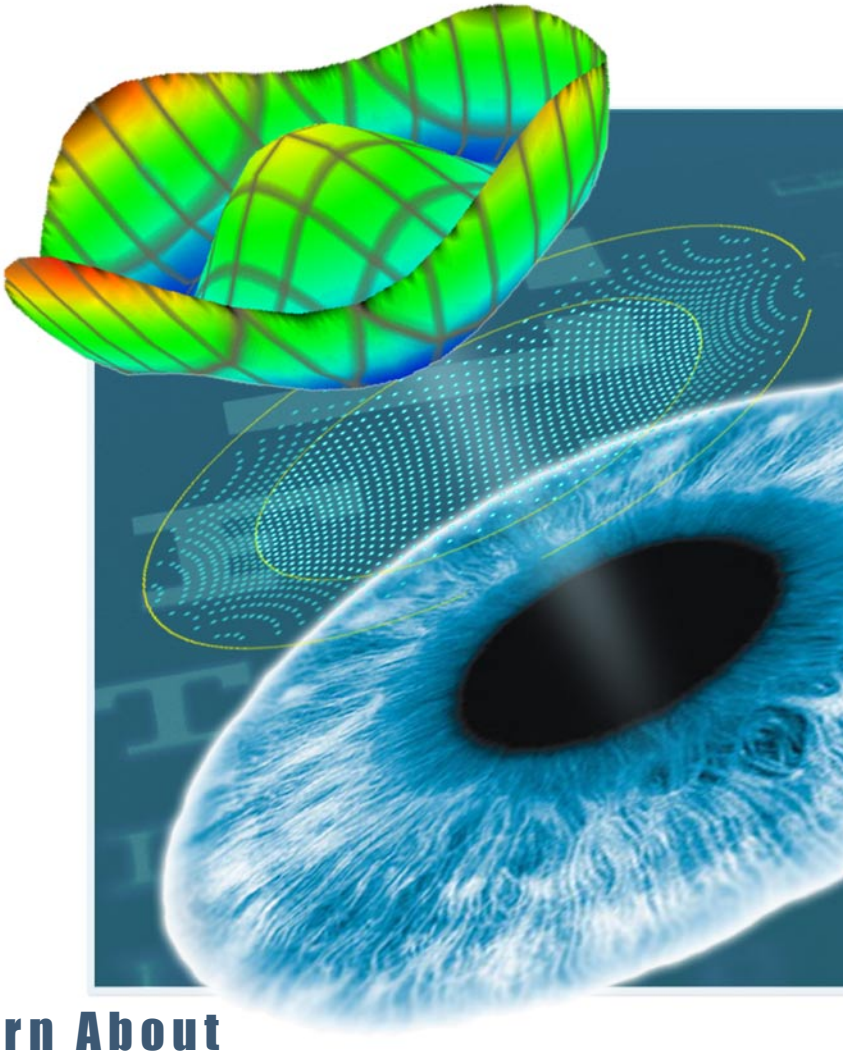
LASIK Vision Correction

Laser In-Situ Keratomileusis



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LASIK
Vision Correction

LASIK
Laser In-Situ Keratomileusis
Laser Eye Surgery

An Overview of Refractive Errors
and Their Treatment
using the Excimer Laser for Laser Eye Surgery

A Guide for Patients

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LASIK Vision Correction was compiled and edited by several of the most outstanding LASIK surgeons in the world.

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Chapter One:
Refractive Surgery: What Is It?

The world of *ophthalmology* (medical, surgical and optical care of the eyes) is one of the fastest evolving fields of medicine. Never before have so many new surgical and diagnostic techniques and scientific breakthroughs been brought before the public in such a short period of time. A host of new procedures, including LASIK, and Custom Wavefront LASIK as well as implantable corneal rings and lens replacement surgery with Crystalens™ and ReSTORE® now offers millions of people the opportunity to see without the use of glasses or contact lenses.

The media is filled with amazing stories about laser eye surgery and how it painlessly corrects vision. What is LASIK this marvelous new laser eye procedure? Is this ultramodern laser eye surgery really safe? How do I know if I'm a good LASIK candidate? Who should perform my LASIK eye surgery? This book is designed to help you answer all of these questions.

Refractive Surgery

Refraction: This word as it relates to vision has to do with the ability of your eye to *refract* (bend) rays of light. In order to see clearly, light that enters the eye must be bent in such a way that it is focused on the *retina* (the nerve lying on the back surface of the eye). If the light is not bent properly and is focused instead in front of or behind the retina, then we will not see clearly, and what we have is a *refractive error*. *Refractive surgery* is any surgical technique or procedure that may safely be used to help the eye bend the light rays properly, focus them on the retina, and restore clear vision.

Refractive Surgical Procedures

The most common refractive surgical procedures performed today are:

- LASIK (Laser In-Situ Keratomileusis)
- Custom Wavefront LASIK
- PRK (Photorefractive Keratectomy)
- Custom PRK
- Corneal Ring Segments (Intacs™)
- AK (Astigmatic Keratotomy)
- CK (Conductive Keratoplasty)
- CLE (Clear Lens Extraction)
- Lens Replacement Surgery with Crystalens™ Accommodating Intraocular Lens
- Lens Replacement Surgery with ReSTORE® Pseudoaccommodative Intraocular Lens
- Lens Replacement Surgery with ReZOOM Pseudoaccommodative Intraocular Lens
- Versyse Implantable for Extreme Myopia Phakic Intraocular Lens Implants (PIOL)
- Bioptics

New refractive procedures currently under development or refinement include Surgery for Presbyopia:

- Anterior Ciliary Sclerotomy (ACS)
- Scleral Expansion Bands (SEB)

These procedures may be combined to suit your particular needs. For example, if you have extremely high myopia, you might receive a phakic intraocular lens followed later by a refinement with LASIK--a combination commonly called *Bioptics*.

The names of these procedures may be hard to pronounce, but the results in correcting poor vision due to refractive errors have been excellent. The high rates of success reported with these procedures--and LASIK in particular--have led to their widespread acceptance within the ophthalmologic community throughout the world. Which procedure is right for you depends on multiple variables, all of which will be presented in this book.

The increasing number of refractive procedures developing throughout the world is testimony of the enormous number of people

seeking relief from glasses and contact lenses. In some parts of the world, the incidence of nearsightedness is more than fifty percent. In the United States alone, as many as seventy million people are believed to be afflicted with myopia. Estimates by the National Institutes of Health report that in the United States as many as one adult in four suffers from myopia.

While there are many types of refractive surgery, this book focuses primarily on LASIK, which is performed with the excimer laser. This procedure has proved to be highly effective and safe for most ranges of nearsightedness, farsightedness, and astigmatism and is readily accepted by ophthalmologists today.

Chapter Two:
How the Eye Works

In order for you to fully understand how refractive surgery works, you need to understand how your eye works. This basic knowledge will help you determine if LASIK is right for you. The primary purpose of your eye is to focus light. When the rays of light are not focused properly, you need glasses or contact lenses.

Your eye works very much like a camera. Light enters the eye through the *cornea*, the clear front surface or "window" of the eye. As the light passes through the cornea, it is bent or refracted. This bent light then travels through the *pupil* (the opening in the colored iris) and into the natural "crystalline" *lens*. The lens acts to fine tune the focus of light onto the *retina*. The retina turns the light energy into electrical impulses that travel along the *optic* (eye) *nerve* from the eye to the brain, where the image is interpreted. (You actually see with your brain, not with your eyes.)

On the following pages is a series of pictures and short descriptions of the various parts of the eye that will help you understand the vision process, why vision is sometimes blurry, and how these vision disorders can be corrected.

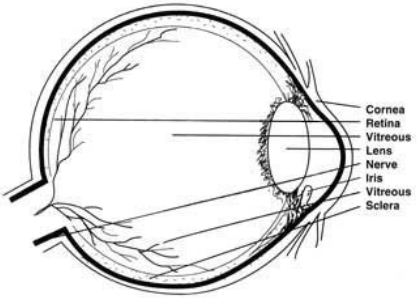
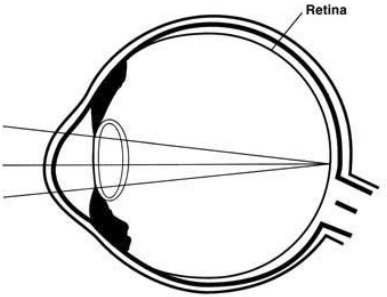


Diagram of the anatomy of the eye



Normal eyesight is present when light rays are in focus on the retina, causing a clear image to form

Sclera

The *sclera* is the outer support layer of the eye. It is the white part of the eye that you see in the mirror and provides structure and protection for the eye.

Cornea

The cornea is the front-most surface of the eye, like the crystal of a watch. It provides most of the eye's focusing power. Most of the refracting (bending) of light is achieved by the cornea, so small changes in the surface of the cornea can have a large effect on how your eye focuses light.

There are three main parts of the cornea: The *epithelium* is the thin outer protective layer that undergoes continuous regeneration. The *stroma* comprises the bulk of the corneal tissue and is inert. The *endothelium* is a single cell layer comprising the innermost cornea and serves to maintain corneal clarity by regulating corneal fluid content. The cornea is approximately the diameter of a dime and the thickness of a credit card.

Iris

The *iris* is the colored part of the eye. The muscles of the iris act to control the size of the pupil.

Pupil

The pupil is the opening that appears as a black spot in the center of the iris. The pupil acts to regulate the amount of light that enters the eye. In bright sunlight it becomes small to let in less light. In a dark environment the pupil expands to allow more light to reach the retina.

Lens

The crystalline lens is a normally clear structure located behind the pupil. It acts to fine tune the focusing. By changing shape, the lens allows us to focus near and far. This ability to focus near (accommodation) gradually worsens with age as the lens gets harder and less supple. Most people notice this in their early forties, at which time they begin to need reading glasses or bifocals. In people over sixty, the lens may become cloudy. This clouding of the lens is called a cataract and may interfere with your vision.

Vitreous

This is the clear gel substance that fills the space between the lens and the retina. If there are opacities in the vitreous, you may see them as “floaters.”

Retina

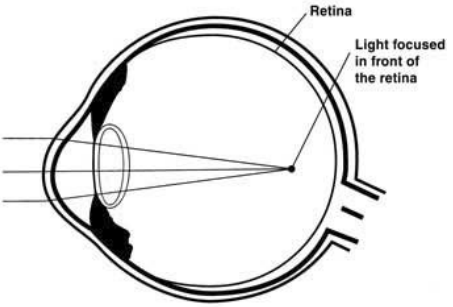
The retina is the thin layer of nerve tissue that lines the inside wall of the eye. It is very similar to film in a camera and functions to capture and transmit images for interpretation to the brain.

Optic Nerve

The optic nerve carries the images from the retina to the brain.

Refractive Errors

Refractive errors (vision-focusing problems) refer to disorders that are related to how your eye focuses light. The word refraction is used to describe the way light is bent by your eye. The factors that influence how your eye refracts (bends) rays of light are the curvature of your cornea, the power of your lens, and the length of your eye.



In myopia (nearsightedness), rays of light focus in front of the retina instead of upon it, causing distant objects to appear blurred

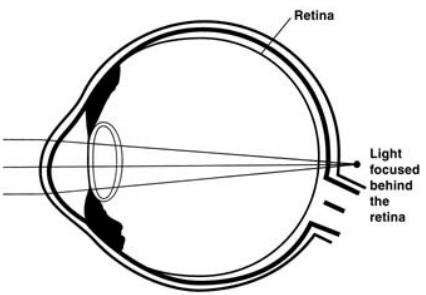
Myopia (nearsightedness)

Myopia occurs when the eye is functionally too long for the focusing power of the cornea and lens. In some eyes, the cornea is too steep. As the light rays pass through the cornea, they come to a point of focus in front of the retina. This creates a blurred image. Patients with myopia are able to see near objects well but have difficulty with their distance vision.

Hyperopia (farsightedness)

Hyperopia occurs when the eye is functionally too short or (rarely) the curvature of the cornea is effectively too flat. The light rays that enter the eye are not bent sharply enough, causing them to come to a point of focus behind the retina. This produces a blurred image. Farsightedness means distant objects are seen more clearly than near objects. Although farsighted patients see distant objects more clearly than near objects, they often have difficulty with both, especially after age thirty.

In hyperopia (farsightedness), rays of light focus behind the retina



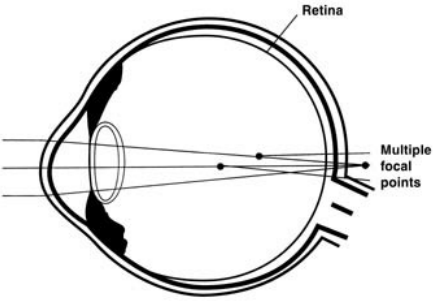
Some younger people who are mildly farsighted are able to use the focusing muscle around their lens (accommodation) to bend the light more steeply. This brings the point of focus forward toward the retina and allows them to see more clearly. However, this ability decreases with age, so that reading glasses are needed at an earlier age than normal, and glasses or contact lenses may also be needed to see at different distances.

Farsightedness is often confused with presbyopia. *Presbyopia* is the age-dependent need for reading glasses. Even people who have never worn glasses before find that they start needing reading glasses in their forties and fifties. This is because the up-close focusing ability of the natural lens is progressively lost with age. This occurs with everybody. At first they just need them for seeing things up close (presbyopia). Farsighted people in whom the length of the eye is too short require the natural lens to supply the additional focus for both near and distance vision. Therefore, many farsighted individuals as they age lose not only their near vision but their far vision as well, becoming totally dependent on their glasses or contact lenses. This phenomenon is called *latent hyperopia*.

Astigmatism

Many patients with myopia or hyperopia have some degree of *astigmatism*. This means that your cornea, rather than being completely spherical like a basketball, is slightly oval and shaped more like half a football. People with astigmatism experience blurred vision and sometimes distortion of images due to unequal bending of the rays of light entering their eyes. Astigmatism causes blurred vision for both distant and near objects.

Almost everyone has at least a small amount of astigmatism. For many people, their astigmatism has very little effect on their vision. Unfortunately, the word “astigmatism” is one of those magic words in the English language that almost everyone remembers and is frequently concerned about. The good news is that almost everyone with significant astigmatism can dramatically improve his or her vision using refractive surgery to reduce the amount of astigmatism.



In astigmatism, light entering the eye focuses in multiple areas rather than in one location

Presbyopia

Presbyopia (literally, “old eyes”) is a normal aging process. It occurs as the protein composition of the lens changes, making it harder and less flexible. As the lens loses its ability to flex, it can no longer bend light rays as sharply, and the ability to focus on near objects is impaired. The onset of presbyopia typically occurs between age forty and fifty and continues to worsen through age sixty-five. When this occurs, people who already wear glasses may need bifocals, and those who have never worn glasses may require reading glasses.

Presbyopia is an important concept to understand. The excimer laser has no effect on your eye’s focusing muscles or on the lens, so it cannot treat pure presbyopia. Thus, if you only need glasses for reading, refractive surgery is not likely to help you unless you choose to have surgical correction for monovision (adjusting one eye for reading, mentioned on the following page). Additionally, if you are mildly nearsighted and in your forties, you may notice that while you cannot read clearly with your glasses or contact lenses on, you can read well without them. One advantage of mild myopia is the ability to remove your glasses after presbyopia sets in and still be able to read.

If you are myopic, over forty, and obtain excellent distance vision after undergoing laser vision correction, you will typically become normal sighted. This means that you will lose the ability to read without glasses once presbyopia begins. Like other normal sighted individuals, you will begin to require reading glasses for small print, generally sometime in your forties.

One way to counteract the loss of near vision if you are nearsighted is to keep one eye slightly myopic after LASIK. If you are farsighted, your

surgeon could overcorrect one eye and make it slightly nearsighted. Your brain will automatically use this eye for reading and the fully corrected eye for distance. This is called *monovision* or blended vision. (Remember, you see with your brain, not with your eyes.) You may want to discuss this possibility with your doctor. LASIK Eye Surgery designed for monovision should be reserved for those individuals who are already accustomed to and comfortable with monovision utilizing contact lenses.

Monovision is good for people with relaxed personalities and those who do a lot of simultaneous near-distance activity, like schoolteachers, salespeople, and busy parents. It usually does not work for people with rigorous vision needs such as professional tennis players, accountants, or architects.

Measurement of Refractive Errors

You may hear your vision referred to as 20/20 or 20/40 or even 20/400. This is a measurement of your *visual acuity* using a Snellen chart (vision chart with progressively smaller letters). The notation 20/40 means you can see at twenty feet what a normal sighted person sees at forty feet. These numbers measure your vision but do not quantify your refractive error. There are other variables that affect an interpretation of the chart, such as squinting, guessing at the letters, and room light.

Quantifying your refractive error is done in diopters. This is the number used to determine your refractive treatment. The more nearsighted or farsighted you are, the higher your prescription is in diopters.

Your prescription for glasses may be written in three numbers. Let's take the prescription -4.00 -1.50 X 90

The first number (-4.00) identifies your degree of nearsightedness or farsightedness. The sign is an indication of whether you are nearsighted (-) or farsighted (+).

The second number (-1.50) represents your degree of astigmatism. This can be written as either + or -.

The third number (90) represents where the astigmatism lies. In this person the astigmatism is at ninety degrees or vertical. When your ophthalmologist corrects your refractive disorder, he uses this prescription to determine the treatment.

Your prescription (measured in diopters) forms the basis for the number entered into the computer that controls the excimer laser. This number determines how much and in what pattern the laser removes tissue from the cornea. The amount of tissue removed depends upon the refractive error and is usually no more than ten to twenty percent of the total thickness of the cornea.

Nonsurgical Vision Correction Options

Before considering LASIK Eye Surgery, you should review the variety of different nonsurgical ways refractive disorders can be corrected. All have benefits and drawbacks.

Glasses

Glasses are time proven and have been in existence for a thousand years. They are affordable (unless you buy multiple pairs of designer frames), easy to maintain, and versatile. They may, however, restrict peripheral vision, be difficult to wear in certain weather conditions, cause minification of images, cause a number of visual aberrations (including halos around lights), and have a limited usage life. They may interfere with certain occupations and recreational activities, and some people don't like the impact glasses have on their appearance.

Contact Lenses

Contact lenses are another common solution for the correction of refractive visual problems. Advantages include more natural vision, no change in cosmetic appearance, improved visibility, more freedom in recreational activities, and better peripheral vision. On the other hand, contacts are high maintenance, may get lost, are less comfortable for patients with dry eyes, may cause visual aberrations (including halos and fluctuating vision), and always carry an increased risk of infection and possible corneal scarring. In higher altitudes many adults become intolerant of contact lenses over time because of dry climate and decreased oxygen in the air.

There are so many types of contact lenses available today-soft, rigid, gas permeable, toric for astigmatism, disposable, etc.-that the vast majority of people can be fit comfortably, regardless of their level of nearsightedness, farsightedness, or astigmatism. For people who are presbyopic and over thirty-five, contact lenses can be fit asymmetrically to obtain monovision for reading. Ophthalmologists and optometrists recommend not sleeping with any contact lens in because this increases the chance of corneal infection.

Orthokeratology

This is a technique that uses a series of rigid contact lenses to flatten your cornea to treat myopia. The effects are not permanent and require continued dependence on part-time retainer lenses. The technique is expensive, high maintenance, and requires continuous follow-up visits. The long-term effects may also lead to permanently warped corneas. The risk of keratitis or infection is also considerably increased over normal contact lens wear.

Chapter Three:
History of Refractive Surgery

Forerunners to Modern Refractive Surgery

The study of visual problems and refractive errors began in the early sixteenth century when Leonardo da Vinci contemplated the possible source of visual disturbances. A little later, in 1619, Scheiner measured the shape of the anterior surface of the cornea. His discoveries are still used by ophthalmologists today who recognize that refractive surgery often depends on changing the cornea's anterior contour. Even lens removal as a means of correcting high degrees of myopia was discussed by Boerhaave in 1746. But real progress in the field of vision correction was constrained until a better understanding of how the eye functions was acquired.

Johannes E. Purkinje observed in 1823 that images form on optical surfaces when they reflect external light. His observations led to the development of the Purkinje principles and the four Purkinje images. From these developments our modern-day understanding of *keratometry* (measuring the curvature of the cornea) and theories of lens accommodation began to grow.

Several decades later, the advent of *topical* (eye drop) *anesthesia* led to less painful cataract surgery after the Civil War. In 1867, with the development of the *keratometer* (an instrument for measuring the curvature of the cornea), surgeons could measure astigmatism following cataract surgery.

In 1869 Snellen (after whom the vision charts of today are named) proposed using incisions across the steep meridian of the cornea to flatten it and treat astigmatism. However, two decades would pass

before Bates in New York would successfully flatten the corneal contour with incisions.

Trials and Experimentation

Not long after a successful cataract surgery technique was developed by van Graefe in the 1850s, ophthalmologists everywhere began to recognize the impact of corneal shape on astigmatism. In 1895 Faber performed a full thickness corneal incision to decrease naturally occurring astigmatism in a nineteen-year-old patient, thus enabling him to pass his vision test for entrance into the Royal Military Academy. But all of these efforts were focused on astigmatism; no one looked beyond astigmatism to myopia or hyperopia. It soon became apparent that a better understanding of the principles of *keratotomy* (the making of incisions in the cornea) was needed before any further progress could be made.

It was about this time that a Dutch physician, Leendert Jan Lans (working at the time on his doctoral degree), began to systematically study and define the principles of keratotomy and corneal heating. So fundamental and comprehensive was his research that it soon became the standard of refractive surgery. He practiced and promoted the principles of corneal flattening that could be achieved by incisions made on the anterior surface of the cornea. By varying the number, direction, and shape of the incisions, Lans could manipulate the effects and tailor the visual correction. His work formed the historical basis of modern refractive keratotomy and thermal keratoplasty.

In addition to surgical techniques, there were nonsurgical attempts at reducing myopia by manipulating the shape of the eye. One novel remedy was an eye cup with a spring-powered mallet designed to pound the cornea flat through a closed eyelid; another was a firm rubber band used to flatten it. But these techniques failed to produce any significant degree of visual correction.

With the exception of the work performed by Lans, Bates, and some Italian collegues, 1885 to 1939 was principally a time of trial and error for refractive surgery. Nevertheless, the successes and failures of this period helped determine which refractive procedures worked and which did not.

Modern Refractive Surgery

In 1939 in Tokyo, Japan, Tsutomu Sato observed a flattening of the cornea in patients who had a peculiar corneal disease. The corneas of these patients were irregular and abnormally steep (*keratoconus*) but

flattened after episodes of spontaneous corneal swelling. His work led to numerous animal and human studies of radial keratotomy, built upon the principles outlined by Lans nearly half a century earlier and applied to the treatment of keratoconus corneas. Sato and his colleagues brought anterior and posterior keratotomy to clinical practice in hundreds of patients and reported his results in the 1940s and 1950s.

Sato also applied his posterior keratotomy technique to the correction of astigmatism; this technique of posterior corneal incision caused disruption of the *corneal endothelium*, the internal cells of the cornea. Unfortunately, the role of the corneal endothelium in maintaining corneal clarity was not fully understood in Sato's time, and the subsequent development of corneal swelling in many of his patients who received this treatment went undetected until after his death. Nevertheless, Sato's work was the basis for the development of modern radial keratotomy.

In 1948 Harold Ridley, a physician to British Royal Air Force pilots in World War II, noted that pilots whose eyes harbored slivers of Perspex (cockpit "glass") seemed to have little or no reaction to this foreign material. This led him to suppose that a small lens made out of the same material could probably be tolerated inside the human eye. Soon he began experimenting with plastic lens designs, and the modern era of intraocular lens implantation for cataract surgery was born.

About the same time that Ridley envisioned the plastic intraocular implant, José Barraquer in Bogota, Columbia, developed the idea of *lamellar* (layered) corneal surgery to alter the shape of the cornea. He discovered that lamellar keratoplasty could flatten the cone of a keratoconus patient, significantly reducing myopia.

In 1949 Barraquer described the principles of lamellar surgery. He changed the cornea's shape by removing a disc of the anterior portion of the cornea (the equivalent of today's corneal flap) with an instrument called a *microkeratome*, freezing the disc, and grinding it into a new shape with a mechanical lathe called the *cryolathe*. In the mid-1980s the cryolathe rose to its highest state of precision through automation. In 1985 in New York, Casimir Swinger developed a method of changing the shape of the cornea without freezing it (nonfreeze keratomileusis). He did this using the microkeratome only. Then in 1987 Luis Ruiz, a protégé of Barraquer, modified the principles of microkeratome corneal resection by using an automated form of the instrument to perform the operation directly on the eye. This procedure, called *automated lamellar keratoplasty* (ALK), was used to correct high levels of

myopia and hyperopia.

Halfway around the globe, a handful of Russian ophthalmologists began research to determine whether or not RK (*radial keratotomy*, or straight-line incisions placed in a spoke-like pattern around the periphery of the cornea) could be effective if it was confined to the anterior side of the cornea. This would thereby avoid the long-term problems that arose from the disruption of the corneal endothelium in Sato's posterior keratotomies.

By the mid-1970s, Russian scientists such as Durnyev, Yenaleyev, and Fyodorov had determined that most of the radial keratotomy flattening effect could be obtained with sixteen or fewer incisions placed only on the anterior cornea. Fyodorov developed a system of anterior radial keratotomy that, by varying the number of incisions and the amount of uncut clear central zones between them, permitted him to control the amount of visual correction. It was he who popularized radial keratotomy (RK) for the reduction or elimination of myopia.

Leo Bores introduced radial keratotomy into the United States in 1978. It soon became a subject of great interest and careful scientific scrutiny. In 1980 the National Institutes of Health sponsored the PERK (Prospective Evaluation of Radial Keratotomy) study. The principal investigation of this study (based at Emory University in Atlanta, Georgia) involved nine different eye centers around the country, lasted fifteen years, and cost over $20 million. It produced the first factual, scientific data on radial keratotomy and set refractive surgery in general on a solid clinical base. At the same time many researchers, such as Richard Lindstrom in Minneapolis, refined the hundred-year-old technique of *transverse keratotomy* for astigmatism--a single, effective treatment still in use today.

The Arrival of the Excimer Laser

The first step in the evolution of laser eye surgery occurred when experts researched the application of laser technology to vision correction. In 1980 Beckman and Peyman and their associates used a carbon dioxide laser to create thermal shrinkage of the cornea in order to change corneal contour. A year later John Taboada reported at a meeting of the Aerospace Medical Association that the argon-fluoride excimer laser had the ability to indent surface epithelial corneal tissue.

It was Steve Trokel, an acknowledged expert in laser eye treatments, and Srinivasan, a Ph.D. researcher who discovered the principle by which an excimer laser removes substances and tissues (photoablative

decomposition), who combined their knowledge and proposed applying the excimer laser to reshaping corneal tissue. First, they tried the laser for radial keratotomy (unsuccessful). Later, in conjunction with John Marshall in London, they devised the idea of sculpting the cornea into a new shape by ablating tissue in a controlled pattern.

The first use of the excimer laser on blind human eyes took place in 1985 by Theo Seiler in Germany. This was followed in 1987 by L'Esperance of the United States. The procedure was called *photorefractive keratectomy* (PRK) and involved the ablation of the surface of the cornea to flatten its central portion in order to correct nearsightedness.

Numerous American ophthalmic surgeons, such as Margaurite McDonald and Sard Herbert Kaufman of New Orleans, began to investigate and refine PRK in conjunction with European colleagues, leading to the first U.S. Food and Drug Administration (FDA) approval of the Summit brand excimer laser in 1995.

PRK became popular around the world but had two nagging problems: (1) Patients' eyes were sore for forty-eight hours and had blurry vision for almost a week after surgery because PRK left the corneal surface raw and exposed. (2) The process required to heal this raw area produced corneal haze, and in rare cases scars blurred the vision and altered the accuracy of the treatment.

Surgeons subsequently conceived of ways to avoid these problems by returning to time-honored keratomileusis (layered carving), which left the corneal surface smooth immediately after surgery. In the late 1980s, Luccio Burroto in Italy used the excimer laser instead of the cryolathe to reshape the back of the remniel corneal disc. Ionnos Pallikaris used the laser to reshape the corneal bed, modifying the inaccurate ALK technique and giving rise to the modern, accurate, LASIK procedure. The LASIK acronym refers to "LASer" (meaning excimer laser), "In situ" (meaning in place in the corneal bed under the flap), and "Keratomileusis" (meaning to carve the cornea).

The LASIK procedure avoids the anterior stromal haze and pain generally associated with surface ablation by the excimer laser (PRK). This result is achieved because the laser is applied only within the corneal tissue rather than removing a large area of *epithelium* (the thin, sensitive, outer surface layer of the eye). When the epithelium is removed during PRK, the nerve endings are exposed. These exposed nerve endings cause pain during recovery. Additionally, there are more

fibroblasts underneath the epithelium, and these contribute to scarring. The epithelium also forms the smooth optical surface of the cornea required for sharp vision, so when it is removed, vision becomes blurry until the epithelium heals.

Lastly, the epithelium is the eye's mechanical barrier to bacteria. Removing it increases the risk of *keratitis* (infection). With LASIK, the epithelium remains almost entirely intact. As a result, the nerve endings stay covered, there is minimal pain during recovery, and sharper vision returns in twenty-four to forty-eight hours. With the *epithelium* intact and healed within twelve hours after the procedure, there is a lower risk of infection and scarring.

The initial clinical trials of LASIK in the United States began in 1996 by Stephen Slade and Stephen Brint. A broad series of clinical investigations culminated in the approval by the FDA of the LASIK eye surgery procedure in 1999.

With LASIK eye surgery, the realm of refractive surgery has given wings to the space-age dream of a relatively quick, virtually pain free, highly accurate, refractive correction procedure, one that is now taking off. But, as with most of medical science, research continues and results improve, refining laser vision correction. Microtreatments are becoming more refined. Excimer lasers are becoming more sophisticated, refractive surgeons are becoming more skilled, and methods of measuring vision and the eyes are expanding.

A goal of laser eye surgery is to allow you to be less dependent on glasses or contact lenses or eliminate them completely. Most individuals can see 20/20 with optical correction; this is average "best corrected" vision. But the normal eye is capable of seeing better than 20/20: 20/16, 20/12, 20/10, and rarely, 20/05.

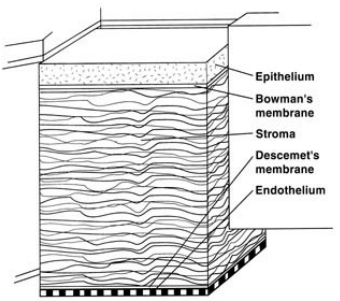
The goal of LASIK surgeons around the world is to refine refractive surgery techniques in general, and laser eye surgery in particular, to allow patients to experience significantly improved quality, as well as quantity of vision by correcting not only the lower order aberrations, causing nearsightedness, farsightedness and astigmatism but also higher order aberrations that cause dissatisfaction with glasses and contact lenses. This will be accomplished, in part, by using newly developed clinical instrumentation that will allow us to measure these aberrations and then by designing a custom laser eye surgery treatment for each individual eye. This will be further discussed in Chapter Eleven.

Chapter Four:
Laser Eye surgery with the Excimer Laser

LASIK eye surgery is the most technologically advanced method available today for reducing dependence on glasses and contact lenses. The procedure is performed on an outpatient basis and is effective for treating nearsightedness, farsightedness, and astigmatism. The results are rapid and permanent. Over 4 million procedures have been performed throughout the world, and the number is growing daily.

How Does the Laser Work?

Many patients ask, “How can a laser correct my vision?” The laser removes tissue from the center of the cornea (in the case of myopia) to flatten its curvature and correct nearsightedness. In the case of farsightedness, tissue is removed from the periphery of the cornea to steepen its curvature. The laser essentially reshapes the cornea’s front surface. To do this, the *corneal stroma* (tissue beneath the corneal epithelium) must be exposed. This can be accomplished by directly removing the corneal epithelium with a laser (PRK) or by creating a corneal flap with a microkeratome (LASIK).



The Human Cornea. With PRK, treatment is performed on the surface after the epithelium has been removed. With LASIK, the treatment is performed in the stroma, and the anterior architecture is preserved.

Many types of lasers are used in laser eye surgery. Argon lasers heat tissue and have been used for years to treat disorders such as diabetic retinopathy and glaucoma. YAG lasers break tissue bonds by creating a shock wave and are used following cataract surgery and to treat certain types of glaucoma. The excimer laser is a gentle, cold-beam laser uniquely suited to the task of refractive corneal surgery.

The goal is to reshape the cornea so that rays of light that enter the eye are focused clearly onto the retina. The excimer laser produces a cool, ultraviolet beam of light (193 nanometers in length) that literally vaporizes tissue as it breaks carbon-to-carbon bonds without harming adjacent tissue. Tissue is removed in a precise fashion on a microscopic level, leaving adjacent tissue unharmed. This vaporizing process is called *photoablation*.

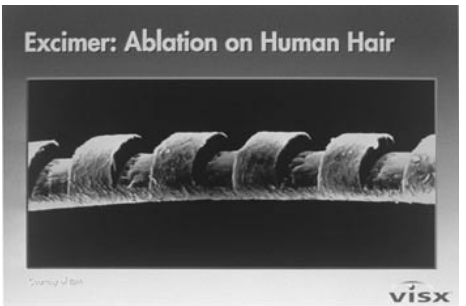


Photo of human hair ablated

The unparalleled precision of the excimer laser makes it uniquely suited to the task of refractive corneal surgery. Each pulse of the laser removes 0.25 microns of tissue. Think of it as slicing 1/200 of a human hair, 1/28 of a red blood cell, or 1/39 millionth of an inch in 4 billionths of a second. This allows the surgeon to literally sculpt the cornea, gently and precisely, into a more desirable shape that allows rays of light to focus properly on the retina.

Myopic Correction

As explained in the previous chapter, patients with nearsightedness have corneas that are too steep for the length of their eyes. The excimer laser is used to flatten the cornea so that the light rays that pass through it come to a point of focus *on* the retina, rather than in front of it.

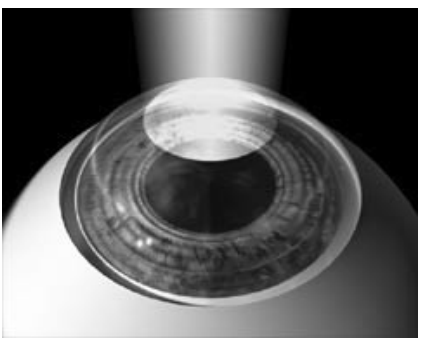


Diagram of myopic correction

Hyperopic Correction

As explained in Chapter Two, patients with hyperopia have corneas that are too flat for the length of their eye. The excimer laser is used to steepen the cornea so that light rays are focused *on* the retina, rather than behind it.

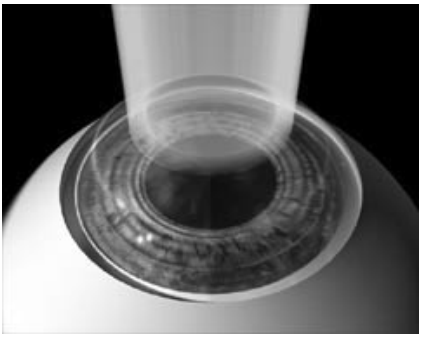


Diagram of hyperopic correction

Photorefractive Keratectomy (PRK)

This is a procedure in which the front surface of the cornea is directly sculpted by the excimer laser. The surgeon prepares the eye by gently removing the surface layer known as the corneal epithelium. This layer regenerates itself within a few days. Computer-controlled pulses are directed at the exposed surface (corneal stroma) to reshape the cornea. Less than ten percent of the cornea is affected, with the deeper layers remaining untouched. The entire procedure takes approximately ten minutes per eye and is virtually pain free.

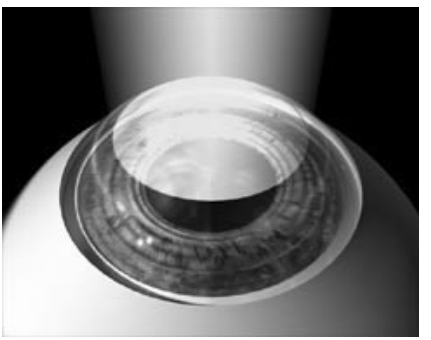


Diagram of Photorefractive Keratectomy

Laser In-Situ Keratomileusis (LASIK)

The LASIK process also uses the excimer laser to reshape the cornea, but is done under a thin, protective, corneal flap. Refractive vision correction performed in the interior of the cornea (LASIK) offers numerous advantages over refractive vision correction performed on

the cornea's surface (PRK). Rather than vaporizing the epithelial cells to expose the corneal stroma, a specialized instrument known as a microkeratome creates a flap of corneal tissue that is attached by a "hinge." This flap is gently pulled back like a tiny, clear, hinged lid and the corneal stroma is exposed. The laser part of the LASIK procedure takes place in the exposed corneal bed (corneal stroma). The laser application itself usually takes about thirty to ninety seconds.

After the exposed corneal stroma is treated by the laser and minute amounts of cells are vaporized, the flap is replaced in its original position. Amazingly, the flap is held in position by the eye's natural suction facility, providing increased comfort and decreased recovery time for the patient. The entire procedure takes approximately ten to fifteen minutes per eye and, again, is virtually without discomfort.

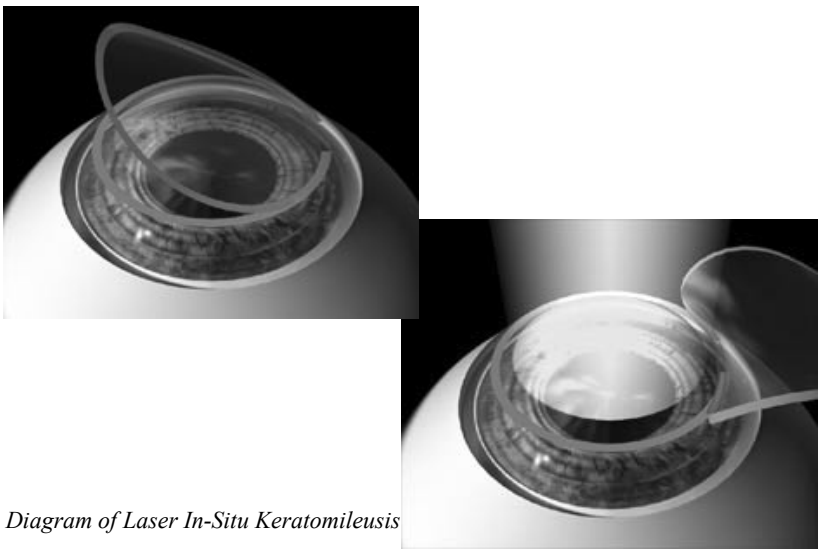


Diagram of Laser In-Situ Keratomileusis

The amount of tissue removed in each of these procedures is determined by the patient's degree of refractive error. Before the laser is employed to vaporize the tissue, the degree of refractive error is translated into numbers that are entered into the laser's computer. The quantity and pattern of tissue removal unique to each patient are then calculated. Both PRK and LASIK are refractive procedures that utilize the precision of the excimer laser to reshape the cornea by vaporizing stromal tissue.

A brief comparison of PRK and LASIK is outlined in the following chart.

	PRK	LASIK
Range of correction	Low to moderate	Low to severe
Depth of penetration	Superficial	20%
Intraoperative pain	Minimal	Minimal
Postoperative pain	Moderate, 24-48 hours	Minimal, 12 hours
Postoperative medications	1-3 months, possibly longer	1-2 weeks
Functional vision recovery	3-5 days	24 hours
Visual results fully recognized	3 weeks to several months	1-4 weeks
Return to work	3-5 days	1 day
Risk of complications	Low (less surgeon dependent)	Low (more surgeon dependent)
Risk of haze (scarring) in the central cornea	1-2%	<1%

As you can see in the table above, LASIK offers numerous advantages over refractive vision correction performed on the cornea's surface (PRK). This is undoubtedly the reason that LASIK has become the corrective surgery of choice for both doctors and patients. Which procedure you should have is best determined by consulting with your surgeon.

Although no surgeon can promise 20/20 vision without *correction* (the use of glasses or contacts), historically ninety-five percent of typical myopic patients have achieved vision within two or three lines of 20/20 without correction. In fact, the vast majority of patients can drive without glasses the day after their LASIK surgery. With current technology and more accurate LASIK *nomograms* (the formula the surgeon enters into the excimer laser's computer for performing your procedure) ninety-eight percent of patients see 20/20 or better, and the majority see some

of the 20/15 letters on the Snellen chart. Patients are astounded with their new ability to see more clearly.

Because this book is dedicated to LASIK eye surgery, nearly all of its chapters discuss the LASIK procedure and the important things you need to know concerning it. A brief explanation of the many other refractive procedures, past and present--including PRK--can be found in Chapter Eleven.

Chapter Five:
How to Choose a LASIK Surgeon

The keys to successful, safe surgery in any field of medicine are an informed patient with realistic expectations and a skilled, experienced surgeon. Take the time to research the surgeon and the laser eye surgery practice that you are considering for correcting your vision. *Ask questions!* The following guidelines will help you in your quest to gain a greater understanding of the LASIK procedure.

Begin with People You Know

A word-of-mouth network often provides a good initial source of information. Ask family, friends, and associates if they could recommend a surgeon based on personal experience. Additional leads can be obtained by speaking with an optometrist or ophthalmologist whom you trust.

Many of the foremost LASIK surgeons advertise their services in one way or another. However, the hard-sell technique of employing testimonials from radio personalities or sports figures (who usually have had their LASIK procedure performed at no cost) can be misleading. Claims of having been the inventor of certain LASIK techniques likewise will not always stand up in the light of scientific scrutiny.

It is imperative that you have the conviction that your LASIK surgeon will treat you with your best interest at heart. A high-quality eye surgeon who has successfully treated friends and family is usually a good bet.

Consult Physician Directories

Physician search directories available on the Internet may be helpful. Keep in mind, however, that these directories are not exhaustive listings of all the refractive surgeons in your area, only those who have chosen to participate in them. Moreover, many directories simply list the surgeon for a fee. Keep in mind, too, that the majority of these sites do not check a surgeon's credentials. Make sure you thoroughly research a surgeon's credentials before making the final decision.

Contact Ophthalmic Boards and Medical Associations

Ophthalmic boards and medical associations offer useful information about board certification, licensing, and other pertinent criteria. Among the better-known entities are the American Academy of Ophthalmology, the American Society of Cataract and Refractive Surgery, the American Board of Ophthalmology, the Association of State Medical Board Executive Directors, and the International Society of Refractive Surgery.

You should contact your local or national ophthalmic associations for their lists of member surgeons. Be sure to contact more than one professional organization, as not all ophthalmologists are members of each one. Even if you have heard of good surgeons from a friend, relative, or acquaintance, take the time to check their professional credentials.

What to Look For

Board Certification

Always look for a board-certified physician. This is the medical profession's generally accepted form of accreditation. This information can be obtained from the American Academy of Ophthalmology, the American Board of Ophthalmology, or the American Medical Association (AMA).

Additional Certification

Completion of additional training following ophthalmology residency adds credence to a surgeon's dedication to his or her profession but by itself is not an absolute in determining surgical competency. Some of the finest LASIK surgeons today began their practice before fellowship training in laser correction surgery was available. Among surgeons who do undertake additional training, some receive further certification by the American College of Surgeons (FACS). Likewise, participation in research activities, lecturing, and writing professional articles and books

also indicate a certain level of respect by the surgeon's peers.

FDA Clinical Trial Participation

Some ophthalmologists are invited to participate as principal investigators for FDA clinical trials sanctioned by laser manufacturers. Typically, these principal investigators are selected because of their demonstrated skill and ability, and their complete understanding of laser vision correction and the laser being used.

Malpractice Suits

Check with your state medical board to see if the surgeon has had multiple malpractice suits against him or her. Even the best doctor may have had a lawsuit for medical malpractice. A good rule of thumb is to check for more than one malpractice suit for every year or two of practice. Multiple lawsuits require an explanation.

Experience with the Procedure

When a physician earns a general medical degree, he or she may practice any specialty that he or she wishes. But not all doctors share the same degree of training and experience in that field. Hence, it is important to be careful when choosing a LASIK surgeon. Here are some things you should know and look for when deciding upon a LASIK surgeon.

Numerous studies have shown that surgeons experience a learning curve with the LASIK procedure. It has been shown that surgeons who have performed over 300 procedures have a lower complication rate than those who have performed fewer. Moreover, it generally takes approximately 200 to 500 LASIK procedures before a LASIK surgeon's *nomogram* is reasonably well developed. The nomogram defines the formula that the surgeon enters into the excimer laser's computer for performing your procedure. It is based on a series of measurements performed at the time of the preoperative exam and includes factors such as degree of refractive error and age, as well as on the surgeon's technique and the laser used. A well-developed nomogram allows the surgeon to more accurately program the laser for each patient, decreasing the probability that an enhancement procedure will be necessary. You need to be aware, however, that even in the best hands, enhancement procedures are necessary five to ten percent of the time because different people respond differently to the laser.

In the process of performing these procedures, the surgeon should make every effort to meet or exceed benchmark standards in order to achieve good outcomes. By constantly analyzing surgical outcomes, the

better surgeons find that the consistency of their results improve, even beyond the initial 1,000 procedures.

Find out how much experience the surgeon has with your procedure--the more the better. Time and experience have shown that surgeons who concentrate on LASIK eye surgery and who do a lot of it, as well as intraocular refractive procedures, are better at it.

Benchmarking

As a potential patient, you should ask your LASIK surgeon how he or she tracks LASIK procedure outcomes. The surgeon's response can tell you a great deal. If the surgeon has numbers readily available--charts and graphs or can quote specific outcomes--the likelihood is high that the surgeon is *benchmarking* (tracking LASIK outcomes). In addition, if the surgeon presents his or her data at well-respected national or international conferences to other surgeons, or publishes in professional journals, you can be confident that he or she is benchmarking.

Unless a surgeon is participating in sanctioned clinical trials, there is no mandatory central reporting database for benchmarking. The important thing is to determine *if* the surgeon is benchmarking and not worry too much about any one specific number. The fact that the surgeon is tracking LASIK outcomes shows his or her concern for achieving the best possible results. Your goal is to find someone for whom achieving excellence is a paramount concern.

Success and Complication Rates

Next, ask the surgeons how long they have been performing LASIK and about their success and complication rates. Your surgeon should discuss the potential success rate for your individual surgery as well as any potential complications. Surgical success means more than knowing how to avoid complications; it means knowing how to handle difficult situations before they arise. Identifying problems early and dealing with them in a timely manner is the hallmark of excellent surgeons. All surgeons have complications, but having a complication does not mean that anything was done improperly. What is important is that the surgeon have a low complication rate and that the ultimate visual outcomes are good.

It is also important to know about their experience with refractive errors similar to your own. The surgeons should have adequate experience with people of the same age, gender, and race as you because the surgical techniques needed to correct refractive errors in these groups may differ slightly from the norm.

Awareness of New Developments

Most doctors keep up with the latest developments by reading or attending conferences. Some doctors take this a step further and immerse themselves in a life style of innovation by lecturing at major conferences, writing journal articles and textbooks, participating in clinical trials for new technology, and consulting for ophthalmology companies.

Ask the doctors you talk to if they know what is being achieved, both nationally and internationally, in their field. Or contact one of the major ophthalmologic societies directly with the same question.

Personal Compatibility

Remember, personal chemistry is extremely important. Choose a surgeon with whom you feel comfortable; someone who is easy to talk to, friendly, and professional; someone who listens closely to what you want and cares about what you need. Make sure he or she is willing to take the time necessary for your understanding of the procedure. A good doctor-patient relationship is important in helping devise a treatment plan that best suits your needs.

The art of medicine entails blending the science of medicine with the needs and expectations of the individual patient. Many excellent LASIK surgeons and LASIK centers offer educational seminars or consultations that give you an opportunity to assess the quality and excellence levels of the person to whom you are entrusting your eyes.

Competent, Compassionate Staff

Verify that the laser center is staffed with highly trained, competent people. Determine for yourself whether the LASIK surgeon has a kind, compassionate staff to help support you emotionally throughout the LASIK process.

Care Provider and Style of Care

Determine what part the LASIK surgeon plays in your preoperative and postoperative care. Avoid the “shopping mall” approach to surgery where patients are shuffled through the surgical suite without having first met with the surgeon. Most doctors employ a knowledgeable staff to help perform tests and answer questions. However, the final decision to have surgery must rely on *informed consent*, something only possible through discussion with the surgeon.

Some patients choose to see their family optometrist or ophthalmologist for their preoperative and/or postoperative care. Be sure the person doing your postoperative care is well trained for this task. The majority of patients have an uncomplicated postoperative course. However, you want your provider to be skilled enough to recognize complications and provide or refer you for treatment before any long-term complication arises.

Practice Style of Care

The following questions may help you determine which practice care style works best for you:

- Will the surgeon evaluate and speak with you prior to surgery?
- Who will be your main contact at the office?
- Who will perform the preprocedural exams?
- Who will perform the follow-up exams?
- What are the qualifications of the person providing the follow-up care?

The intent of these questions is to help you find a practice whose approach best fits your needs.

Find a Qualified Surgeon

Find an experienced LASIK surgeon who will make the commitment to you to take full responsibility for your LASIK result, who will meet you prior to surgery, and who will be actively involved in every aspect of your LASIK procedure.

Be sure you know who is actually doing the procedure. Ask who will be doing your follow-up. Ask about their qualifications. Find out how many procedures he or she has done. While higher volume does not necessarily imply a better surgeon, you will want someone who has done at least 300 to 500 surgeries. Ask what his or her success rate is for 20/25 vision or better. What is his or her loss rate of best-corrected vision?

Remember, when evaluating the criteria that you feel a LASIK surgeon should meet, take time to listen to your feelings. This is one sure way to feel comfortable with the surgeon you finally select. At any point in the decision-making process, should you have doubts about the surgeon or his or her medical opinion, go elsewhere and obtain a second opinion.

Ask How Many LASIK Procedures the Surgeon Has Performed

It is important to be specific with regard to LASIK since many surgeons have performed other laser procedures that require different skills than those required for LASIK. Just because the surgeon has done thousands of retinal or glaucoma procedures does not mean that he or she has done many LASIK procedures.

Does the Surgeon Maintain a Database of Procedures?

This database will allow the surgeon to provide you with statistics regarding his or her results. Specifically, the surgeon will be able to provide you with a reasonable prediction of what your result will be (based on your preoperative refraction) and the likelihood of needing an enhancement procedure to fine tune your result.

Choose the Right Surgeon and Pay What It Costs

Discount surgery is as good as a discount parachute. Many advertisements push low-cost surgery. This is an important warning signal to proceed with caution. Go for the best qualified surgeon.

Use Only an FDA-Approved Laser

If your LASIK procedure will be performed in the United States, make sure it is done on an FDA-approved excimer laser. Ask what laser your doctor uses, and then contact the laser company directly to confirm whether he or she is qualified to use it. Laser companies frequently have lists of doctors on their web sites who are certified to use their lasers. Remember, surgeons in other countries (including Canada and Mexico) may use lasers that have not had to withstand FDA scrutiny.

Beware of the Hard Sell

If you feel like you are getting a hard sell, you probably are. Be wary of promises or guarantees seen in advertisements, especially promises like “20/20 vision or your money back.” Of necessity, statements like this contain fine print and initiate the doctor-patient relationship in a rather deceptive manner. Go elsewhere. Run--don’t walk! You are not buying a car. This is real surgery. Your surgeon should be well aware of the limits of LASIK and readily acknowledge the probability of complications in high-risk patients.

Keep Searching

Many leading LASIK surgeons have taken the extra effort to establish web sites that detail their practice, qualifications, and success rates. Be certain to ask for the Internet address of each surgeon you are

considering. And while you investigate, don't lose sight of the benefits: For most people, a lifetime of bad vision can be cured in less than twenty minutes.

LASIK has improved the eyesight of over a million people in the United States alone, and nearly the same number again around the world. Your LASIK surgeon need not be your best friend, but you should have every confidence that he or she possesses the skill and experience necessary to apply the technique of LASIK in a way that best serves your interests.

What to Look for

Always investigate and evaluate the following criteria before deciding upon a surgeon:

- Training and education
- Certifications--board certifications as well as manufacturer certifications on lasers and microkeratomes
- Professional memberships and important offices held
- Training and teaching activities
- Research and writing activities
- Awards and recognitions
- Reputation
- The equipment the surgeon uses

Chapter Six:
The Preprocedure Consultation

If you decide to proceed with LASIK eye surgery, there will be three distinct parts to your experience:

- The preprocedure consultation with the LASIK surgeon and his/her staff
- The LASIK procedure
- LASIK postprocedural care

This and the next two chapters review in detail each part of the experience.

The Preprocedure Consultation

Before you proceed with LASIK vision correction, you need a preprocedure consultation with the surgeon and his or her staff. This consultation is important for several reasons. First, it must be determined whether you are a candidate. It is also vital for you to learn as much as you can about your options and have as many of your questions answered as possible. With few exceptions, you must meet the following criteria to be considered a good candidate:

- Be over eighteen years of age for treatment of myopia up to -14.00 diopters or hyperopia up to +6.00 diopters, with or without astigmatism (up to 6.00 diopters).
- Have vision that has been stable for at least a year.
- Be free from certain diseases of the cornea, lens, and retina.
- Not be pregnant or nursing.
- Be in good general health.

Fear of the Unknown

Of all the concerns that face people considering refractive surgery, fear of the unknown is perhaps the greatest. Este's story is the norm for

people about to undergo LASIK:

"Talk about high anxiety. I almost didn't go through with it because of fear of the unknown. I completely freaked out and was a basket case. After the procedure, I could tell that I could see better, but there was a bit of a haze. By the evening, I was reading the stock exchange numbers that scroll across the bottom of the TV on CNN. By the morning, I could see perfectly. It was amazing. I just can't believe that one day I'm wearing glasses and a day later I'm not. I absolutely encourage anyone who needs or wants this surgery to do it. It is probably one of the best decisions you will ever make." --*Este W.*

Wesley's story is a bit different, and notwithstanding all the study and preparation he did prior to choosing LASIK, he still experienced that very normal nervousness and trepidation of having someone work on your eyes. This is what he went through:

"I must admit that I was incredibly nervous undergoing the LASIK procedure on my eyes. I had read numerous articles, discussed the procedure with numerous professionals, and researched various centers and doctors before deciding to have the surgeon I chose perform my LASIK procedure. In retrospect, the worst part of the experience was the anticipation of having someone operating on my eyes.

The surgery was completely painless and was completed within fifteen minutes on both eyes. I couldn't believe that it would be so easy. I was totally comfortable during the surgery and was engaged in a relaxing conversation with the surgeon and his staff. Immediately after the procedure I stood up and couldn't believe how well I could already see. It was incredible!

On the way home, I could already see license plates and road signs. In the morning, my vision was better than perfect. I went from 20/200 vision to 20/15 vision in less than twenty-four hours. It's a true miracle. I was able to return to my duties as a police officer the following day. The freedom experienced by being contact lens and glasses free is exhilarating. I would encourage anyone contemplating the surgery to have it done. The LASIK procedure has changed my life and is one of the best decisions I have ever made." --*Wesley L.*

These are but a few of many testimonials from thousands of thrilled patients who have undergone LASIK. In a matter of minutes, they have been transformed from a lifetime of visual bondage to freedom, no longer dependent on cumbersome eyeglasses or irritating contacts.

What to Expect

Medical and Ocular History

At your preprocedure evaluation, a thorough eye exam will be performed. This will include collecting a careful medical and ocular history. It is important for your doctor to know everything about your medical history as certain systemic diseases such as rheumatoid arthritis, lupus, certain healing disorders, diabetes, and a current or planned pregnancy may need special consideration. The ocular history will include questions about previous contact lens wear and eye disease. One specific eye disease that the doctor must know about is *herpes simplex* on the eye. He will explain that diseases such as glaucoma or diabetes will not preclude you from having the procedure, but they must be identified and controlled. It is important for you to notify the doctor of any ongoing changes or problems with your vision during the consultation. If you have a significant cataract and are experiencing glare, changing vision, or decreased sight compared to what you normally see, you should not undergo LASIK eye surgery.

LASIK Measurements

The examination will include a measurement of your refractive error and a complete exam of your eye, including a sophisticated digital mapping of your cornea with a device known as a *corneal topographer*. The thickness of your cornea and your intraocular pressure will be measured. Also, your dominant eye will be determined and your pupil size measured.

Contact lenses, particularly hard or rigid gas-permeable lenses, have been known to warp the cornea and interfere with some of these measurements. If you wear contact lenses, they must be removed prior to the final LASIK measurements in order to allow the cornea to return to its natural shape--three to seven days for soft lenses, two to three weeks for *toric* or gas-permeable lenses, and possibly longer for hard lenses.

After the LASIK measurements, if you are unable to tolerate glasses for the length of time necessary for unwarping to occur, some hard-lens wearers may be able to switch to soft lenses until two weeks before the surgery. It is important that your refraction and corneal topography readings be stable *before* you proceed with surgery.

Pupillary Dilation

To get an accurate check of your refraction, drops will be instilled to temporarily relax your eye's focusing muscles. This pupillary dilation also allows the doctor to examine the back of your eye, including the

retina and the optic nerve. These dilating drops will make you sensitive to light and may affect your near vision for up to thirty-six hours, so you should plan accordingly. You may want to have someone drive you home. Also, there are eye drops that will reverse dilation sooner.

Monovision

If you are in your late thirties or older, the option of monovision (or blended vision) should be discussed at your preoperative consultation. Monovision allows some patients to see near objects without the use of reading glasses. As mentioned in Chapter Two, patients in their late thirties to mid-forties begin to develop presbyopia, or difficulty with their fine focusing. The laser cannot correct this problem. Thus, a patient who has presbyopia in addition to nearsightedness or farsightedness will still need reading glasses if both eyes are corrected perfectly for distance.

Monovision refers to the "undercorrection" of one eye in a nearsighted patient or the "overcorrection" of one eye in a farsighted patient. The technique involves correcting the dominant eye for distance and the nondominant eye for near vision, thereby reducing the need for reading glasses. When both eyes are functioning together, the brain naturally "looks" through the eye that is clearer. So, for distance vision the brain sees mostly with the dominant eye, and for near vision it sees mostly with the nondominant eye. Having eyes for different purposes might sound unsettling, but some patients do quite well with some degree of monovision.

The best way to decide if this is something you want is to discuss it with your doctor. He or she may be able to show you with contact lenses what it will feel like before you have your surgery. Additionally, in the event you do try monovision and do not like it, additional laser correction can be added to make both eyes equal, although ideally this is determined in advance to avoid the risk of unnecessary surgery.

Education

In addition to obtaining the medical information necessary for your laser eye surgery, an equally important objective of the consultation is to educate you regarding all aspects of LASIK eye surgery. Learning about the procedure and discussing your options are important for making an informed decision. The initial educational process should include videos and written information to help you understand what you can reasonably expect from the procedure. Reasonable expectations are an essential ingredient for a happy postoperative patient.

If you are over forty, your ability to read normal size (twelve-point) text should be discussed, including the option of correcting your nondominant eye for reading (monovision).

You will be asked to decide whether you want both eyes done at the same time or whether you prefer that the procedures be done on separate days. While most patients prefer to have both eyes done at the same time, this is optional rather than mandatory. Some surgeons only perform surgery on one eye at a time to reduce risk or increase accuracy, but studies have shown that there is no statistically significant difference in the refractive outcome between sequential and simultaneous bilateral LASIK.

While much of the education process can be done by a specially trained counselor or technician, you will still be given the opportunity during the preprocedure evaluation to have a one-on-one meeting with the surgeon for him or her to carefully evaluate your eyes and answer any questions you may have. It is most important that you feel comfortable and confident with your doctor.

LASIK requires a highly skilled surgeon to create the flap--one dedicated to obtaining precise results--in order to properly program the excimer laser. The follow-up care is relatively simple in most cases.

Previous Surgery

Patients who have previously had certain types of surgery are sometimes candidates for LASIK or PRK as a second procedure to enhance visual results. LASIK on top of a previous radial keratotomy (RK) to correct myopia and astigmatism is a technique that has been used successfully in many cases, provided that the patient's vision is relatively stable and there is no significant corneal scarring.

Patients who have had a previous corneal transplant can have a secondary LASIK or PRK procedure to enhance the results. This is especially effective for patients who develop a high degree of astigmatism that is surgically induced. A clear corneal transplant can only allow good vision if it has a relatively smooth corneal surface. Laser vision correction is especially beneficial to corneal transplant patients with unusual refractive errors and can smooth out astigmatic curves in the cornea. These are often more difficult surgeries with less predictable results, and patients should consult with their surgeon to determine their eligibility.

Price

You will decide with your surgeon which procedure is best for you, and that procedure will be discussed with you in detail. You may also view a video that further demonstrates the procedure. Time will then be taken with you to answer any questions that you may have. After you decide to undergo LASIK vision correction, the only other preliminary step remaining is to have you sign an informed consent form and arrange for payment of the procedure.

The cost of LASIK and PRK varies from $1,500 to $3,000 per eye, depending on the procedure, your area of the country, the type of equipment used, the experience of your surgeon, and whether follow-up care and enhancement (retreatment) procedures are included. You should always feel comfortable about asking questions of your surgeon, both prior to and following the procedure.

Chapter Seven:
The LASIK Procedure: What to Expect

On the day of the procedure, you should arrive at the laser center as rested and relaxed as possible. You should probably allow about a two to three hour stay at the laser center. This may vary from center to center. Wear comfortable clothing. Do not wear makeup, perfume, or cologne on the day of your laser surgery. These things may interfere with the cleanliness of the procedure and the function of the excimer laser.

You should not wear contact lenses following your preoperative LASIK consultation unless it will be some time before your scheduled surgery. Soft lenses need to be out at least three to seven days prior to surgery, and gas permeable or hard lenses need to be out two to three weeks prior to surgery. It is essential that your eye be in its most natural state at the time of surgery.

With LASIK, a mild oral sedative may be administered before the procedure begins, but it is not usually necessary. During the procedure, your surgeon will constantly be talking to you. He or she will talk you through the entire procedure; you will know at all times what to expect. There will be no surprises and no pain.

Because LASIK eye surgery is more surgical in nature than PRK, sterile surgical conditions must be maintained. Your face will be cleaned with a disinfectant, and you will be asked to wear a surgical cap. You will be given an antibiotic drop and possibly an anti-inflammatory drop. These may sting for a few seconds. You will then be taken to the laser suite, positioned under the excimer laser, and given numbing drops. Your eyelashes will be taped out of the way, and an eyelid holder will

be placed between your eyelids to keep you from blinking. This eye *speculum* can sometimes cause mild pressure or discomfort on your eyelids at first.

A suction ring is used to hold your eye in position and maintain pressure within the eye while the corneal flap is being made. This flap varies between 130 to 180 microns in thickness. The usual thickness is 160 to 180 microns, but your surgeon may choose an alternate value, depending on your refraction and the thickness of your cornea. This flap represents about twenty to thirty percent of the thickness of the cornea, which on the average is about 550 microns (about half a millimeter).

You will not feel pain or see anything while the flap is made, but environmental lighting will disappear during that time. There may also be a little pressure sensation. The flap-making process takes about thirty seconds.

When the flap is lifted back, your vision will get blurry. You will be asked to fix your vision on a target light (usually red, green, or yellow). The laser part of the procedure is then performed, taking twenty to ninety seconds. This portion of the procedure is painless, but you may notice a faint odor as the laser photoablation proceeds. You will also hear a clicking or buzzing sound with each pulse of the laser.

During the laser procedure the light will move, become a blur, or disappear. Your job will be to continue to look straight ahead at the fixation light. If your eye does start to wander, the laser will stop instantly, you will be coached to fix again on the target, and the laser procedure will resume. Some surgeons use a fixation ring to assist in the fixation of the eye, which may help to improve the accuracy of the ablation. The ring is left on the eye at very low pressure while the laser is firing. The surgeon utilizes this tool to control the position of your eye and prevent your eye from looking away from the fixation light. This ensures that the laser energy is focused precisely on the center of the cornea during the entire procedure.

After the laser treatment is completed, the hinged flap is then placed back into its original position, and the surgeon waits one to five minutes for the eye to create a natural vacuum to hold the flap down. (The cornea has the unique ability to seal itself back into place as if no flap had ever been made.)

Next, the eye is dried and the lid holder is removed, allowing you to blink normally. While a bandage contact lens is not usually required,

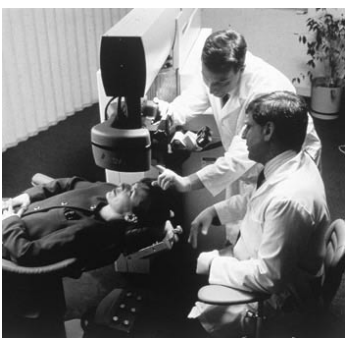
some patients will receive one to aid in their individual healing process.

A newly created corneal flap is held down by four forces:

1. Tissues like to stick together, and within seconds hydrostatic forces between the flap and the corneal stroma create a seal between the two tissues, causing the flap to begin to readhere to the cornea.
2. The endothelial cells (inner lining of the cornea) are constantly pumping fluid out of the cornea to maintain its clarity. This pump function creates a natural vacuum that holds the flap down. This process begins working in a matter of minutes.
3. Within hours the epithelial cells grow over the edge of the flap, helping to glue it down. This process takes a few days to complete.
4. Eventually, the internal healing process allows the flap to be permanently glued down. This occurs over several months.

With LASIK, the top surface of the cornea (epithelium) and the next layer (Bowman's layer) are preserved (see illustration on page 22). This is the reason the recovery time is shorter than with PRK.

A typical LASIK procedure takes between ten to fifteen minutes per eye. Because of the rapid visual recovery experienced by most LASIK patients, both eyes may undergo the procedure on the same day if your surgeon so advises and both of you are comfortable with the decision. Some surgeons only perform eyes on separate days to reduce risk or improve precision. Again, this is a patient decision to be made after appropriate consultation.



Photograph of patient under an excimer laser

Contemplating LASIK?

Marilyn was serious about having LASIK eye surgery performed on her eyes. She had this to say when asked about the experience:

"When I arrived at the doctor's office, a medical assistant took me to a prep room, gave me five milligrams of Valium (which relaxed me), and administered anesthetic eye drops. 'You're all set to go,' she told me.

I was then taken to the laser room where I laid down on a reclining chair under the laser and had my eye taped open with plastic drapes. The surgeon explained each step of the procedure as he went along.

First, he used the microkeratome to lift up a thin, cellophane-like, outer layer of the cornea (called the corneal flap) and folded it back so that the inner cornea was directly exposed. As soon as the corneal flap was lifted, everything looked extremely blurry. Then, in the course of about twenty seconds, ultraviolet light from the excimer laser reshaped the internal cornea. I could hear the laser clicking, but I felt nothing.

Finally, he folded the corneal flap back into place. 'Everything went great,' he reported. Then he proceeded to perform the procedure on the other eye.

Immediately after the procedure, my vision was a bit blurry and my eyes a bit scratchy, but I felt no pain nor any real discomfort. Before I went home, I had protective plastic shields placed on my eyes so I wouldn't rub them.

The next morning the doctor removed my eye shields and I could see 20/20 out of each eye. I now have the freedom to work, play, and ski without the bother of glasses and contact lenses. I trust my surgeon's judgment and skill and continue to recommend him to everyone I know who is interested in the procedure.

P.S. I was a very tough patient! Not only am I a physician, I am also married to an ophthalmologist."

Pros and Cons of LASIK

Pros	Cons
• Low incidence of postoperative pain • Fast recovery • Higher accuracy for higher degrees of correction • Low probability of serious postoperative haze • Ability to perform surgery to both eyes on the same day • On medicated eye drops only five to seven days • Architecture of cornea stays intact	• Possibility of flap complications

Chapter Eight:
LASIK Postprocedure Care

Once your procedure is completed, you will sit with your eyes closed for approximately thirty minutes. Afterward, your doctor will check your eyes to ensure that the corneal cap is properly positioned; then you will be instructed to go home and take a nap. Because your vision will be somewhat blurry and you will have received a sedative, you will need to have someone drive you. Additional drops will be placed in your eyes, and you will be instructed on the use of your medications. You will also be given clear plastic shields to wear at night for as long as your doctor instructs (at least two nights, usually three days to one week). These prevent accidental trauma to the flap during the healing period should you inadvertently bump your eye.

Before you go home to rest, your surgeon may also give you something to help you sleep; this is the best way to keep your eyes closed for the first few hours. Following the LASIK surgery, you may experience some discomfort, which may last for six to eight hours. Patients describe the discomfort as a "sandy feeling" or liken it to having a dirty contact lens in their eye. With LASIK this discomfort is usually gone by the next day. Tylenol®, aspirin, ibuprofen, or similar over-the-counter pain medications are usually adequate to keep you comfortable.

You will also be given antibiotic eye drops, anti-inflammatory eye drops, and lubricant eye drops to promote healing. It is common for the eyes to feel somewhat dry, and the lubricant drops (also called "artificial tears") may be used frequently.

Immediately after the surgery, you can expect your vision to be fairly blurry. It may look as though you are looking through a glass of water or wearing a dirty contact lens in your eye. With LASIK there is usually a dramatic improvement in vision in the first twenty-four hours.

Guidelines for Healing

Follow these guidelines to promote safe and rapid healing:

- Rest. Sleep aids recovery.
- Particularly in dry climates, apply nonpreserved lubricant eye drops very frequently. This encourages rapid recovery and enhances comfort. (Some patients may need these drops every half-hour the first few days, every couple of hours the first week, and at least four times daily for the first three months.)
- Sensitivity to light is normal and will improve. Wear good ultraviolet-protecting sunglasses.
- Avoid rubbing your eyes and squeezing your eyelids for one week.
- Avoid swimming, surfing, and hot tubs for at least two weeks.
- Showers and baths are fine, but avoid getting water and shampoo directly into your eyes for the first few days.
- Avoid dusty or smoky environments for several days.
- Avoid eye makeup for one to two weeks.
- It is a good idea to plan on not driving until you feel your vision has improved. You may drive as soon as you are visually comfortable and your doctor approves. This may be the next day or take a few days.

Postoperative Follow-up Schedule

When you leave the laser center, you will be given complete instructions to follow, including a postoperative appointment schedule.

Here is a typical postoperative appointment schedule:

Purpose of Appointment	Time Frame Following LASIK Procedure
• To ensure that there is no evidence of infection, that the flap is healing properly, and to remove the bandage contact lens (if one was used)	1 day
• To ensure that your eye is healing properly	1 week, 1 month
• To measure your visual progress and to consider enhancement treatment (if necessary)	3-6 months
• To measure the stability of your result, check your eye pressure, and assess your general eye health	12 months/annual exam

The LASIK Recovery Cycle

Your vision improves quickly after LASIK, and many patients feel comfortable enough to drive in one to two days. The corneal flap is relatively adhered in one week, but it is advisable not to rub your eyes vigorously for one month.

The return of visual stability after LASIK varies for each patient. For some, stability can be achieved in as few as two weeks; for others, stability may take from three to six months. As a rule, vision will improve in three hours, more in three days, three weeks, and even in three months. Generally, during the course of the first month, there is gradual improvement in the already good vision following LASIK. You can also expect a small reduction in nighttime halos and some return of near vision in patients over forty.

For the first five to seven days after your operation, you will be using medicated eye drops. It is generally advisable to continue using lubricant drops for the better part of the first month after your procedure. Well lubricated eyes heal better, maintain better visual stability, and are more comfortable. These drops are available over the counter.

It is important that you keep your postoperative appointments as your eye drop regimen may be altered. Also, the doctor may need to monitor your eye pressure if you are on postoperative steroids for any

length of time. Be sure to keep your follow-up appointments.

Most patients enjoy good functional vision during the first month. Fluctuations in your vision are common during the first two to three weeks, especially for higher visual corrections. Patients undergoing hyperopic LASIK (farsightedness treatment) may notice that their near vision is better than their distance vision. This is quite common, and the distance vision will continue to improve during the first month.

Some patients may feel more comfortable with a thin pair of glasses to assist them with more critical distance vision activities, such as night driving or attending a play and trying to see the expressions on the actors' faces. Patients over forty years of age may require a thin pair of reading glasses.

While many patients notice halos around lights or ghosting of images at night, these symptoms tend to diminish substantially within six months.

Patients with drier eyes or who use the computer, who read for long hours, drive long distances, or live in low-humidity climates may notice some minor discomfort and blurring of their vision, particularly toward the end of the day. This is usually related to dryness of the surface of the eye. The frequent use of lubricant drops will help significantly.

With LASIK, your vision usually becomes stable within three to six months. Once your vision is stable, your treatment is permanent. You now have less dependence on, and maybe complete freedom from, glasses and contact lenses.

Chapter Nine:
LASIK Statistics

There are many ways to present patient outcomes after refractive surgery, and the difference in numbers can be confusing. Some doctors may talk about the percentage of patients who achieve 20/20 vision after the first treatment, while others may present data on the number of patients who achieve 20/40 vision. Still others may discuss their results based on patients who have had enhancement procedures (if necessary). What are the important numbers and how can you interpret these outcomes?

First of all, to drive legally without glasses you need to have 20/40 vision. This is an important number. However, it is also important to know your chance of achieving 20/20 vision or your best potential vision without correction by glasses or contacts. Additionally, it is important to know the likelihood that you will need an enhancement (retreatment) procedure. These numbers depend on your initial prescription and are also somewhat surgeon dependent. Patients with higher degrees of nearsightedness or farsightedness have a higher likelihood of needing an enhancement procedure.

The statistics provided below are based on a study including 820 eyes treated by Ernest W. Kornmehl, MD, and provide a good guideline for what you can expect. Keep in mind that the patients in the statistics below who do not achieve 20/20 vision without correction are usually quite happy. They can do most things, including drive a car, without any correction. And when it is absolutely necessary for them to fine-tune their vision, they can use a thin pair of glasses to do so. Some patients appreciate a small amount of myopia in one or both eyes to help with near vision and, thus, do not request an enhancement.

Myopia

Mild Myopia

Mild myopia is defined as less than three diopters (-3.00), with or without astigmatism. The chance that a patient with mild myopia will need an enhancement procedure is approximately two percent. The chance of achieving 20/20 vision without correction is ninety-four percent after an enhancement procedure (if necessary). The chance of achieving 20/40 or better without correction and being able to drive is nearly one hundred percent.

Moderate Myopia

Moderate myopia is defined as a refractive error between -3.00 and -6.00 diopters. There is a six percent chance of needing an enhancement procedure if you fall into this category. Based on the data, eighty-two percent of patients achieve 20/20 vision or better, and ninety-nine percent achieve 20/40 or better.

Severe Myopia

Severe myopia is defined as a refractive error between -6.00 and -9.00 diopters. These patients have approximately a nine percent chance of needing an enhancement procedure, after which they have a ninety-nine percent chance of seeing 20/40 or better and a sixty-nine percent chance of seeing 20/20 or better.

Extreme Myopia

Extreme myopia is defined as refractive error higher than -9.00. The enhancement rate for this group of patients varies from twelve to fifteen percent. Many patients do extremely well; however, other variables such as the thickness and the steepness of the cornea come into play. Patients in this group need to thoroughly discuss the risks and benefits of the LASIK procedure, as well as other options, with their doctor. Although enhancement rates are higher in this group of patients, there may be limitations on what can be done due to other variables of the eye, such as corneal thickness.

Astigmatism

Patients with mild astigmatism (1.00 diopter or less) can expect nearly identical outcomes and enhancement percentages, as can patients with pure myopia. The presence of moderate or high degrees of preoperative astigmatism will reduce your chance of achieving 20/20 vision after the initial procedure, making it more likely that an enhancement will be desired.

Hyperopia

A multicenter trial done for FDA approval for the VISX STAR S2 laser for the treatment of hyperopia in the range of +1.00 to +6.00 provides us with a good general benchmark. In this study, ninety-one percent of the patients saw 20/40 or better, and fifty-three percent saw 20/20 without glasses after the procedure.

Patients being treated for hyperopia should be aware that their healing time is slightly longer than for those patients with myopia, and the chance that they will need an enhancement is slightly higher. Again, these numbers are variable, depending on the patient's original prescription and the surgeon.

Summary

From the data presented above, you can see that while refractive surgery is an exciting new procedure, it is not for everyone. It should not be thought of as a guarantee to eliminate one's need for glasses. Rather, it should be thought of as a way to dramatically reduce one's dependency on glasses and contact lenses.

Chapter Ten:
LASIK Risks and Complications

In order to make a decision as to whether LASIK eye surgery is a good alternative for you, it is important to understand the potential risks. If performed by an experienced surgeon, the risks are low--it is one of the safest surgeries performed today. In contrast to PRK, most risks in LASIK are related to the creation and re-adhesion of the corneal flap. The trade-off for these risks is fast visual recovery with less discomfort. And, in most cases, LASIK is the easiest procedure to fine tune with an enhancement.

The following are several potential risks and side effects of LASIK:

Unrealistic Expectations

It is wise for those who undergo LASIK to be fully informed and to carefully assess their expectations. As a patient, your job is to understand exactly what the procedure can and cannot do. This is where communication with your doctor is essential. Your surgeon should understand all of your expectations and explain what is realistic and what is not. Although the LASIK procedure is one of the most successful in all of medicine, even the most skilled and experienced surgeon cannot promise that you will have 20/20 vision without correction.

A skilled LASIK surgeon can significantly reduce your dependence on glasses and contact lenses, but eventually most patients will need glasses for reading. Some may even need a thin pair of glasses for critical distance activities such as driving at night. It is best to think of this procedure as not eliminating but rather reducing your dependence upon glasses and contact lenses and

improving your natural vision.

Eyesight changes slightly over time, from one year to the next, even if you do not undergo surgery. Following LASIK, your eyes will still change slightly, not because the procedure was unstable, but rather because all eyes change. For most people, their vision will not change enough to require that the procedure be performed again.

Undercorrection

For a given degree of nearsightedness or farsightedness, the amount of laser applied to a patient's cornea is based on a nomogram describing the average person's response to the laser. However, individuals are different and may not respond in an entirely average way to the laser. Usually, this difference in response is not visually significant, but sometimes an undercorrection or overcorrection will occur.

Undercorrection is more common than overcorrection. A slight undercorrection will not seriously affect your vision and may be desirable following a nearsighted treatment in patients over forty to help with reading vision. More significant undercorrections may require an enhancement procedure (which is usually included in the original LASIK cost if performed within the first one or two years after the initial procedure).

The incidence of undercorrection varies with prescription and is more common in patients with higher levels of nearsightedness, farsightedness, or astigmatism. For example, a patient with a prescription of less than 3.00 diopters of myopia has about a two percent chance of needing an enhancement procedure. On the other hand, a patient with more than 9.00 diopters of myopia has about a twelve to fifteen percent chance of requiring an enhancement procedure.

Incidents of undercorrection are reduced by surgeons using consistent technique and constantly analyzing their outcomes. Your doctor and his or her staff should keep an up-to-date database of at least 1,000 procedures and be able to show you what the likelihood is of needing retreatment, based on your preoperative refraction.

The excimer laser comes from the factory with standard recommended settings. By fine-tuning the factory treatment parameters, the surgeon minimizes the chance of significant undercorrection.

Overcorrection

An initial overcorrection may occur and usually corrects itself in the first month. Following a farsighted treatment, an overcorrection will make you temporarily nearsighted, making your distance vision somewhat blurry and your near vision rather good. Following a nearsighted treatment, an overcorrection will make your vision at close range more difficult. These temporary undercorrections and overcorrections can be managed with glasses or temporary contact lenses until they resolve. The number of permanent overcorrections is fewer than that of undercorrections. As with undercorrection, a significant overcorrection may be treated with an enhancement procedure (which is usually included in the original LASIK cost if performed within the first one or two years after the initial procedure). This is usually performed three to six months following the initial treatment after your vision has stabilized.

Induced Astigmatism

In rare circumstances astigmatism can be induced following LASIK, resulting in blurred vision postoperatively. Astigmatism can be easily managed in combination with either an overcorrection or undercorrection retreatment (if necessary). Small degrees of astigmatism are well tolerated and can even enhance vision in some circumstances. If your vision does not meet your expectations after the primary treatment, there is a ninety-eight percent chance that it can be corrected with enhancement LASIK procedures (which are usually included in the original LASIK cost if performed within the first one or two years after the initial procedure).

Enhancement Procedures

The addition of more laser to correct an over or under response to LASIK is generally performed two to three months after the original treatment. The only exception is hyperopic treatments, which are usually performed three to four months after the original surgery to compensate for the longer visual recovery period. Typically, there is no additional cost to the patient.

The original flap created during the LASIK procedure is dermined and lifted with a special spatula-like instrument. There is usually no need to cut a new flap; thus, the risks associated with creating the flap originally are not a factor in retreatment. There are times when a new flap formation may be necessary, but the risk of epithelial ingrowth is increased compared to the initial procedure. The postoperative course is the same as with the original procedure.

"Enhancement" is a funny word to use for additional surgery. It implies that the surgeon is going to make your vision better. It does not say, "The surgeon is going to try to make it better but may make it worse." Neither does it say, "An enhancement carries many of the same risks of the initial surgery, and in some cases more." "Retreatment" may be a better word.

Discuss enhancement procedures carefully with your surgeon. In particular, seriously consider the potential benefits and risks of undergoing enhancement procedures for relatively small gains in visual acuity, and do not undergo unnecessary or unwarranted procedures.

Dry Eye

It is not uncommon for patients to experience "grittiness" in the eye following LASIK. This condition usually tends to resolve itself over the first one to three months. In the meantime, frequent and diligent application of the lubricating eye drops recommended by your surgeon will often alleviate the symptoms and speed the course of resolution.

It is important that your doctor evaluate you for dry eye prior to the LASIK procedure. Tell your doctor if you experience dry eye symptoms with contact lenses or glasses. If dryness exists prior to surgery, or if dry eye symptoms persist after surgery despite the frequent use of artificial tears, your doctor may recommend blocking your tear drainage canals with punctal plugs. This brief, painless procedure prevents your natural tears from draining away so quickly and results in improved lubrication of the surface of the eye.

Haze

Haze is the term used for a cellular reaction that occasionally develops in the corneal stroma following surface laser refractive procedures (PRK). It is the result of material being secreted from the surface cells and deposited in the anterior corneal stroma. Serious haze occurs extremely rarely with LASIK and in less than one percent of patients who have undergone PRK. Even a moderate amount of haze will not affect your vision. Following PRK, haze may be aggravated by ultraviolet light (sunlight), so it is important to wear good ultraviolet protection when in bright sunlight. Ultraviolet light does not cause haze following a LASIK operation.

Increasing the frequency of steroid drops or irrigating underneath the LASIK flap will usually enable the haze to resolve without

affecting your vision. Rarely, however, haze can cause a reduction in the crispness and clarity of vision, and possibly a reduction in best-corrected vision. This is a more serious condition. Fortunately, haze can be removed permanently with mechanical debridement combined with the application of a drug called Mitomycin C. This may restore the vision back to normal.

Corneal Abrasion

It is possible to develop a small corneal abrasion during LASIK. Despite excellent surgical technique and an adequately moistened eye, a small breakdown in the epithelial surface may develop as the flap is made. This occurs in approximately five percent of LASIK procedures because in some eyes the surface cells do not adhere well. The medical term for this is *epithelial basement membrane disorder*.

Unfortunately, surgeons cannot always detect this preoperatively. A very thin bandage contact lens may be placed on the eye by the surgeon if this occurs. It improves comfort and promotes healing. The bandage contact lens is removed in one to three days. Fortunately, the epithelium grows back so quickly that eyes with an epithelial defect usually heal within one to three days, even without a contact lens.

A variant of this epithelial basement membrane disorder may cause the epithelium to become loosened during the microkeratectomy but not fully detached. This can occur with or without incidence of epithelial defects and is treated in a similar manner with a bandage contact lens. In both cases, long-term effects are rare.

Your vision will be blurred during the time that the abrasion is healing. If a significant central defect occurs during your procedure, the surgeon may elect to wait to do the other eye until the first eye heals and has clear vision, usually one to two weeks. It is likely that your other eye will have a corneal abrasion as well when it undergoes LASIK, although lubricating drops used at the time of surgery may help to prevent it. In rare cases recurrent erosions of the cornea may occur and require further treatment. But, again, long-term effects are rare.

Night Glare and Halos

Many nearsighted patients who wear glasses or contacts have symptoms of glare or see halos or starbursts at night. This is due

to having longer eyes than normal sighted patients. Thus, when the pupil dilates at night in a near-sighted patient, peripheral light rays are scattered more before they reach the retina. It is this scattering that results in glare and halos.

These symptoms are sometimes more bothersome after laser surgery, especially if the pupil dilates beyond the size of the treatment zone. While some patients may see halos or a ghosting of images at night during the first month following treatment, it is quite uncommon for these side effects to interfere with their activities. The effects usually improve in the first three months, and the overwhelming majority of significant glare problems resolve on their own by six months. If problems with glare do persist, patients tend to benefit from weak prescription night glasses or from the use of eye drops at dusk that reduce the size of their pupils.

The side effect of glare and halos is difficult to predict. Some patients with very widely dilating pupils, large corrections, and astigmatism may be somewhat more prone to glare and halo effects. Special laser programs that allow larger treatment zones can help reduce the chance of these problems. Certain microkeratomes also allow for larger flap sizes that may help to eliminate an important type of disabling glare. It is important for your surgeon to know if you have problems with glare *prior* to your surgery.

Loss of Best Corrected Vision

A small number of patients may experience a slight loss of visual sharpness following LASIK vision correction. This means that even with your best correction, you may lose the ability to read the bottom one to three lines of the eye chart. This can be due to irregular healing or an irregular flap and may improve over the first year. Careful surgical technique and good follow-up care help minimize the incidence of this problem.

On very rare occasions, one of the above-mentioned complications may lead to a reduction in your best-corrected visual acuity. This means that even with glasses, you may lose some of the crispness and clarity to your vision and no longer be able to read the 20/20 line on the eye chart. Usually, however, the reduction in vision is modest, and you can still read the 20/30 or 20/40 line on the eye chart.

A reduction in best-corrected vision occurs when patients develop significant haze, diffuse lamellar keratitis, or persistent

striae (wrinkles or folds in the cap). All of these complications are extremely rare. A reduction of two or more lines of vision can occur in less than one percent of patients as a result. Most of the time these conditions can be reversed.

Central Islands

Another source of reduction of vision--ghost images or other visual disturbances after LASIK--is a *central island*. This is the result of a small raised area in the treatment zone that receives less laser energy and does not obtain full ablation compared to the surrounding tissue. Often, central islands disappear spontaneously after several months, but some require an enhancement procedure where the cap is lifted and a small amount of excimer laser energy is delivered to treat the raised area.

The diagnosis of a central island is made with the corneal topographer, which produces a digitized contour map of the corneal surface. A color-coded topographical map can usually identify the raised central island. When the central island is removed by additional laser treatment, crisp, sharp vision generally returns.

Some excimer laser systems, such as the VISX Star S2, have anti-island software that distributes additional pulses centrally as part of the initial treatment produced by the laser's algorithm. This software prevents the formation of central islands.

Corneal Flap Risks

For experienced surgeons, corneal flap risks are rare. If they occur, they tend to occur at the time of surgery. Typically, the flap may be too small, too short, too thin, "buttonholed," or irregular. There is also a possibility that the flap may be created without a hinge (very rare with today's newer microkeratomes). Sometimes postoperatively the corneal flap may shift slightly. Hence, it is important--especially during the first few hours--not to rub the eye or squeeze the eyelids excessively and to keep the eyes well lubricated.

If the flap shifts slightly, wrinkles (striae) may result. If these striae are present in the center of the cornea, they may distort vision and require smoothing out. This is done by lifting the original flap and ironing them out with a special instrument. When treated early, striae can usually be completely removed. Occasionally, however, they can be difficult to treat, and rarely they can lead to a reduction

in best-corrected vision.

While any problem with the corneal flap can result in the loss of best-corrected vision, the good news is that the overwhelming majority of flap-related complications are easily managed and rarely have serious consequences in the long run. If a flap complication occurs, this is the time when you hope you have a truly experienced surgeon to manage it appropriately.

If there are problems with a flap, your surgeon may elect not to go ahead with the procedure but perform it at a later date after the eye heals. Allowing the cornea to heal for two to four months is usually adequate. The incidence of visually significant, flap-related complications among experienced LASIK surgeons is less than half of one percent. It is important to understand that even if these complications do occur (though their incidence is very rare), it may take several months to get a complete return of vision following correction of the problem.

Epithelial Ingrowth

Rarely, some of the corneal surface cells (epithelium) may grow beneath the flap created during the LASIK procedure. These cells typically do not create any problem, but occasionally they can cause postoperative blurred vision or irritation. This problem can be easily identified and treated by gently lifting the flap and removing the trapped epithelial cells.

Regression

Regression refers to the tendency of the eye to drift back slightly toward its original prescription. This occurs more commonly in patients who have had PRK but occasionally occurs in patients with higher amounts of myopia, hyperopia, or astigmatism who have undergone LASIK.

If a significant regression does occur, enhancement procedures may be performed to “tune up” the original treatment, provided your cornea is thick enough to allow retreatment. Enhancements for regression are usually performed three to six months following the original procedure to allow time for the patient’s new refraction to stabilize. In some cases, glasses for night driving may be all that is needed.

Diffuse Lamellar Keratitis (DLK)

Diffuse Lamellar Keratitis--also known as the "sands of the Sahara" syndrome--is a general inflammation that sometimes arises between the corneal flap and the underlying corneal stroma.

Diffuse Lamellar Keratitis (DLK) is an extremely rare inflammatory reaction that leaves small white deposits underneath the corneal flap after LASIK. The cause of this reaction is unknown. Depending on the amount of inflammation, you may have no symptoms or you may note some haziness in your vision.

Prevention requires maintaining a clean interface between these two areas. This is aided by meticulously draping the eyelids with sterile tape to keep the eyelashes out of the surgical field and by irrigating (rinsing) the cornea to remove any debris that may be in the tear film before making the microkeratome cut. When folding back the flap, it is important to try to prevent any unwanted debris from accumulating on the interface surface. Irrigating under the flap following the application of the laser may also help to assure a clean interface.

Despite meticulous surgical technique, sebaceous secretions from the patient's own eyelid border may collect beneath the flap. This is usually of no consequence. Occasionally, microfibers from the sterile drapes or swabs may appear. Airborne particulate fibers are also occasionally seen as well as an occasional metallic fragment from the high speed keratome blade. Fortunately, most particulate matter does not cause problems unless it is in the visual axis. By drying around the edges of the eye, the surgeon insures that when the corneal flap is folded back, it will not be sitting in a pool of dirty fluid.

Postoperatively, a *topical corticosteroid* (medicated drop applied to the surface of the eye) is used to suppress inflammation. The steroid is applied for one week because diffuse lamellar keratitis peaks two to five days after surgery. Likewise, a single drop of a nonsteroidal, anti-inflammatory eye drop at the conclusion of surgery is essential. It serves to dramatically reduce pain during the first six hours after surgery.

When present, most cases of diffuse lamellar keratitis respond to treatment with corticosteroid drops. More severe cases may require that the surgeon lift the corneal flap and irrigate beneath it to remove the inflammatory cells. When recognized and treated properly, DLK

rarely affects the ultimate visual outcome; in rare cases, DLK will cause a loss of best-corrected vision.

A different form of lamellar keratitis has recently been reported, *Central Lamellar Keratitis* or CLK. CLK appears within the first twenty-four to forty-eight hours and results in a severe central collection of inflammatory debris. At times the underlying stroma is also involved. Treatment is similar to DLK. However, vision may be more often affected, resulting in the need for additional enhancements after recovery.

At the time of this writing, the exact causes of DLK and CLK are unknown. Speculation of causative factors include an inflammatory reaction related to the patient's own sebaceous secretions, reactions to methlycellulose drops, antigens from bacteria, and even immune reactions to byproducts of the laser treated cornea.

Infection or Severe Inflammation

Although infection is the most feared complication, it is extremely rare. As with any surgery, it is avoided through proper surgical technique. If it does occur, it manifests itself in the first forty-eight to seventy-two hours after treatment. That is why it is important to avoid any contact with substances that may cause infection, such as eye makeup, hot tubs, and swimming pool water, for the first week. Additionally, it is imperative that you go to all of your follow-up visits, even if everything seems to be fine. You will be using antibiotic drops postoperatively to help prevent infection. Starting these drops two days prior to surgery can further reduce your risk.

Summary

LASIK is the procedure of choice for virtually all but the most extreme myopes and hyperopes. In addition, most degrees of astigmatism can be treated. It is a very precise procedure and allows for accurate enhancements when needed.

Chapter Eleven: New LASIK Eye Surgery Technology and Options

While the most popular and widely practiced vision correction procedure performed today is LASIK, laser eye surgeons have access to a wide variety of refractive procedures that may be employed, should your particular needs not fall into the realm of LASIK. The most exciting and potentially beneficial procedures will be based on a technology known as wavefront guided laser eye surgery or Custom LASIK, which is a method of completely customizing your refractive procedure.

Custom LASIK: Wavefront-LASIK Laser Eye Surgery

Many patients do not realize that the eye is an imperfect optical system. As light rays from distant objects pass through the individual optical components of the eye, they are subject to being distorted by the imperfections found in the cornea and the crystalline lens.

The distortions that are created are referred to as “aberrations.” The vast majority--90% or more--of these aberrations create common refractive errors, such as nearsightedness, farsightedness and astigmatism, which can be treated by optical devices, like glasses and contact lenses, or by Laser Vision Correction, using the conventional methods of LASIK or PRK. The remaining 10% of optical aberrations create images which are altered by chromatic aberration, spherical aberration, diffraction, curvature of field, coma, trefoils and quadrafoils--collectively known as “higher order aberrations.” These higher order aberrations only occur in a visually significant manner in 10% to 15% of the general population. When they do occur, they are entirely unique to a particular patient--much like a fingerprint. For these patients, the

use of a wavefront-guided laser technique to create a completely customized reshaping of the surface of the cornea may be the best treatment option.

To achieve a Custom LASIK, it will require measuring the higher order optical aberrations using a wavefront analysis system called an aberrometer and then digitally interfacing it with a laser, using high speed computerized control to direct the delivery of a very tiny beam of laser energy across the cornea.

The Aberrometer Wavefront Measurement System lets the surgeon see refractive aberrations in clear and accurate, rotating 3-D images. This is accomplished by the Aberrometer sending low-energy laser light into the eye. The light reflects off the retina and travels back through the lens and cornea as an outgoing wavefront.

This wavefront is captured by the Aberrometer, which then measures it to determine both higher and lower order aberrations of the entire optical system. The aberrations are then displayed on-screen in precise 3-D images.

To then create a customized corneal ablation from the aberrometer measurements we digitally interface that data with the Excimer Laser System. The Excimer Laser System incorporates the use of a tracking system which is a high-speed computerized eye tracking method that helps the LASIK surgeon enhance your treatment by providing precise registration of the laser beam to create a customized ablation surface.

Custom corneal ablation can be performed by your surgeon, whether you have LASIK or PRK, which we will discuss next.

Photorefractive Keratectomy (PRK)

What to Expect

PRK has been performed for more than 15 years and has been proven to be a safe and effective method of Laser Vision Correction. PRK is relatively easy for your surgeon to perform and can be combined with a customized corneal ablation technique. The real work for the doctor and patient begins after the procedure when the physician has to monitor the healing process very carefully.

Laser Vision Correction with PRK

The procedure for Laser Vision Correction with PRK is very similar to that of LASIK. The biggest difference is that no microkeratome is used to create a corneal flap. Instead, the excimer laser makes its correction directly on the surface of your cornea, removing the central corneal epithelium and Bowman's membrane (the second corneal layer) in the process. This removal of the surface epithelium results in several days of discomfort and blurred vision until the epithelium regenerates. Occasionally, haziness of the cornea develops. The actual laser part of the procedure takes twenty to ninety seconds. At the end of the procedure, a clear-bandage contact lens is placed onto your eye to help keep you comfortable while the corneal epithelium regenerates (usually three to five days). A typical PRK procedure takes about five to ten minutes per eye. Operating on one eye or both eyes on the same day is a decision that is made by the patient after discussing the pros and cons of this option with the surgeon. Depending upon your prescription, the return of functional vision is sometimes prolonged with PRK so that some surgeons prefer to wait about one week before treating on the second eye.

Previous Surgery

Patients who have previously undergone certain types of surgery are sometimes a candidate for PRK as a second procedure to enhance the visual results.

Post Correction Care

Once your PRK procedure is completed, you will sit with your eyes closed for about twenty to thirty minutes. Afterward, the surgeon will check your eyes; then you will be instructed to go home and take a nap. Because your vision will be somewhat blurry, you will need to have someone drive you. Additional drops will be placed in your eyes before you go, and you will be instructed on the use of your medications. You may also be given clear plastic shields to wear at night for as long as

your doctor instructs. These prevent accidental trauma to your eyes while sleeping.

Before you go home to rest, your surgeon may also give you something to help you sleep, for sleep is the best way to keep your eyes closed for a few hours. Following the PRK surgery, you may experience some discomfort and blurriness of vision that can last for a few days. Tylenol®, aspirin, ibuprofen, or similar over-the-counter pain medications are usually adequate to keep patients comfortable. Your doctor may give you a prescription for a stronger pain medication, such as Vicodin® or Percocet®, in case your pain is more severe. You will also use antibiotic eye drops, anti-inflammatory eye drops, and lubricant eye drops to promote healing. Nonpreserved anesthetic drops sometimes may be used sparingly, no more than four or five times over the first twenty-four hours. Excessive use of anesthetic drops is toxic to the cornea and will prevent healing.

You can expect your vision to be fairly blurry, and your vision may worsen over the first three days. It will then begin to improve.

Guidelines for Healing

Follow these guidelines to promote safe and rapid healing:

- Rest. Sleep aids recovery.
- Place a cold compress over your closed eyelids while resting. It is soothing.
- Particularly in dry climates, apply nonpreserved lubricant eye drops very frequently. This encourages rapid recovery and enhances comfort. (Some patients may need these drops every half-hour the first few days, every couple of hours the first week, and at least four times daily for the first three months.)
- Sensitivity to light is normal and will improve. Wear good ultraviolet-protecting sunglasses.
- Avoid rubbing your eyes.
- Avoid swimming, surfing, and hot tubs for at least two weeks.
- Showers and baths are fine, but avoid getting water and shampoo directly into your eyes for the first few days.
- Avoid dusty or smoky environments.
- Avoid eye makeup for one to two weeks.
- It may be a good idea to plan on not driving until you feel your vision has improved. You may drive as soon as you are visually comfortable. With PRK this may be a week.

Postoperative Follow-up Schedule

When you leave the laser center, you will be given complete instructions to follow, including a postoperative appointment schedule similar to the following:

Purpose of Appointment	Time Frame Following PRK Procedure
• To ensure that your eye surface is healing properly	1 day
• To ensure that there is no evidence of infection and to remove the bandage contact lens	2-4 days
• To ensure that your eye is healing properly	1 week - 1 month
• To measure your visual progress	2-3 months
• To check your eye pressure if you remain on medication and to measure the stability of your result	4, 6, 12 months

The PRK Recovery Cycle

Your vision may get worse for the first three days. However, you will notice an improvement in your vision by about day five, and it will continue to improve for several weeks. Most patients can return to work and resume most normal activities after three to five days. However, it may take as long as three months for your vision to stabilize.

During this period, you must continue to use the postoperative steroid drops as your doctor suggests. Deviations from this regimen may lead to haze (scarring of the cornea) or regression of the refractive result. You may be asked to use the drops for up to three months; the exact frequency of usage may be modified at each visit.

Be sure to keep your follow-up appointments as your eye drop regimen may be altered. Also, the doctor needs to monitor your eye pressure while you are on postoperative steroids.

With PRK, your vision usually becomes completely stable within six to twelve months. Once your vision is stable, your treatment is permanent. You will then have less dependence on, and maybe complete freedom from, glasses and contact lenses.

Complications with PRK

The potential complications that may arise from PRK are similar to those in LASIK (see Chapter Ten, “Risks and Complications”). They include unrealistic expectations, undercorrection, overcorrection, induced astigmatism, dry eye, haze, night glare and halos, loss of best-corrected vision, regression, and infection or severe inflammation.

Regression occurs when a patient appears to be adequately treated on the first few postoperative visits, but over the next several weeks to months begins to return toward the original prescription. The amount of regression is usually small; however, occasionally it is visually significant and requires an enhancement procedure. The enhancement procedure is usually performed three to six months following the original procedure. This allows for the refraction to stabilize. Regression occurs more commonly after PRK than after LASIK, and it is more common after PRK and LASIK in patients with higher amounts of myopia, hyperopia, or astigmatism. Enhancement following PRK involves a prolonged healing cycle similar to the initial procedure.

The most common complication following PRK is trace amounts of haze, but even a moderate amount of haze will not affect your vision. If haze does develop during the postoperative period, your surgeon may increase the frequency of steroid drops or even surgically irrigate your eye to alleviate or lessen the haze. Serious haze occurs in less than one percent of all patients who have undergone PRK; it is more common with higher corrections but can occur with low corrections. Symptoms of serious haze can by eliminated with treatments that mechanically remove the haze concurrent with applications of the drug Mitomycin C.

Pros and Cons of PRK

Pros	Cons
• As effective as LASIK for low levels of correction • Reduced surgical risk (no flap) • Preferred treatment for certain patients, those with history of basement membrane disease • Recurrent corneal erosions • Thin corneas • Previous glaucoma surgery • Superficial corneal scars	• Greater incidence of serious postoperative pain • Slower recovery (up to four weeks) • Greater incidence of serious postoperative haze • Possible inability to have surgery on both eyes on the same day • Need for medicated eye drops for about three months • Possibility of late-onset corneal haze from sunlight (ultraviolet light) • Contraindicated in patients with a history of keloid formation

Intacs™ Corneal Ring Segments

Approved in April 1999, the *Intacs™ corneal ring segments* offer patients with mild myopia and minimal astigmatism another option for correcting their nearsightedness. Currently, the rings are approved for correction of nearsightedness up to 3.00 diopters in patients twenty-one years or older who have no more than 1.00 diopter of astigmatism. This procedure does *not* correct astigmatism, and patients who have astigmatism--even less than 1.00 diopter--need to understand they will be astigmatic postoperatively.

The procedure involves inserting two small plastic “ring” segments in the peripheral cornea through small incisional channels. A temporary suture is then used to close the incision. The rings cause the central cornea to flatten. The advantage of Intacs™ is that the tiny ring segments may be removed if the patient wishes to reverse the correction.

In most patients in the clinical trials, when the rings were removed, the eyes went back to their preoperative state. In a few patients, they did not. Because of those few patients whose eyes did not return exactly to their preoperative condition, the FDA will not allow the use of the term "reversible," but Intacs™ are removable if desired.

Intacs™ insertion is accomplished in a time frame slightly longer than LASIK, taking roughly fifteen minutes per eye under anesthetic drops. The recovery of clear vision seems to take slightly longer than LASIK and doesn't seem to have quite the "wow" effect of rapid visual recovery. In addition, patients tend to experience more postoperative discomfort. The procedure is newer than LASIK or PRK, so it doesn't yet have the track record that the other two procedures do.

The cost of Intacs™ is roughly equal to or more than LASIK in most centers. Removal of the rings, either for fine tuning the result or from dissatisfaction, is accomplished with a second surgery. The segments are removed, the eyes are allowed to heal, and an alternate procedure (such as LASIK or PRK, or a change in ring size) may be performed once the eyes have healed. The treatment range for Intacs™ is currently very limited, and they cannot treat astigmatism; hence, patients with astigmatism are not good candidates for Intacs™.

Astigmatic Keratotomy (AK)

Astigmatic Keratotomy (AK) is similar to RK, but its purpose is to correct astigmatism. Usually, two incisions are made in the cornea in such a way as to make it more round (analogous to loosening the laces on a football). This procedure is often combined with radial keratotomy (RK) and has a similar long track record.

AK is still considered an excellent procedure for correcting pure astigmatism (patients without coexisting nearsightedness or farsightedness). AK can also be used to enhance the results of LASIK and PRK by correcting small residual amounts of astigmatism. However, most surgeons prefer to correct astigmatism with the excimer laser.

Cataract Surgery

For patients with significant cataracts who are looking for an option for correcting their nearsightedness or farsightedness, cataract surgery presents the best option for achieving this goal. After removing the cataract with ultrasonic power, the surgeon can implant a lens that will reduce or eliminate nearsightedness and farsightedness. With the development of new toric intraocular implants, astigmatism can also be treated.

This procedure is not performed in younger patients without cataracts because the surgery involves entering the eye and, therefore, slightly increases the risk of more serious complications. The surgery also involves removing the natural crystalline lens, which in young people allows them to focus up close. LASIK surgery, which leaves the lens intact, is a better option for younger patients.

Automated Lamellar Keratoplasty (ALK)

Automated Lamellar Keratoplasty (ALK) is a refractive procedure that was done on high myopes prior to the invention of the excimer laser. It is similar to LASIK in that it uses a special instrument called a microkeratome to separate the surface layer of the cornea. This "flap" is temporarily folded back (similar to the first part of the LASIK procedure), and a thin disc of corneal tissue is removed with a second pass of the microkeratome. The procedure is much less precise than LASIK and was associated with a much higher complication rate. It is primarily used to correct large amounts of myopia.

Satisfactory results are not always obtained the first time though, and a high percentage of eyes need additional procedures to achieve the desired result. Sometimes an irregular corneal surface results from the procedure, causing some distortion of vision.

Automated lamellar keratoplasty is rarely performed today due to the advent of LASIK. LASIK has essentially replaced ALK because of the increased accuracy afforded by the excimer laser in making the second "cut."

Radial Keratotomy (RK)

Until recently, *Radial Keratotomy* (RK) was the most commonly performed refractive procedure for nearsighted patients. With the aid of a high-powered microscope, the surgeon makes a series of radial microscopic incisions (usually between four and eight) on the surface of the cornea in order to reduce its curvature. This procedure is well suited for patients with low myopia and has been used for over twenty-five years. A form of RK called *mini-RK* is still used occasionally for very minute degrees of nearsightedness, such as those resulting from slight undercorrections in LASIK.

Although rarely performed as a primary procedure anymore because of the increased accuracy and stability of the excimer laser techniques, RK is still an effective vision correction technique and is used in those areas of the world that do not have access to the much more expensive laser technologies.

Bioptics

Bioptics is a combination procedure involving a phakic intraocular lens implant followed by LASIK. It is recommended for the most extreme levels of myopia and hyperopia when neither technique alone will entirely correct the refractive error. This combined technique can be used to correct over 30.00 diopters of myopia--nearly twice the maximum amount of myopia that can be safely corrected with LASIK.

Clear Lens Extraction (CLE)

Clear Lens Extraction (CLE) involves removing the internal lens of the eye, just like in a cataract operation. This is done with a special ultrasound instrument and may be done with eye-drop anesthesia (similar to LASIK). The procedure can be performed without the need for stitches. A flexible synthetic lens implant of the proper power is then placed inside the eye through an extremely small incision to correct the refractive error.

This procedure is more commonly performed for treating higher levels of farsightedness in patients over age forty. The optical results are excellent and the visual recovery period is brief. Clear lens extraction may also be used to correct higher levels of nearsightedness and may be fine tuned with LASIK if a small refractive error remains. Some surgeons have used this procedure to treat extremely nearsighted or farsighted patients who are not candidates for PRK or LASIK.

The major drawbacks of this procedure are the increased risk of postoperative retinal detachment, the increased risk of intraocular surgery, and that patients usually need reading glasses afterward. An intraocular lens called the ARRAY® is a multifocal lens that can be implanted at the time of lens extraction. The ARRAY intraocular lens allows you to see both near and far after the operation. In order for it to work to its maximum potential, both eyes should be implanted with the lens. Because of its multifocal capacity, some patients experience a loss of contrast at night and also develop halos around lights. If these symptoms become problematic, the ARRAY lens can be removed and replaced.

Conductive Keratoplasty (CK)

Our 40's present us with the inevitable need for bifocals or reading glasses. A recently FDA approved vision correction option, called Conductive Keratoplasty, or CK may be a solution for some. CK is a simple, non-laser technique that can be used to restore the ability to see close-up and even read small print.

Although you might have perfect distance vision, your ability to see close objects and the ease with which you can shift your focus between distant and close objects, begins to decrease at about age 40--and usually continues to slowly, but progressively, worsen with age. Currently, more than 70 million Americans who are over the age of 40 are farsighted or have difficulty reading small print at close distances. For many of these people, CK may offer an alternative to bifocals or reading glasses.

CK uses a precisely controlled emission of radio frequency (RF) energy to reshape the cornea. CK does not use a laser or require cutting or removal of any corneal tissue. Since it is considered minimally invasive, the CK procedure avoids the risk of most surgical procedures.

In CK, a few numbing drops are placed in your eye so that you are comfortable. A circular treatment pattern is placed on the cornea, using easily rinsed ink. The surgeon then uses a tiny probe--thinner than a strand of human hair--to apply the RF energy to the cornea in the circular pattern, in order to shrink small areas of corneal tissue. This circular shrinkage pattern causes a fine band of tissue to contract, similar to tightening the belt around your waist. This results in the cornea becoming steeper and increasing its focusing power.

CK is quick, usually taking less than three minutes per eye. CK is performed in the comfort and convenience of the surgeon's office. The majority of CK patients are able to return to work and other normal daily activities the day after treatment. Many experience improvement in their vision almost immediately. The full effect of CK usually takes a few weeks as your eyes adjust to the treatment.

Laser Thermal Keratoplasty (LTK)

For low amounts of farsightedness, a technique called *Laser Thermal Keratoplasty* (LTK) is a possible method of thermally changing the shape of the cornea. A special holmium laser is used to deliver laser energy to the peripheral cornea to slightly tighten the fibers and thereby steepen its curvature. The technique only seems to work for low amounts of farsightedness.

The Sunrise Hyperion™ LTK System received FDA approval for the treatment of hyperopia (0.75 to 2.50 diopters) in January 2000. The procedure is noncontact, takes less than three seconds per eye, and is performed with the patient seated. Many doctors see the benefits of the LTK system for treating not only low degrees of hyperopia, but also

occasional overcorrections from LASIK procedures. Although not a cure for presbyopia, some physicians are using LTK to create monovision in patients, thus treating presbyopic symptoms by reducing or eliminating the need for reading glasses.

Phakic Intraocular Lens (PIOL) Implants

Implantable contact lens technology has arisen out of the incredible advances in modern cataract surgery. Current technology allows ophthalmologists to insert flexible intraocular lenses (used to replace the natural lens after cataract surgery) through extremely small incisions. The lenses are flexible enough to allow folding and insertion through a small incision opening.

Once in the eye, the lens expands to its full size, allowing the eye to remain relatively untraumatized, thus reducing astigmatism and recovery time. This same “small incision” lens technology allows the surgeon to insert an even thinner, foldable lens in front of the natural lens to correct nearsightedness or farsightedness.

A *Phakic Intraocular Lens* (PIOL) is a lens implanted inside the eye for the correction of either extreme nearsightedness or extreme farsightedness. In effect, the lens becomes an internal contact lens rather than a contact lens on the surface of the eye. It is usually recommended for patients whose visual correction is outside the range that can safely be treated with LASIK.

Because of the slightly increased risk of more serious complications, the PIOL is reserved for high amounts of nearsightedness or farsightedness--above the current limits of LASIK. In places where this technology is available, surgeons are implanting the PIOL in patients with myopia greater that 12.00 to 15.00 diopters and hyperopia greater than 4.00 to 6.00 diopters.

Despite the excellent outcomes in most cases, complications associated with the implants are currently the biggest concern. Specifically, in the early studies a small percentage of patients developed cataracts shortly after implantation of the lens. There is also a small risk of *endophthalmitis* (infection within the eye) because the surgical incision actually enters the eye. This rare complication could lead to complete loss of vision. Endothelial cell loss with some lens designs is also a concern and is being studied rigorously.

Some ophthalmologists in the United States are currently performing this procedure as part of an FDA clinical trial. The procedure holds

a lot of promise for extremely nearsighted or farsighted individuals. Ophthalmologists are anxious to see how the implantable lenses fare in current studies using newer lens designs and implantation techniques.

These lenses are currently being used in Europe and South America with very high success rates. The results will be presented to the Food and Drug Administration with the hope that the FDA will authorize other eye surgeons to use this exciting new technology.

Surgery for Presbyopia

One of the more exciting areas of ophthalmology is the surgical treatment of presbyopia, the stiffening of our natural lens that decreases near vision as we age. Several devices and surgeries have been tried, all of which direct their effect at enlarging the circumference of the front of the eye and tightening the fibers that control the focus of the lens.

One of the principle theories of presbyopia suggests that these fibers stretch and become less effective as we age. By enlarging the circumference of the eye, the fibers should once again become tight and thus effective at focusing the lens.

Anterior Ciliary Sclerotomy (ACS)

Anterior Ciliary Sclerotomy (ACS) is a surgical procedure for relieving presbyopia. It involves the creation of several small incisions in the sclera (coating of the eye) directly over the muscle that controls the eye's natural lens. The purpose of this procedure is to expand the circumference around the equator of the eye.

Scleral Expansion Bands (SEB)

Scleral Expansion Bands (SEB) is another procedure for relieving presbyopia. It consists of a number of thin silicon bands implanted in the sclera to stretch or expand the equator of the eye in order to restore accommodation (the ability to read without corrective lenses after age forty-two).

The theory behind both procedures is that expansion of the eye will allow increased room for the eye's natural crystalline lens to move normally, enabling the eye to see near objects again. These procedures are still being investigated in the United States.

To date, there is much controversy about both the theory and the effectiveness of these types of surgery. Until scientific studies show more consistent results, monovision and reading glasses or bifocals are still the best options for treating presbyopia.

Chapter Twelve:
Questions and Answers

What Is the Difference Between PRK and LASIK?

Both procedures use the excimer laser to reshape the cornea and correct nearsightedness, farsightedness, and astigmatism. The difference is that with PRK the laser is used on the surface of the eye, while in LASIK the laser work is performed under a thin, protective, corneal flap. The long-term results of both procedures are similar. Additionally, visual recovery with LASIK is usually faster, with less discomfort and less possibility of scarring.

With PRK, postoperative drops are needed for up to three months, whereas with LASIK, medicated drops are only needed for five to seven days. Since its advent, LASIK has become the procedure of choice over PRK.

Does LASIK Hurt?

Before the LASIK procedure begins, your eye is made numb by drops. While you may feel a pressure sensation as the corneal flap is being made, actual pain is rare. Any discomfort you may feel subsequent to the LASIK procedure will last only a few hours. Sleep and lubrication, as well as Tylenol® or ibuprofen, are usually enough to counteract any discomfort.

Can You Guarantee 20/20 Vision?

As with any surgical procedure, there are no guarantees. Although the results are extremely good (ninety-five percent of patients in national studies no longer need glasses for driving), the results of the procedure depend on your initial refraction, your own healing characteristics, and other factors. It is good to look at LASIK vision

correction surgery as a way of achieving an extreme decrease in your dependence on glasses or contact lenses. If 20/20 vision is not obtained after the primary LASIK procedure, enhancements may be effective to further improve vision. 20/20 can only be achieved in patients who have the potential to obtain 20/20 vision. For example, LASIK performed on a patient with a lazy eye that can only see 20/40 will only achieve 20/40 best-corrected vision.

Has Anyone Ever Gone Completely Blind from Their LASIK Procedure?

No. In over 1.7 million cases done worldwide, no one has ever gone completely blind from a LASIK or PRK procedure, although you can lose a significant amount of vision if the procedure is not performed correctly or if you develop an extremely rare complication, such as an infection.

Can Both Eyes Be Done at Once?

LASIK is often done on both eyes at the same sitting. The results are so predictable and the procedure safe enough that most people undergoing LASIK surgery prefer to have both eyes done on the same day. The advantage of bilateral surgery is the convenience of having both eyes done at once. It also restores your balanced vision as quickly as possible, especially if you are unable to wear a contact lens in the unoperated eye.

If you undergo PRK, however, you may want to have your eyes done on consecutive weeks as it may take a few days for functional vision to return. By doing one eye at a time, you can rely on the other while the postoperative eye is healing. Additionally, surgeons may elect to do one eye at a time in patients with extreme myopia, as these patients can be less predictable in terms of their response to the laser.

One theoretical advantage of unilateral surgery is that if one eye should become infected, the second eye would have an increased risk for this complication if it were treated concurrently. Infection turns out to be a very rare occurrence, so this advantage becomes more of a theoretical benefit than a real one. Another theoretical advantage quoted by proponents of unilateral surgery is that the results of the first eye can be used to fine tune the results of the second. Again, in practice this turns out not to be clinically significant in most cases.

At the time of your consultation, you will be advised of the advantages and disadvantages of both options. The final decision should be based on your surgeon's recommendations and your desires.

What Are the Results of LASIK Surgery?

Results may vary from surgeon to surgeon and from center to center. Results also vary depending on your initial refractive error. With higher amounts of myopia, hyperopia, and astigmatism, results are less predictable and retreatments are more common. It is important to ask your surgeon about his or her experience and results.

How Long Will the Correction Last?

Once your eye has stabilized (which is about three months with LASIK and six months with PRK), your correction is permanent. Any additional need for glasses after that will be the result of normal aging processes that befall everyone and not due to any instability of the refractive procedure.

What about Enhancement Surgery?

In the event that you are undercorrected or overcorrected, it is possible to perform an additional treatment. But first your eye must stabilize. Typically, retreatment with LASIK usually takes place two to three months after the original procedure. With PRK this can occur after about six months to one year. In PRK, the front surface of the cornea is treated again, and the recovery time is a week to a month.

With LASIK, the corneal flap may not need to be recreated. Using specialized instruments, the surgeon can gently lift the preexisting flap and perform additional laser work. Recovery time is similar to the original procedure. Such enhancement surgery is usually not an additional charge but is considered part of the original fee if performed within a specified time after the original surgery.

I Have "Dry Eyes." Will This Affect My LASIK Surgery?

Many patients seeking refractive surgery do so because they have dry eyes and are unable to wear contact lenses anymore. It is important that your dry eyes be treated. This usually involves the use of tear supplements and punctal plugs (tiny silicone plugs placed in the tear drainage openings of your eyelid) that delay the drainage of your own tears so your eyes will stay moist.

After the procedure, your operated eye may feel temporarily drier because the corneal nerves are severed during LASIK surgery,

causing the eye to make fewer tears. This condition is temporary and typically lasts three to six months.

Dry eye symptoms can be particularly noticeable if you use the computer frequently, read for long periods of time, or drive extended distances. These types of activities exacerbate dry eyes because they cause you to stare and not blink as often. It is important to use ample lubrication, especially during the first few months after surgery.

If I Need to, Can I Wear Contact Lenses after Surgery?

If you have a residual refractive error and you choose not to have an enhancement procedure, you may elect to wear contact lenses. With PRK you may need to wait up to three months; with LASIK you may wear contact lenses within a few weeks. If you were a good contact lens wearer before LASIK, it is unlikely you will have problems afterward.

What Is Monovision?

In patients in their mid-forties who are already experiencing difficulty with reading in their distance correction, it is possible to treat one eye for near vision and the other for distance vision, thus decreasing the necessity for both near and distance glasses.

If you are considering monovision, it is advisable to try it out with contact lenses before proceeding directly to LASIK surgery. If you have already been successful with monovision in contact lenses, you will most likely enjoy this type of correction following PRK or LASIK. If you are over forty and hope to avoid glasses altogether in your life, this is presently the only way to accomplish this.

Can There Be a Problem with My Eyes Twenty Years from Now Because I Had LASIK?

This is very unlikely. LASIK is a form of lamellar refractive surgery, and lamellar refractive surgery (myopic keratomileusis) has been performed since 1949. Patients who have undergone these related but less accurate and more invasive procedures fifty years ago have not developed any unusual problems.

Can I Have Cataract Surgery If I Need It in the Future?

Yes. The surgical technique used will not change. However, your lens implant will be calculated using a different formula.

Will Having LASIK Prevent Me from Getting Other Eye Diseases?

No. LASIK does not prevent cataracts, glaucoma, retinal detachment, macular degeneration, or any other eye disease. Ophthalmologists term LASIK as *disease neutral*: It doesn't cause disease, it doesn't prevent disease, and it doesn't prevent diseases encountered in the future from being treated.

A Note on Retinal Detachment: Severely nearsighted people are at greater risk for retinal detachment. Generally, the more nearsighted one is, the greater the risk. It is important to understand that after LASIK or PRK, the eye is still anatomically myopic (structurally too long) and subject to the same retinal detachment risk as before the procedure.

Is LASIK Approved by the Food and Drug Administration?

In 1995 the FDA approved the use of the excimer laser for the treatment of myopia using PRK. In recent years LASIK has gained popularity in many practices and has become the procedure of choice worldwide. Since 1999, the Food and Drug Administration approved LASIK when performed with a number of laser systems including the VISX Star S2, S3 and S4 and the Alcon Ladarvision® Excimer Laser System.

What Does Laser Vision Correction Surgery Cost?

PRK costs from $1,500 to $3,000 per eye, depending on your area of the country, the laser used, the experience of your surgeon, and the services covered. LASIK, because of higher material costs, may cost a little more. This fee usually includes the surgery, a post-op kit containing medication and sunglasses, follow-up care, and any enhancement procedures during the first year. It typically does not include the cost of temporary glasses or contact lenses, if needed. Affordable payment plans are usually available to qualified candidates. Please ask about payment options available and services that are covered.

One way to save substantially is to use flexible benefit or medical savings accounts to pay for the procedure using pretax dollars. Ask your employer's benefits administrator about flexible benefits. Laser vision correction practices often have a financial counselor available to discuss payment options and covered services.

Will Insurance Companies Pay for LASIK Surgery?

Some insurance companies will pay for the procedure, but that is the exception rather than the rule. It doesn't hurt to ask.

Who Is a Candidate for LASIK Vision Correction?

You must be at least eighteen years old and have a stable prescription. Good candidates have myopia up to -14.00 or hyperopia up to +6.00. Your level of astigmatism may be as high as 6.00 diopters. You cannot be pregnant or nursing, have any unstable medical condition, or any uncontrolled eye diseases. It is also important that you have reasonable expectations.

Who Is Not a Good Candidate for LASIK Surgery?

- Anyone whose prescription is actively changing more than one diopter per year.
- Pregnant or nursing mothers with unstable refractions.
- Anyone who feels that he or she must absolutely gain 20/20 vision without glasses or contact lenses. (No surgeon can guarantee 20/20 vision without correction. Think of it, instead, as achieving a vastly decreased dependency on glasses and contact lenses.)
- Anyone unwilling to accept the possible risks and complications of LASIK surgery.
- Anyone with an uncontrolled or untreated eye disease. Certain corneal dystrophies or a history of *herpetic keratitis* (a herpes infection in the eye) may be relative contraindications, as are certain arthritic syndromes and other autoimmune disorders.
- Anyone on certain medications such as Acutane, etc.

When Can I Drive?

With LASIK you can usually drive within one to three days. With PRK you should probably not drive for a week. This depends on whether you have one eye done at a time or have simultaneous surgery on both eyes. The Department of Motor Vehicles typically grants unrestricted driving privileges to individuals who possess 20/40 or better vision. Over ninety percent of all patients who undergo LASIK surgery have this level of vision or better by the first day after their procedure.

When Can I Return to Work?

With PRK you should plan on taking off at least two days if you have both eyes done simultaneously, as you will experience some

discomfort and your vision will be fairly blurry. With LASIK the majority of patients can return to work the next day, although it is advisable to take twenty-four hours off following surgery on both eyes. If you work in a dusty environment, you should wait forty-eight hours prior to returning to work.

While most patients can function normally at work the day after their LASIK procedure, we recommend that you not schedule any unbreakable appointments or meetings on that day. If your recovery is delayed slightly, you will still be able to accommodate the delay without any undue stress.