LASER SURGERY IN OPHTHALMOLOGY

Practical Applications

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LASER SURGERY IN OPHTHALMOLOGY

Practical Applications

This volume is dedicated to our fathers
Samson Weingeist, MD
and
Robert J. Sneed, MD
teacher, friend, and ophthalmologist

Preface

The concept of this book initially arose from a course on laser photocoagulation given at the University of Iowa in 1982. Since that time, many technological improvements have been developed for treating ocular disease with laser surgery. Similarly, results of numerous controlled clinical trials (Diabetic Retinopathy Study, Macular Photocoagulation Study, Early Treatment Diabetic Retinopathy Study, Branch Retinal Vein Occlusion Study) have proven the efficacy of laser surgery in the treatment of ocular disease as outlined in NIH Publication No. 90-2910 entitled *Clinical Trials Supported by the National Eye Institute.*

The aim of this book is to clearly describe laser techniques for more common and some infrequently encountered ocular diseases. The techniques of laser surgery described in this book have been successfully used by many ophthalmic surgeons, but are not necessarily the only ways in which the ophthalmologist might treat a particular disease entity. Variations of the techniques described herein are successfully used by ophthalmologists.

This book is intended for ophthalmology residents, fellows, and for general ophthalmologists who may use laser in treating more common ocular disease. Ophthalmology subspecialists may find the book useful as a reference when treating less common ocular disorders. Laser surgeons should find the tables describing laser parameters and goals for specific ocular diseases to be particularly helpful in planning and performing laser surgery. Variations of the described techniques may develop based upon clinical experience and further advances in the ophthalmic literature. This book is not intended as a "how to" text for ophthalmologists not trained in laser surgery. Formal "hands on" laser surgery under the direct supervision of an experienced laser surgeon is necessary for learning the techniques of laser surgery.

Several aspects of laser surgery in ophthalmology are not covered in this text. Use of the CO_2, the Argon laser, and the scalpel Nd:YAG lasers in oculoplastic surgery is becoming increasingly popular in treating orbital and ocular plastic conditions. Similarly, the excimer laser is being used in keratorefractive surgery and may become a more practical tool as more clinical results are published. The diode laser has been successfully used to treat various retinal diseases, and to perform laser peripheral iridectomies and cyclodestruction. The small size and low maintenance of the unit as well as the good penetration of retinal edema and cataractous lenses are advantages that may lead to more widespread use of the diode laser. The ability to "choose" a particular wavelength makes the dye laser an attractive instrument for the laser surgeon. The dye yellow wavelength is highly absorbed by hemoglobin and may be useful for treating vascular lesions of the eye. Increased use of these "newer" lasers may develop as more laboratory and clinical experience is acquired.

This book is the product of a combined effort of many people, particularly the contributing authors and their staff. Our wives, Catherine and Cristy, and our children shared in their own ways, the burden of producing this book. The editors are particularly grateful to Ramona Weber who helped to organize the materials for this project and assiduously typed multiple revisions of the manuscript. We would also like to extend our thanks and appreciation to Joan Meyer, Medical Editor of Appleton & Lange, and her staff for their patience and support throughout the creation and production of this book.

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Foreword

In 1949, Meyer-Schwickerath introduced ophthalmology to xenon photocoagulation, and ophthalmology subsequently introduced laser photocoagulation to the medical world. During the past decade, the rapid acceleration of laser technology has extended into almost every subspecialty of medicine. What began as a tool used by a few ophthalmologists for the treatment of several diseases of the ocular fundus has expanded to the treatment of disorders affecting virtually every part of the eye and adnexal structures. Laser photocoagulation is rapidly becoming part of the therapeutic armamentarium of every ophthalmologist. While controlled clinical trials have provided guidelines or indications and techniques for photocoagulation treatment of some of the more common ocular disorders, less information is available concerning management of other diseases. This very readable book will be helpful to those experienced, as well as those less experienced, in improving their clinical judgment and skills in the techniques of photocoagulation. Although not designed as a primer for those with no training in photocoagulation, it includes informative introductory chapters that review the anatomy of the eye, principles of photocoagulation, and the histopathologic changes induced by laser.

The primary contribution of this book is the presentation by a number of seasoned and skilled practitioners of their experience in photocoagulation treatment of a wide variety of ocular diseases. Included are individual nuances of thought and technique that will be helpful to even the most experienced in photocoagulation. The authors have succeeded in making this a practical guide for the laser surgeon.

J. Donald M. Gass, MD

Contents

CHAPTER 1

Anatomy of the Eye

Thomas A. Weingeist

- The Chamber Angle
- The Iris
- The Retina
- The Choroid
- References

Success in laser surgery is dependent in part on a clear understanding of the anatomy of the eye. Knowledge of the location and the type of ocular pigments also is essential. The most important pigments are melanin, hemoglobin, and xanthophyll. The transparency of the ocular media allows radiant energy to enter the interior of the eye without appreciable loss. Coagulation of the eye tissues is due in large part to absorption of electromagnetic radiation by pigments and conversion of this energy into heat.

The main purpose of this chapter is to review those parts of the ocular anatomy that are important in laser photocoagulation therapy. Attention to anatomic details can mean the difference between success and failure. The anatomy of the following structures is reviewed: the anterior chamber angle, the iris, the retina, and the choroid.[1–3]

THE CHAMBER ANGLE

The chamber angle, which lies at the juncture of the cornea and the iris, consists of (1) Schwalbe's line, (2) the trabecular meshwork and canal of Schlemm, (3) the scleral spur, (4) the anterior border of the ciliary body, and (5) the iris (Fig. 1–1).

Many of the chamber angle structures can be visualized by gonioscopy. Schwalbe's line, the termination of Descemet's membrane, often can be seen as a hazy zone at the border of the cornea. If a thin slit beam is used to illuminate the angle obliquely, a corneal wedge is formed by the two converging beams at Schwalbe's line, which is located at the anterior border of the trabecular meshwork. Iris processes frequently can be seen extending from the surface of the iris into the trabecular meshwork. They should not be confused with peripheral anterior synechiae. The ciliary body is visible above the iris root. The longitudinal muscle fibers of the ciliary body insert into the trabec-

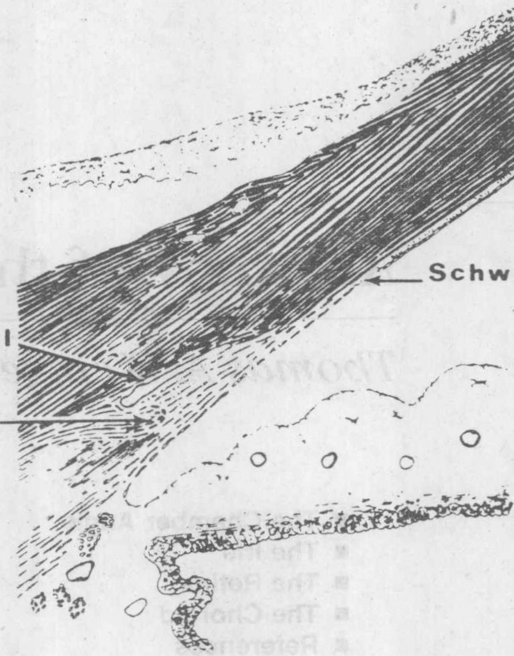

Figure 1–1. Schematic diagram of anterior chamber angle and iris.

ular meshwork. The scleral spur is formed by collagen fibers that invaginate between the anterior portion of the ciliary body and the canal of Schlemm. Schlemm's canal lies in the scleral sulcus just anterior to the scleral spur, between the middle and the posterior third of the trabecular meshwork. It appears as a faint gray line, or if blood has refluxed from the episcleral veins via the collector channels, it will stand out as a fine red line.

The pigmentation of the trabecular meshwork is variable. It tends to be greater in individuals with brown irises than in those with blue irises. However, the only reliable means of determining the degree of pigmentation is by gonioscopy. The lower chamber angle often is more pigmented than the upper. The melanin granules located in the trabecular beams are structurally identical to those found in the posterior pigmented layer of the iris.

The trabecular meshwork consists of a series of thin, perforated connective tissue sheets arranged in a laminar pattern. Each sheet is comprised of several components: a central core of collagen and elastic fibrils surrounded by a thin basal lamina and a single continuous row of thin endothelial cells with multiple pinocytotic vesicles. Intertrabecular and transtrabecular spaces exist throughout the meshwork.

The canal of Schlemm closely resembles the structure of a large lymphatic. It is formed by a continuous layer of nonfenestrated endothelial cells and a thin connective tissue wall. Tight junctions join the lateral walls of the endothelial cells. Collector channels arising from Schlemm's canal drain through a circuitous route into the aqueous veins.

THE IRIS

The iris is the most anterior extension of the uveal tract. It is comprised of blood vessels and connective tissue, in addition to melanocytes and pigmented cells, which are responsible for its distinctive color. The iris is unusual, since it fails to undergo wound repair even if its cut edges are sutured together.

The anterior surface of the iris normally is avascular, and it is not covered by a continuous layer of cells. The aqueous humor flows freely through the loose stroma, which contains melanocytes, collagen fibrils, blood vessels, and nerves.

The posterior border of the iris can be divided into two layers. The anterior layer comprises the dilator muscle. The posterior layer forms the pigmented layer of the iris. Ectropion uveae with and without rubeosis iridis occurs when these two neuroectodermal layers curve around the pupillary margin and extend onto the anterior surface of the iris. In order for surgical or laser iridotomy to succeed, an opening must exist through both pigmented layers of the iris.

THE RETINA

The retina is a thin, transparent structure that differentiates from the inner and the outer layers of the optic cup. The structure of the outer, pigmented epithelial layer is relatively simple compared with the overlying inner or neurosensory retina (Fig. 1–2).

The retinal pigment epithelium (RPE) consists of hexagon-shaped cells that extend from the optic disc posteriorly to the ora serrata anteriorly. The pigmented granules within the cytoplasm are primarily responsible for the absorption of radiant energy that occurs during laser photocoagulation.

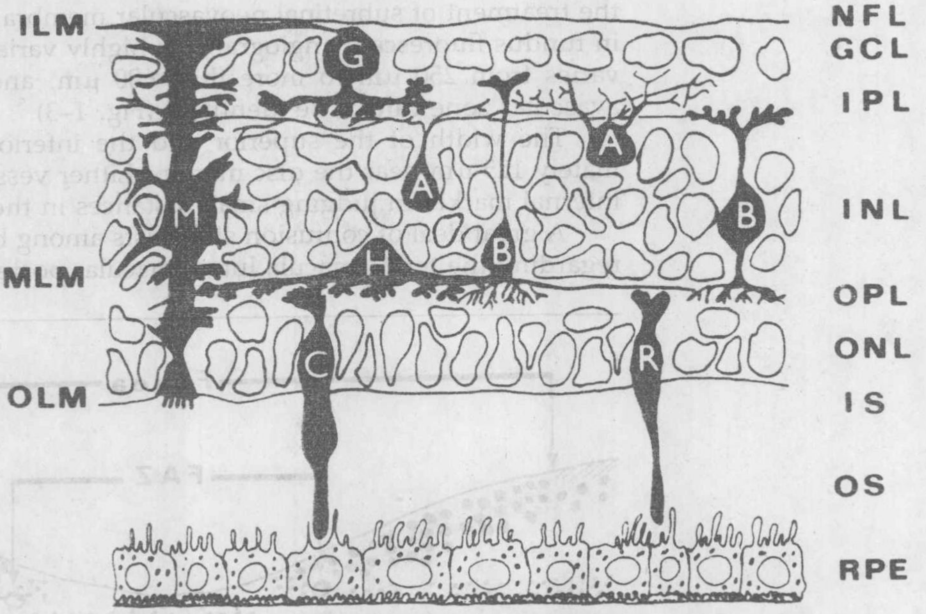

Figure 1–2. Cross-sectional representation of retinal architecture. ILM, inner limiting membrane; MLM, middle limiting membrane; OLM, outer limiting membrane; NFL, nerve fiber layer; GCL, ganglion cell layer; IPL, inner plexiform layer; INL, inner nuclear layer; OPL, outer plexiform layer; IS, inner segments; OS, outer segments; RPE, retinal pigment epithelium; ONL, outer nuclear layer. A, amacrine cell; B, bipolar cell; C, cone photoreceptor cell; G, ganglion cell; H, horizontal cell; M, Müller cell; R, rod photoreceptor cell. *(Modified from Dowling JR: Organization of vertebrate retinas.* Invest Ophthalmol. *1970;9:655–680.)*