosecond-assisted cataract surgery, sutured intraocular lenses, anterior segment reconstruction, and corneal transplants.

Wassef Chanbour, MD is an assistant professor at the University of Minnesota. After obtaining the medical degree from the Lebanese University in Beirut, he completed the ophthalmology residency at the Beirut Eye and ENT Specialist Hospital. He is specialized in cornea and refractive surgery, and his fellowship training was at Beth Israel Deaconess Medical Center and Boston Vision, under the guidance of Dr. Samir Melki. His practice includes all patients with different medical and surgical corneal and anterior segment diseases. He treats adults and children with the latest surgical techniques including endothelial keratoplasties in addition to the latest refractive procedures including LASIK, ICL, and femtosecond-assisted cataract surgery.

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Abbreviations

AC	Anterior chamber
AI	Artificial intelligence
AK	Arcuate keratotomy
ART-max	Ambrósio relational thickness-maximum
ASN	Acute stromal necrosis
AS-OCT	Anterior segment optical computed tomography
BCL	Bandage contact lens
BCVA	Best corrected visual acuity
BL	Bowman's layer
CAIRS	Corneal allogenic intrastromal ring segments
CBI	Corneal Biomechanical Index
CCT	Central corneal thickness
CXL	Collagen cross-linking
DALK	Deep anterior lamellar keratectomy
DLK	Diffuse lamellar keratitis
EBMD	Epithelial basement membrane dystrophy
Epi-ON CXL	Epithelium-ON collagen cross-linking
FS-ICRS	Femtosecond-assisted intracorneal ring segment implantation
ICL	Implantable collamer lens
ICRS	Intrastromal corneal ring segments
IOL	Intraocular lens
LALEX	Laser-assisted lenticular extraction with a small incision
LASIK	Laser-assisted in situ keratomileusis
LRI	Limbal relaxing incisions
LVC	Laser vision correction
OBL	Opaque bubble layer
OCT	Optical coherence tomography
OZ	Optical zone
PK	Penetrating keratoplasty
PRFI	Pentacam random forest index
PRK	Photorefractive keratectomy
PTA	Percent of tissue altered
PTK	Phototherapeutic keratectomy
RK	Refractive keratectomy
RSB	Residual stromal bed
SMILE	Small incision lenticule extraction
TBI	Tomography and biomechanical index
UCVA	Uncorrected visual acuity
VGB	Vertical gas breakthrough

Acknowledgements

We wish to thank the contributing authors of this book, whose hard work has resulted in a more up-to-date text. We are deeply grateful to the doctors who generously shared their expertise and clinical cases, making this book a rich resource for medical professionals and students alike. Your contribution to this book, through your photographs and compelling clinical cases, is invaluable and will undoubtedly make a difference in the lives of many patients. Thank you for being a vital part of this project.

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Introduction

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Jason Brenner, Wassef Chanbour, and Samir A. Melki

Refractive surgery has undergone tremendous transformation in the last 20 years. While modern refractive surgical techniques have improved safety and reliability over prior generations, they still have their own variety of challenging intraoperative and postoperative complications.

"Refractive Surgery Atlas: Surgical Techniques and Complications" is a review guide to the latest surgical techniques and complications in refractive surgery. This book will function first as a step-by-step intraoperative description of the surgical procedures, second as a visual reference encompassing not only common but also rare complications that can arise intra-operatively and following surgery, and third, the book follows a case-based approach offering practical tips for preventing and managing these complications.

The book is written by leading experts in the field of refractive surgery and is aimed at residents and fellows in training, ophthalmologists, optometrists, and other medical professionals who are interested in expanding their knowledge and skills in this area. It is an invaluable tool for both experienced surgeons and those new to the field covering both common and uncommon complications that can be encountered following surgery.

Most of the presented data comes from real life cases that were managed at Boston Vision, one of the busiest refractive surgery practices in the New England area where more than 40,000 cases have been performed over the last 30 years primarily by author Dr. Samir Melki but also by Dr. Jason Brenner. In addition, many of the top US refractive specialists have contributed photographs and cases that they have encountered during their years of practice.

Each chapter will discuss a different pathologic entity, it will include a summary of the most recent updates (pathophysiology, presentations, risk factors, preventions, and management…) followed by example pictures showing these pathologies. Pictures will be combined into cases that will include patient history, clinical description of the pictures, management and learning points. The case studies provide real-world examples of how these complications are managed in the clinical setting. In the end of each chapter, we will include take home messages that summarizes the learning aspects of the aforementioned cases.

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Surgical Techniques

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Wassef Chanbour, Samir A. Melki, and Jason Brenner

Surface Ablation Techniques

Photo Refractive Keratectomy (PRK)

Step 1: Epithelial ablation:, it can be performed with corneal brush, alcohol, blade, or trans epithelial ablation (Figs. 2.1 and 2.2).

Step 2: Laser stromal ablation (Fig. 2.3).

Step 3: Mitomycin application (Fig. 2.4).

Step 4: Bandage contact lens placement.

Fig. 2.1 Corneal brush used for epithelial ablation. Brush size: Myopic: 6.5 mm; Hyperopic: 9.0 mm; Hyperopic XL: 9.5 mm. (Innovative Excimer Solutions©, Inc. *Courtesy of Ravi Patel, MD*)

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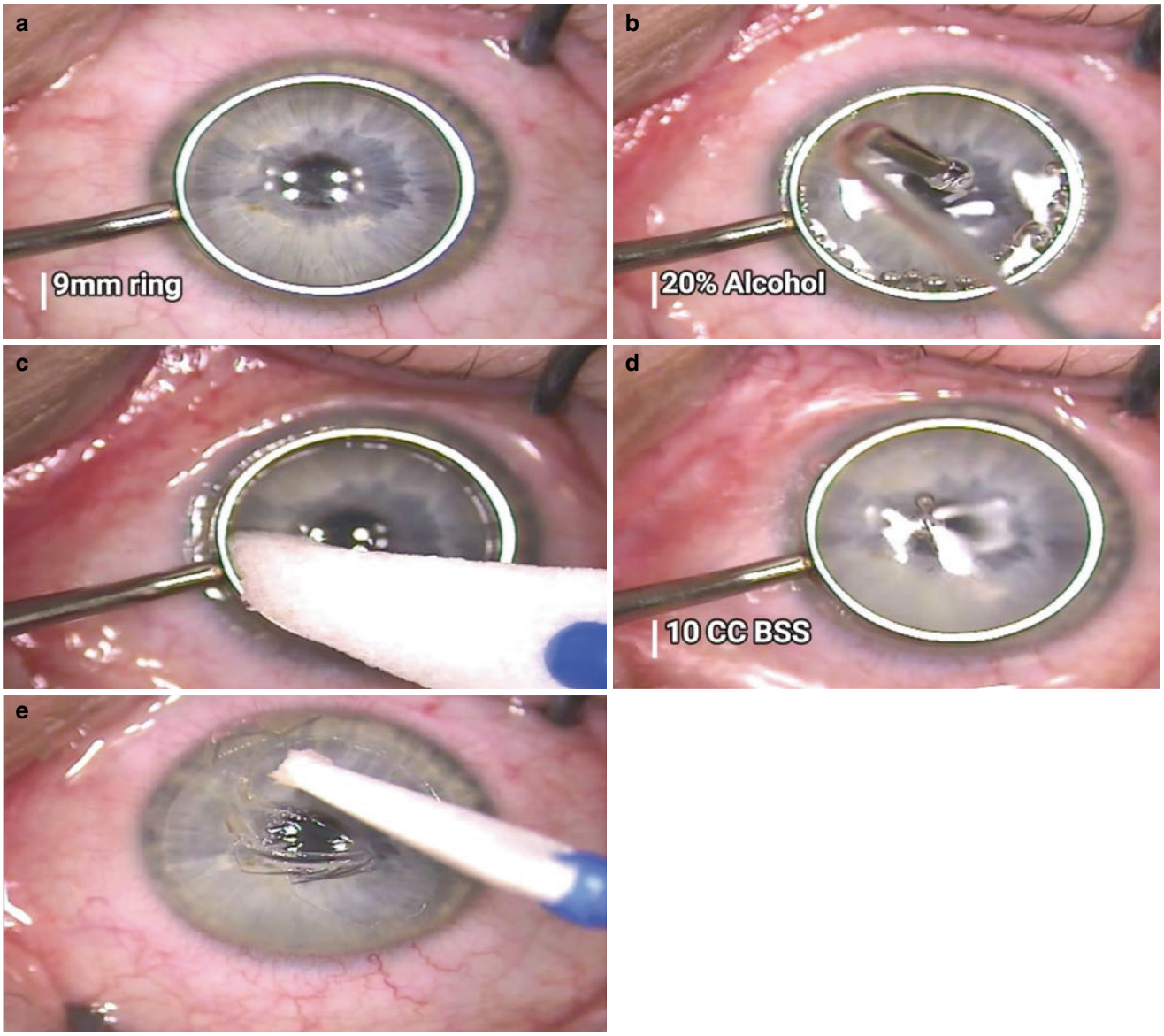


Fig. 2.2 Steps of epithelial ablation with alcohol. Cone (8.5–9.5 mm) applied to the cornea (**a**) . 20% alcohol added in the cone (**b**). Removal of Alcohol with weck-cel after 40 s (**c**). Irrigation of all the surface with BSS (**d**). Epithelial scraping with instrument or weck-cel (**e**)

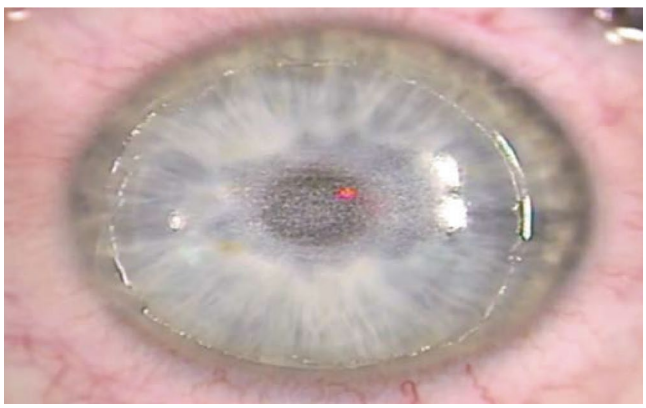


Fig. 2.3 Centered laser with activated stromal ablation

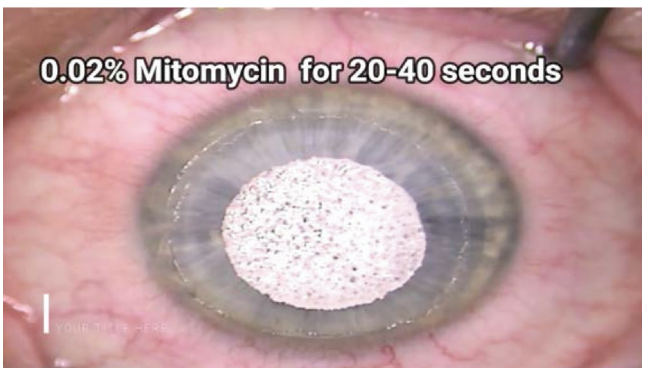


Fig. 2.4 Sponge soaked with 0.02% mitomycin placed over the ablation zone

Variants of PRK

Laser Subepithelial Keratomileusis LASEK

A spatula is used to separate a flap of full-thickness epithelium from the underlying Bowman's layer. The epithelium is delicately folded back leaving a small "hinge," which is usually located superiorly or temporally (Fig. 2.5).

Epi-LASIK

The microkeratome is modified with a dull blade and thin applanation plate to mechanically remove the epithelial flap without the use of alcohol.

Epi-LASEK

Epi-LASEK is similar to Epi-LASIK except that alcohol is added with the goal of facilitating creation of the epithelial flap.

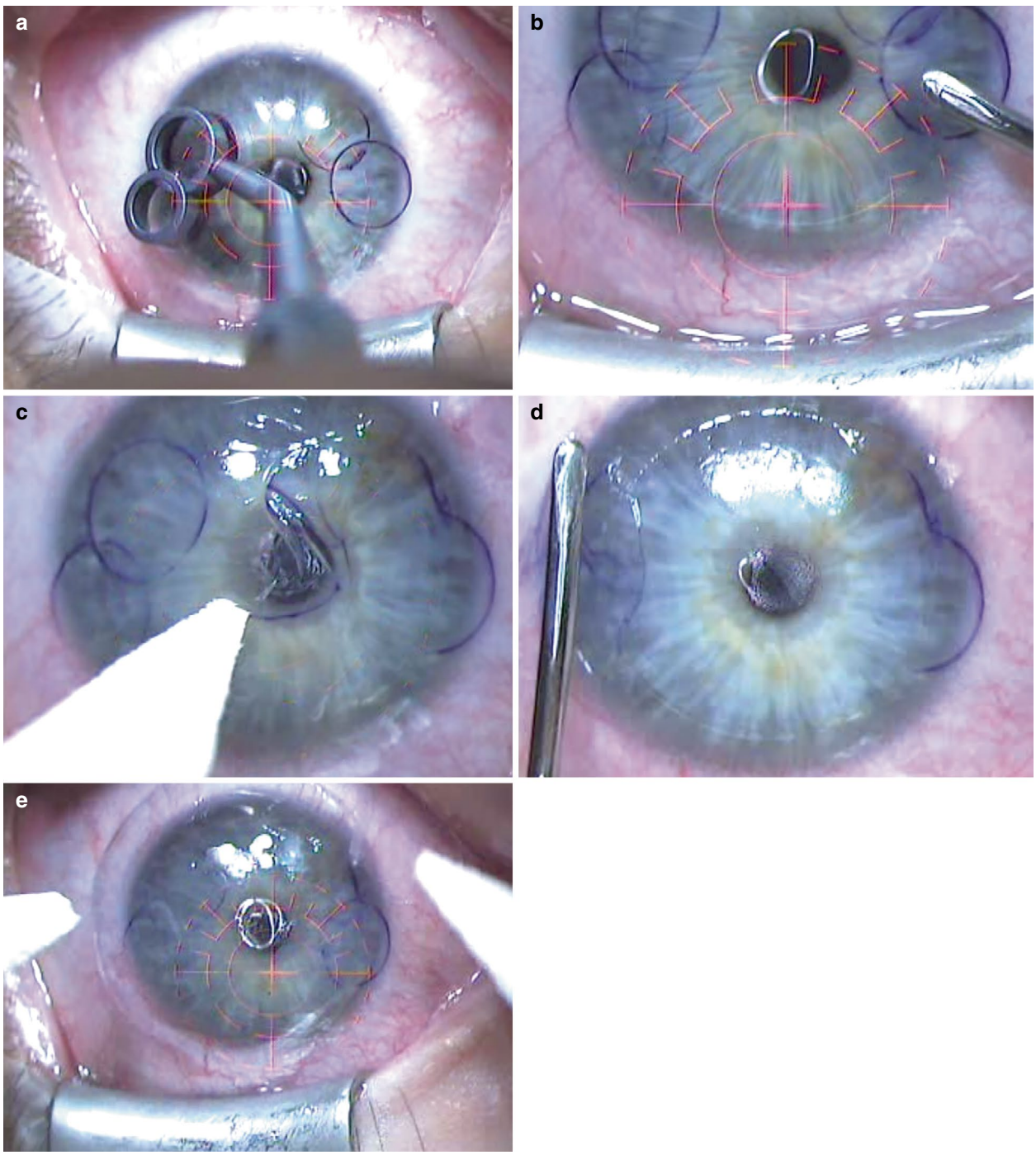


Fig. 2.5 Steps of LASEK surgery. Epithelial marking (**a**). Alcohol application (5 s) followed by dissection of an epithelial flap with a spatula (**b**). Weck-cel used to slide the epithelium out of the treatment zone (**c**). Epithelium folded temporally (**d**). Following the laser treatment, epithelium is repositioned back to original position and a BCL is placed on the cornea (**e**)

Femtosecond LASIK

See Figs. 2.6 and 2.7.

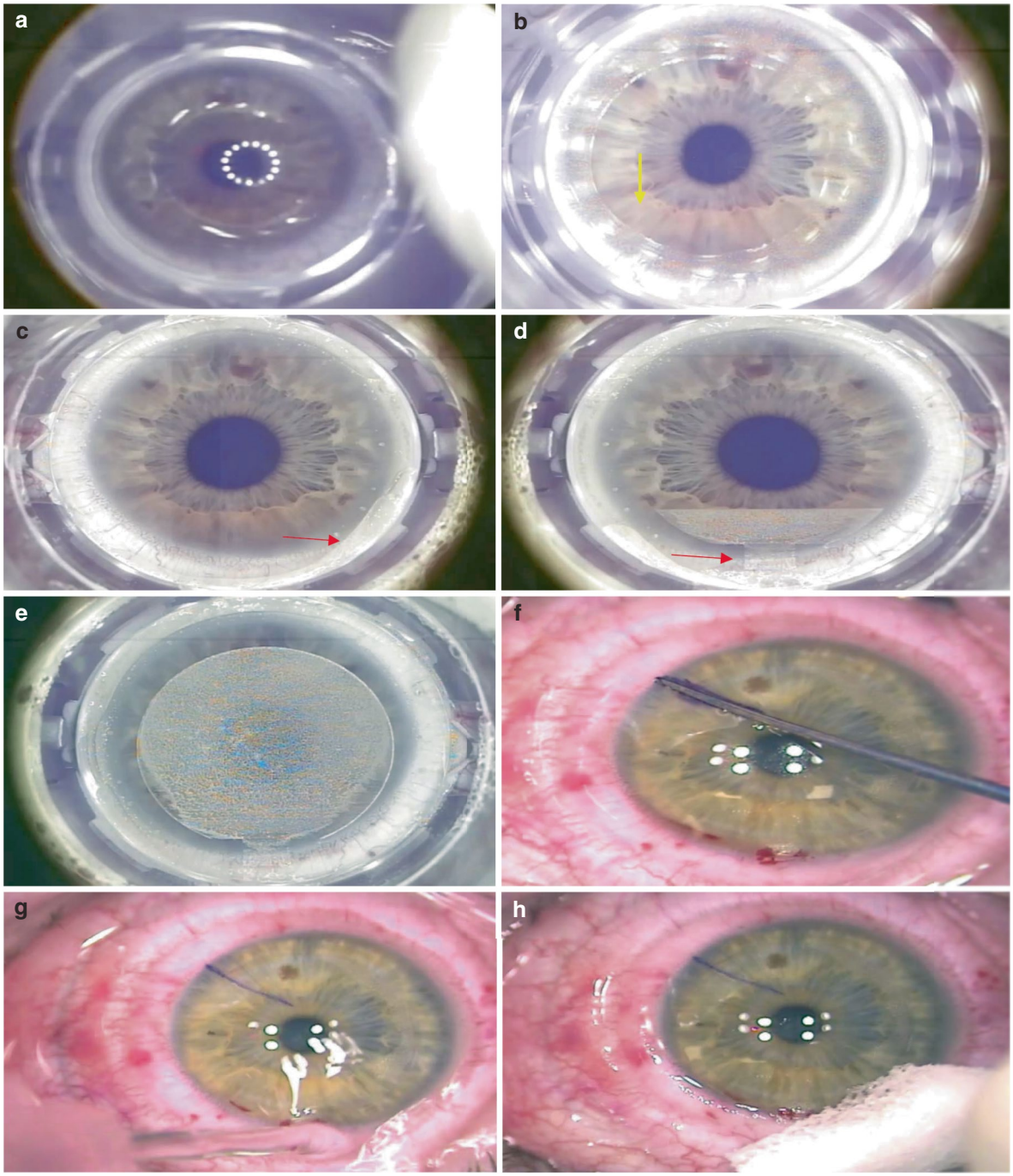


Fig. 2.6 Steps of femtosecond LASIK surgery. WaveLight® Alcon refractive suite was used for this case. Suction ring placed with the cornea centered (**a**). Applanation cone lowered with partial corneal applanation (*yellow arrow*) (**b**). Complete corneal applanation, soft docking is noted as peripheral air is present on top of the conjunctiva (*red arrow*) (**c**). Superior channel *(red arrow)* created with ongoing Femtosecond Flap cut (**d**). Compete Flap creation with ongoing side cut (**e**). Marking of the flap edge with a straight metal instrument (**f**). Surface irrigation with normal saline to remove debris (**g**). Drying the surface with weckcel (**h**). Flap lifter used to identify and engage the flap (**i**). Flap dissection until the superior hinge (**j**). Inferior partial flap dissection (Not to dissect beyond the edge) (**k**). Complete dissection of the remaining attached area followed by flap lift (**l**). Drying the stromal interface with a weckcel (**m**). Laser treatment (**n**). Hydrating the interface to facilitate flap reposition (**o**). Flap repositioning (**p**). Surface irrigation to remove debris (**q**). Irrigation under the flap to remove debris (**r**). Soothing the surface with the cannula to remove remaining interface fluid (**s**). Drying the flap edge to see a complete silver ring with equal gutter on both sides (**t**)

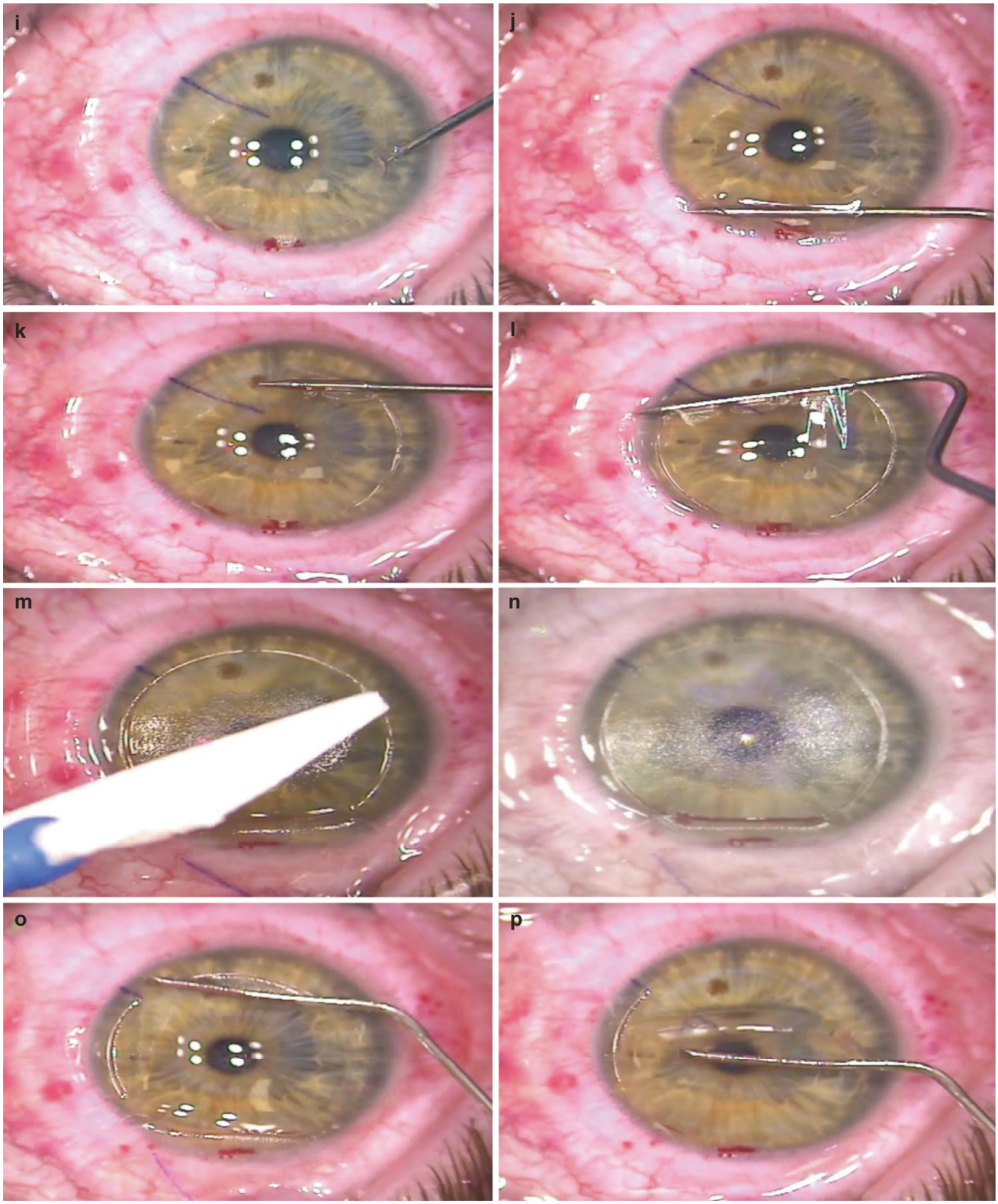
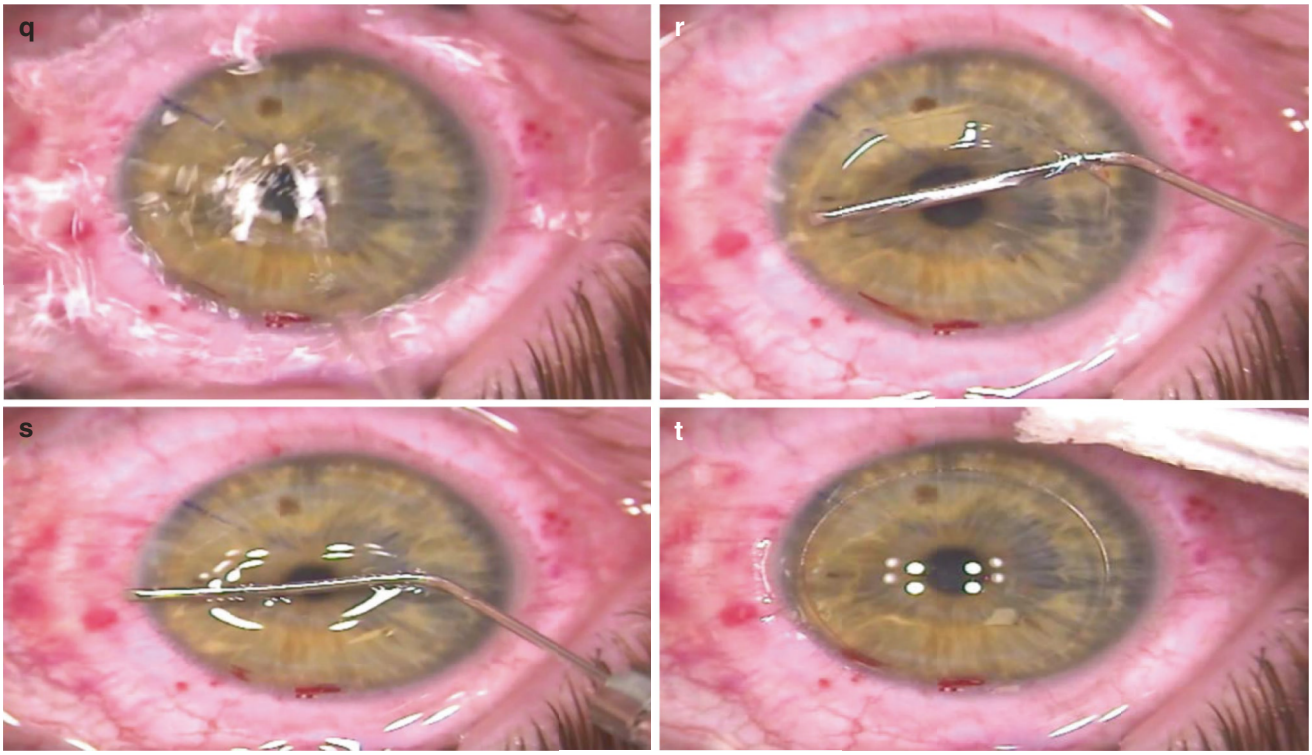


Fig. 2.6 (continued)



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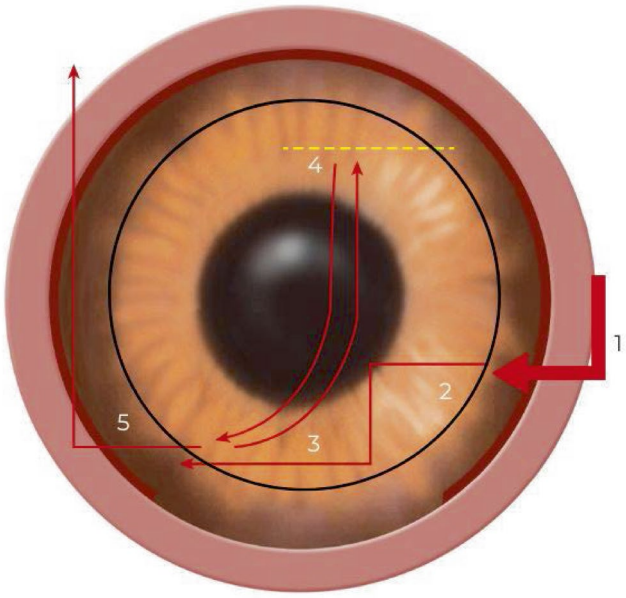

Fig. 2.7 Consecutives steps for flap dissection. Note that step 1 requires a downward movement to enter the gutter before proceeding into the horizontal movement to dissect the flap in step 2

Microkeratome LASIK

Suction ring is centered to the cornea and vacuum is activated followed by keratome insertion and activation to create a flap (Fig. 2.8). (The rest of the procedure is similar to Femtosecond LASIK).