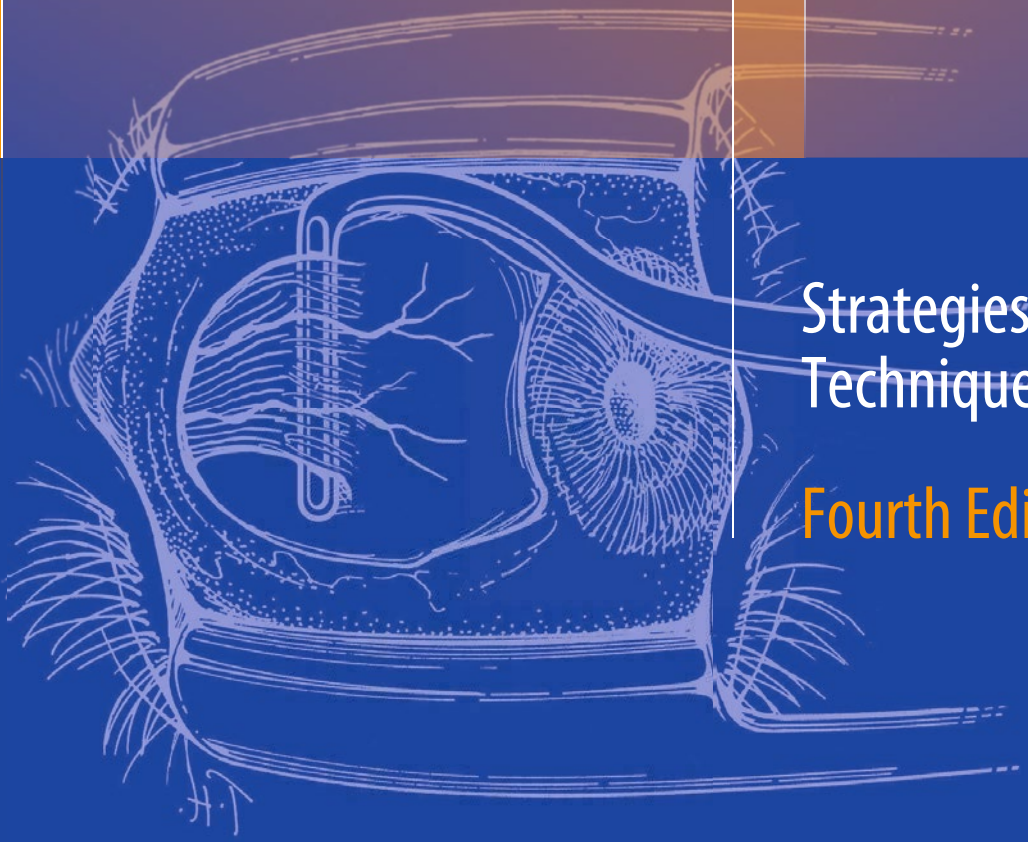
Kenneth W. Wright
Yi Ning J. Strube

Color Atlas of Strabismus Surgery



Strategies and Techniques

Fourth Edition

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Kenneth W. Wright • Yi Ning J. Strube

Color Atlas of Strabismus Surgery

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Preface to the Fourth Edition

We are now in our fourth edition of the *Color Atlas of Strabismus Surgery: Strategies and Techniques*. The first edition was published in 1991 by Lippincott. To the author's knowledge, these 23 years represent the longest-running printing of any textbook on ophthalmic surgery. We are sincerely honored to present the latest edition.

Since our last edition, several new strabismus surgery techniques have been developed. We have included detailed descriptions of these techniques including amniotic membrane transplant and minimally invasive procedures. Many of the minimally invasive procedures have been developed by me, Kenneth W. Wright, MD, including central tenotomy and central plication. These new minimally invasive procedures can be done with topical anesthesia.

As the senior author, I must acknowledge the great contribution of Yi Ning J. Strube, MD, FRCSC. Her expertise as a strabismus surgeon and her attention to detail has greatly enhanced this edition. We acknowledge the Wright Foundation, which supports pediatric ophthalmology and strabismus through research, education, and patient care.

Many readers have praised past editions because of the easy-to-read descriptions and simplicity of the line drawings yet applaud the fine details provided by the companion color photographs. They have said, "You can learn and do the procedure right from the book!" This is high praise, and the authors have made every effort to make the fourth edition hold up to that high standard.

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Los Angeles, CA, USA — Kenneth W. Wright, MD
Kingston, ON, Canada — Yi Ning J. Strube, MD, MS, FRCSC, DABO

Preface to the Third Edition

Strabismus can be devastating to our patients yet often difficult to treat even for the seasoned veteran. The goal of the *Atlas of Strabismus Surgery* is to clearly and succinctly share with the reader strategies and surgical techniques that will improve the care of our patients. The atlas covers the management of a wide range of strabismus disorders from the relatively simple horizontal strabismus to complex cyclovertical deviations. A variety of surgical techniques are presented, starting with the simple basics and progressing to complicated surgical techniques such as the delicate superior oblique tendon expander procedure and the retrieval of a slipped/lost rectus muscle. The atlas is designed to help surgeons of diverse experience, from the resident ophthalmologist to the most experienced strabismologist.

The third edition underwent a true makeover, with virtually every chapter receiving significant changes. Examples include a section on "Planning for success" in Chap. 2 that provides a logical approach to forming a treatment plan. Incomitant strabismus and torticollis associated with nystagmus or strabismus can be challenging to treat, so we have added a chapter specifically dealing with these important disorders. Throughout the book, clinical case examples have been added to illustrate strabismus treatment strategies. Relatively new to most strabismus surgeons is the use of topical anesthesia for strabismus surgery. Topical anesthesia strabismus surgery requires special techniques to avoid patient discomfort, and a chapter has been added on this up-and-coming procedure. The book has been updated to reflect changes in choice of suture materials such as the use of nonabsorbable suture for inferior rectus recession. We are also introducing several new titanium instruments from Titan Surgical Company that improve the efficiency and safety of strabismus surgery.

As in previous editions, color photographs are paired with line drawings to help explain the surgical techniques. The simplicity of the line drawing helps to teach technique, while the photographs add the reality of the surgical field. This format innovated by the author in the first edition won a publishers award in Philadelphia. To even further improve on this winning format, the third edition has a companion DVD with more than 10 videos of strabismus surgery. This combination of line drawings, color photographs, and surgical videos provides the student with the next best thing to live surgery.

I would like to give special thanks to my dear friend Sonal Farzavandi, MD, for her tenacity in editing every line of text, checking each index entry, and helping with the content. Without Sonal's help, this project would still be lingering today. Lisa Thompson, MD, one of my outstanding fellows, also deserves sincere thanks for her encouragement and for helping with editing the book. It is my sincere hope that the third edition will help the surgeon better manage strabismus, improve patient outcomes, and make the great field of strabismus even more rewarding.

Los Angeles, CA, USA — Kenneth W. Wright, MD

Preface to the Second Edition

The second edition of the *Color Atlas of Ophthalmic Surgery—Strabismus* is an updated version of the original award-winning textbook published in 1991. The new atlas retains the same style of simplicity and clarity of the first edition. In addition, we have added a new section, "Management Strategies," which includes seven chapters on the practical management of strabismus syndromes. The idea is to provide the reader with a concise synopsis of what to do for a specific type of strabismus. Section 2 details strabismus surgical techniques and has been extensively revised and updated from the original edition. Chapter 22, "Reoperation Techniques," was added and describes the management of slipped/lost muscles and strabismus after retinal detachment surgery. As in the first edition, the section on surgical techniques combines line drawings and color photographs of actual surgery to offer both simplicity and realism required for teaching new techniques. I hope you will find this new edition useful in your strabismus practice.

I would like to add special thanks to Tina Kiss, our pediatric ophthalmology administrator, for her many long hours and weekends without which this project would not have come to fruition. I would also like to extend my sincere gratitude to Laura Bonsall for her encouragement to pursue this project and for her expertise and creativity in the layout and formatting of this book. In addition, I would like to acknowledge all of my fellows who have influenced the material in this book, especially Peter Spiegel, Dean Bonsall, and Gabriela Salvador for their thorough review of the manuscript. Finally, I would like to recognize Allergan, Bausch & Lomb Surgical, Ethicon, Discovery Fund for Eye Research, Cedars-Sinai Medical Center, and University of California, Irvine, for their unselfish support.

Los Angeles, CA, USA — Kenneth W. Wright, MD

Preface to the First Edition

The Strabismus volume of *Color Atlas of Ophthalmic Surgery* was written as a practical text to teach strabismus surgical technique. The best surgical training is obviously hands-on experience; however, a surgical reference is critical to prepare the novice student for the surgical experience and also for the veteran surgeon to review or expand his surgical repertoire. No drawing can capture the true appearance of the surgical scene, yet a photograph lacks the simplicity that is necessary for the teaching of a surgical procedure. Our strategy was to provide both line drawings and photographs of actual surgery to provide the most realistic presentation yet with the simplicity necessary for teaching new techniques.

Teaching surgical technique is the major goal of this atlas; however, background information such as muscle physiology and indications for surgery is provided when applicable. The atlas is intended to be a "how-to" book and to describe in detail the most effective specific surgical procedures rather than present a short overview of every surgical procedure. Throughout the atlas, surgical drawings and photographs present the surgeon's view, with the upper lid at the bottom and lower lid at the top. The drawings and photographs of surgical procedures show the left eye unless otherwise stated.

The author would like to thank the other contributors, Dr. Laurie Christensen, Dr. Michael Repka, Dr. Burton Kushner, Dr. Monte Del Monte, and Dr. Malcolm Mazow for their excellent work. Acknowledgment must also go to Dr. Marshall M. Parks and Dr. David L. Guyton, under whom I was fortunate enough to train. Much of the material in this volume has come either directly or indirectly from their brilliant and innovative work. I would also like to express my sincere gratitude to the fellows who have so greatly influenced and improved my own surgical techniques: Doctors Andrea Lanier, Laurie Christensen, John McVey, and Andrew Terry. I would like to extend special thanks to Dr. Byng-Moo Min and Dr. Chan Park, visiting research fellows from Korea, and Dr. Ann U. Stout for their expert review of the manuscript. Finally, I would like to acknowledge the contributions from Margaret Brown-Multani, Surgical Technician, Children's Hospital of Los Angeles; Paula Edelman, C.O., Children's Hospital of Los Angeles, for clinical support; and my sister Lisa Wright for her long hours of editing, revising, and re-revising the manuscript.

Too often, strabismus surgery is referred to as "easy" and is often delegated in training programs to first-year residents. Strabismus surgery is easy when performed properly; however, the untrained surgeon has the potential to do more harm than good. It is the author's sincere hope that this atlas will improve strabismus surgical techniques and ultimately benefit patients with strabismus.

Los Angeles, CA, USA — Kenneth W. Wright, MD

Acknowledgment

Thanks to the supporters of Wright Foundation for Pediatric Ophthalmology and Strabismus who help us with our mission:

To reduce blindness and suffering from eye disorders in infants and children and to improve the treatment of strabismus through research, education, and clinical care.

Contents

Part I

Management Strategies

Amblyopia Treatment

1

Amblyopia is poor vision caused by abnormal visual stimulation during early visual development. The abnormal visual stimulation disrupts neurodevelopment of visual centers in the brain. Abnormal stimulation can arise from a blurred retinal image, or strabismus with strong fixation preference for one eye and cortical suppression of the nondominant eye. Children under 8 years of age are capable of strong cortical suppression and hence can eliminate double vision. Children who alternate fixation and use either eye will alternate suppression and do not develop amblyopia. The **vertical prism induced tropia test** can be used to determine fixation preference and diagnose unilateral amblyopia in preverbal children with straight eyes or small-angle strabismus [1]. This test is performed by placing a vertically oriented 10 PD prism over one eye, either base down or base up. The vertical prism induces a hypertropia, allowing evaluation of fixation preference. Strong fixation preference for one eye is indicative of amblyopia [2]. Amblyopia can be bilateral in children with bilateral blurred retinal images (e.g., bilateral congenital cataracts, or bilateral high hypermetropia >+5.00 sphere).

Vision is the foremost priority in ophthalmology, so strabismic children with amblyopia should have the amblyopia treated prior to strabismus surgery. After strabismus surgery, the parents often assume that all is well, and will default follow-up appointments. Thus our best chance for treating amblyopia is before strabismus surgery. An exception to this rule is amblyopia associated with large-angle esotropia, with the amblyopic eye fixed in adduction (**strabismus fixus**) so the visual axis is occluded. Part of the amblyopia treatment is to operate on the amblyopic eye to bring it into primary position, to clear the visual axis and allow occlusion therapy.

Amblyopia therapy works best when initiated in children under 3 years of age, but even older children up to 8 or 9 years of age can show visual acuity improvement with diligent amblyopia therapy. Visual acuity improvement has been documented when children are treated in late childhood, after 8 years of age, especially in those children with no history of prior amblyopia treatment [3]. It is also important to monitor children after strabismus surgery for the development of amblyopia until the ages of 8–9 years. There are two basic strategies to treat amblyopia:

1. Provide a clear retinal image.
2. Correct ocular dominance.

1.1 Clear Retinal Image

The first goal of amblyopia therapy is to ensure the presence of a clear retinal image. A careful **cycloplegic refraction** is required for all children with amblyopia and strabismus. Topical cyclopentolate 1 % with tropicamide 1 % given twice can achieve adequate cycloplegia for most patients. Patients with densely pigmented irides may require multiple drops, or even atropine 1 % given twice a day for 3 days if retinoscopy shows variable readings.

Table 1.1 lists refractive errors that are potentially amblyogenic and need correction. Prescribing spectacles for patients with accommodative esotropia is covered in Chap. 4. Patients with straight eyes and anisometropic amblyopia usually have some degree of peripheral fusion. These patients often show significant improvement of visual acuity with optical correction alone, even

Table 1.1 When is a refractive error amblyogenic?

Type of amblyopia	Refractive error requiring correction[a]
Hypermetropic anisometropia	>+1.50 D of anisometropia
Myopic anisometropia	>–4.00 D of anisometropia
Astigmatic anisometropia	>+1.50 D anisometropia
Bilateral hypermetropia	>+5.00 D OU
Bilateral astigmatism	>+2.50 D OU

[a]These are only suggestions for prescribing spectacles in children, based on the cycloplegic refraction. Decisions on whether or not to treat a specific refractive error should be based on the whole clinical picture, including visual acuity when attainable

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4939-1480-7_1) contains supplementary material, which is available to authorized users.

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without occlusion therapy. As a rule, give the full hypermetropic correction to the amblyopic eye, because amblyopic eyes do not fully accommodate. If the good eye is mildly hyperopic (+0.75 to +1.50 sphere) it is advisable not to give the full plus to the good eye, as doing so will blur the vision and the child may not wear the spectacles (see Example 1.1). The key is that the spectacles must be worn full time—even in the bathtub or swimming pool!

Example 1.1
Anisometropic Amblyopia

3-year-old
VA:
OD 20/25
OS 20/100
Cycloplegic refraction:
OD + 1.00 sphere
OS + 3.50 sphere
Stereo acuity without correction: 400 s arc (1/3 animals Titmus test)
Alignment: Orthotropia for distance and near
Diagnosis: Anisometropic amblyopia OS with good binocular function
Treatment: Prescribe spectacles:
OD + 0.50 sphere
OS + 3.00 sphere
Note that the plus was slightly reduced to facilitate tolerance for spectacle use. Patient to return every 4 weeks to monitor visual acuity improvement. If improvement plateaus, then start part-time occlusion of the right eye 3–5 h a day.

Patients with bilateral high hypermetropia (>+5.00 sphere) will have bilateral amblyopia. These patients are so hypermetropic that they do not fully accommodate and they do not typically develop accommodative esotropia. They require full hypermetropic correction to provide a clear retinal image and treat the amblyopia (see Example 1.2).

Example 1.2
Bilateral Hypermetropic Amblyopia

5-year-old
VA: 20/200 OU
Cycloplegic refraction: +8.00 sphere OU
Alignment: Orthotropia for distance and near

Treatment: Prescribe spectacles with the full plus +8.00 sphere OU.
Note that patients with bilateral high hypermetropic amblyopia will not fully accommodate, so they need their full plus correction to provide a clear retinal image. These patients usually have straight eyes and do not typically have accommodative esotropia as they hypoaccommodate.

1.2 Correct Ocular Dominance

Patients with unilateral amblyopia will have strong dominance for the "good eye" and will suppress the amblyopic eye. Part of the strategy to treat amblyopia is to stimulate the amblyopic eye by forcing fixation to the amblyopic eye. There are two ways to switch fixation to the amblyopic eye: (1) occlude the dominant eye, and (2) blur the vision of the dominant eye (penalization).

1.2.1 Occlusion therapy

Occlusion therapy consists of patching the sound eye to force fixation to the amblyopic eye. For patients with binocular fusion and amblyopia (e.g., intermittent esotropia and anisometropic amblyopia), part-time occlusion therapy is preferred over full-time in order to maintain binocular fusion. If the child has a constant esotropia and no fusion (e.g., congenital esotropia), then full-time occlusion can be done. Follow-up visits for full-time occlusion therapy should be scheduled at intervals of 1 week per year of the child's age. For example, a 2-year-old should be checked every 2 weeks to examine the good eye for occlusion-induced amblyopia in addition to monitoring visual improvement of the amblyopic eye. In children less than 1 year of age, part-time occlusion for half of the waking hours is suggested, to avoid the complication of occlusion amblyopia of the good eye.

1.2.2 Penalization therapy

Penalization works by blurring the image of the sound eye to force fixation to the amblyopic eye. Blurring of the sound eye can be accomplished by adhesive tape on the spectacle lens, a blurring optical lens, or by atropine drops if the "good eye" is hypermetropic. Atropine penalization consists of instilling one drop of atropine 1 % in the sound eye each day and removing the optical correction of the sound eye while full optical correction is given to the amblyopic eye. If the cycloplegia of the good eye blurs the vision enough to switch fixation to the amblyopic eye, then atropine penalization will usually improve vision [4]. The vertical prism induced tropia test can be used to determine which eye is fixating. The "good eye" must be hypermetropic (at least +2.00 sphere) in order for atropine cycloplegia to blur the vision enough to force fixation to the amblyopic eye, at least for near targets (see Example 1.3). Atropine has been reported to have a beneficial effect for patients between the ages of 3 and 7 years and with acuity of 20/40 to 20/100 [5]. When atropine penalization works, it can provide strong antisuppression therapy, which may result in reverse amblyopia and loss of vision of the sound eye. To avoid reverse amblyopia, patients should be followed closely at intervals of 1 week per year of the patient's age, not to exceed 3 weeks. Stop penalization if visual acuity in the "good eye" decreases.

Fig. 1.1 Atropine penalization of left eye. Left eye is treated with atropine 1 % every day and removal of optical correction. Note that the left pupil is dilated and the spectacle lens has been removed

Example 1.3
Penalization (see Fig. 1.1)

5-year-old, patching failure
VA:
OD 20/200
OS 20/30
Cycloplegic refraction:
OD +5.50 sphere
OS +3.00 sphere
Stereo acuity without correction: 3,000 s arc (Positive fly Titmus test)
Alignment: Orthotropia for distance and near
Diagnosis: Dense amblyopia, patching failure
Treatment: Optical correction right eye; no correction left eye and atropine drops once a day:
OD + 5.50 sphere
OS plano + Atropine 1 % every day

Note: The goal is to blur the vision of the "good eye" (left eye) with atropine and no optical correction in order to switch fixation to the amblyopic eye (right eye), which has full optical correction. If atropine penalization induces a switch in fixation to the amblyopic eye, then vision will improve. If the patient continues to fixate with the atropinized good eye, then vision in the amblyopic eye will not improve. In these cases, patching plus atropine penalization may be effective. Note that for atropine penalization to work, the "good eye" must be significantly hypermetropic (>+2.00 sphere).

1.3 End Point for Amblyopia Treatment

Amblyopia treatment is usually continued until vision in the amblyopic eye improves to within 1 or 2 Snellen lines of the sound eye. After improvement is achieved, maintenance therapy consisting of part-time occlusion of the sound eye for 1–2 h a day may be necessary until the patient is 7–8 years old. Patients with anisometropic amblyopia and binocular fusion tend to maintain their vision after being treated, even without maintenance occlusion therapy, as long as optical correction is continued.

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Principles of Strabismus Surgery

2

2.1 Planning for Success

Prior to strabismus surgery, an important and seemingly obvious question should be asked: "Why are we operating?" Is our treatment goal to establish binocular fusion, eliminate diplopia, expand the field of binocular vision, correct a compensatory head posture, or simply to improve cosmetic appearance? Establishing the goals prior to surgery helps us clarify indications for surgery, and formulate a logical treatment plan. The plan that is made should be the one that is best for the patient—not just the plan that is best for correcting the angle of deviation.

The indications for surgery should be based on the patient's needs: either binocular function or cosmetic appearance (Table 2.1). Urgent surgery is indicated to reestablish binocular fusion in a child with an esophoria that has recently broken down to a tropia. The family should be told that surgery is indicated to regain binocular fusion and not just to improve the cosmetic appearance. In contrast, surgery for a long-standing sensory esotropia secondary to a blind eye is cosmetic, as there is virtually no potential for binocular fusion. In this case, the indication for surgery should be based on the cosmetic desires of the patient. In some cases, it may be difficult (or even impossible) to determine the binocular potential. For example, an older child with equal vision and a history of esotropia since infancy may or may not have binocular fusion potential. I tend to give these patients the benefit of the doubt and treat them as if they have fusion potential.

Table 2.1 Indications for strabismus surgery

Binocular function
Establish binocular fusion
1. Early surgery infantile esotropia
2. Partially accommodative esotropia
3. Decompensated intermittent exotropia
Binocular diplopia
1. Acquired incomitant strabismus (restriction or paresis)
2. Acquired comitant strabismus
3. Postoperative anomalous retinal correspondence—paradoxical diplopia
Binocular field
1. Expand binocular visual field
2. Correct face turn or head tilt (associated with nystagmus or incomitant strabismus)
Cosmetic appearance
1. Sensory strabismus (associated with unilateral poor vision or dense amblyopia)
2. Long-standing infantile strabismus (late surgery for congenital esotropia)
3. Lid fissure changes (Duane's syndrome III co-contraction)

Understanding the functional goal also helps direct the surgical plan. Esotropic patients with fusion potential generally require large amounts of surgery, more than the standard surgical numbers (see Chap. 4). A plan based on standard surgery in these patients routinely results in undercorrection. Esotropic patients without binocular fusion potential are ill served by planning for "more" surgery, however, as a consecutive exotropia will inevitably increase over time, and an exotropia is a poor cosmetic outcome. In these patients without fusion potential, it is better to do less surgery, as a small residual esotropia is more stable and has a better appearance than a consecutive exotropia. Consideration of the functional outcome also influences the selection of the type of surgery. Monocular recession-resection surgery produces incomitance, which is not optimal in a fusing patient, as incomitance can cause diplopia in eccentric positions of gaze. Monocular surgery on the blind eye, however, is the procedure of choice for sensory strabismus, to protect the only seeing good eye. These are but a few examples that demonstrate the importance of considering the potential for binocular fusion when planning strabismus surgery. Table 2.2 lists some important signs that indicate the potential for binocular fusion.

Prior to surgery, it is helpful to establish a specific strabismus diagnosis. Most cases of strabismus can be classified into a type, such as partially accommodative esotropia, intermittent exotropia, Duane's syndrome–esotropia type 1, congenital superior oblique palsy, or Brown's syndrome. At times, it may be difficult to determine the exact etiology of

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