Better Sight for Flight

Although laser eye surgery is growing in popularity, some aeromedical specialists warn that — for pilots — it may carry risks.

BY LINDA WERFELMAN

Increasing numbers of pilots are choosing surgery over eyeglasses or contact lenses to correct some vision problems.

As medical personnel have gained experience with refractive surgery — so named because its goal is to correct refractive errors, another name for defects such as nearsightedness, farsightedness and astigmatism that interfere with the eye's proper focusing and therefore cause a reduction in visual acuity — and as new surgical procedures have been developed, acceptance of the procedures has increased among aeromedical authorities.

Nevertheless, these procedures are not without risks, including loss of pilot medical certification.

"These technologies advance so fast, typically to fill a public need, but they

don't always fill a pilot's need," said Dr. William A. Monaco, a specialist in aviation optometry (see "Consider This…").

With normal vision, light enters the cornea, the transparent dome at the front of the eye. The cornea bends — or refracts — the light, which then passes through the pupil to the lens, which focuses the light on the retina, the eye's innermost lining. The retina converts the light into electrical signals, which travel along the optic nerve to the brain, where the image is interpreted (Figure 1, page 14).

In nearsightedness — also called myopia — the cornea bulges out, increasing the distance light must travel from the cornea to the retina; as a result, light rays focus in front of the retina instead of on it, and this makes distant objects appear blurred. In farsightedness — also called hyperopia — near vision is blurred because the cornea is not curved enough or the eyeball is too short from front to back and, as a result, light rays focus behind the retina. In astigmatism, the shape of the cornea is irregular; as a result, light rays focus at more than one point, and blurred vision results.

For years, refractive surgery was performed to correct only nearsightedness, but new techniques are being used today to correct farsightedness and astigmatism. Surgery also is available to correct presbyopia, an age-related difficulty in focusing on near objects that begins to affect people in their 40s and 50s.

Blades and Lasers

Some eye specialists trace the concept of refractive surgery to attempts in the mid-1800s to flatten the bulge in the cornea by applying a spring-mounted mallet through a closed eyelid.[1] Most, however, say that the first refractive surgeries were performed in the 1930s and '40s by researchers in Japan who made incisions in the cornea to flatten it and correct nearsightedness. In the 1960s, a Soviet physician refined the process — known as radial keratotomy (RK) — which involved use of surgical blades and a standardized formula for vision correction; this was the first type of refractive surgery to be widely performed.

Today, RK is rarely used. In its place, new types of surgical procedures have been developed, many of which are performed with a high-energy laser light known as an excimer laser, which disrupts and vaporizes the molecules in the surface of the cornea. Like RK, these procedures reshape the cornea so that light focuses properly on the retina.

The first procedure performed with the excimer laser was photoreactive keratectomy (PRK), in which the outer layer of the cornea is removed and the curved part of the cornea is reshaped by the laser. When PRK was introduced in the late 1980s, it was used only to correct

Consider This …

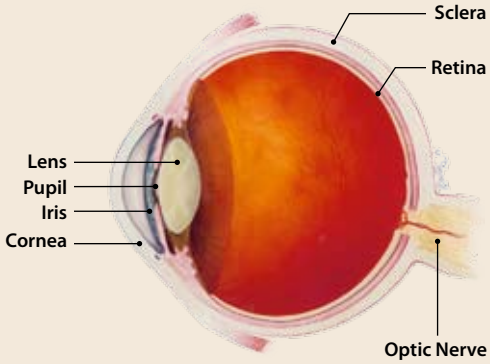
Pilots considering refractive surgery should think carefully about several factors, including:[1]

- For some patients, complications are unavoidable and may be permanent;
- Some aviation employers prohibit certain refractive procedures;
- Medical insurance usually does not pay for refractive surgery;
- People with "refractive instability" — a change in a contact lens or eyeglasses prescription in the previous year — usually are not good candidates for refractive procedures. Neither are people who have experienced some eye diseases, eye injuries or previous eye surgeries;
- People with dry eyes may find the condition aggravated by refractive surgery, and the procedures may place those with an eyelid inflammation called blepharitis at increased risk of infection or inflammation of the cornea;
- People with large pupils could be at increased risk of postoperative side effects such as glare, double vision and the appearance of halos around lights; and,
- People with unusually thin corneas may face increased risks of blindness.

Note

1. U.S. Food and Drug Administration. *LASIK Eye Surgery: When Is LASIK Not For Me?* <www.fda.gov/cdrh/LASIK/when.htm>.

The Eye



Source: U.S. National Eye Institute, National Institutes of Health

Figure 1

low-to-moderate nearsightedness; later, treatments were developed for higher levels of nearsightedness, as well as farsightedness and astigmatism.

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The most common procedure in use today is laser-assisted *in situ* keratomileusis (LASIK), which combines the excimer laser and a knife blade called a microkeratome. An eye surgeon uses a microkeratome to cut a flap in the outer layers of the cornea and an excimer laser to remove underlying corneal tissue; the flap is then replaced. The procedure originally was used on very nearsighted patients, but recent advances have allowed for its use to also treat those with farsightedness, astigmatism and lower levels of nearsightedness.

A report by the U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute said that, in comparison with patients who underwent PRK, LASIK patients "experienced less pain, stabilized faster, had less regression, did not require extended use of topical steroids and had fewer complications and side effects."[2]

Nevertheless, LASIK also "requires a greater surgical skill and therefore does have a greater risk of surgical complications," the report said.

A number of related LASIK procedures have been developed in recent years, including IntraLase, which eliminates the need for surgical blades, and wavefront — or custom — LASIK, in which the surgeon is guided by three-dimensional measurements of how the eye processes images.

According to 2003 data, 15 million LASIK procedures had been performed worldwide, about half of them in the United States, where they continue at a rate of about 1 million a year.[3]

A procedure similar to LASIK is laser-assisted subepithelial keratectomy (LASEK), in which an eye surgeon cuts a flap not in the cornea but in its protective covering, or epithelium, before removing corneal tissue and replacing the flap. Because LASEK requires the removal of less of the cornea, it sometimes is recommended instead of LASIK for people with thin corneas.[4]

These procedures — LASIK, LASEK and PRK — vary somewhat when they are used to treat farsightedness and astigmatism. For farsightedness, the procedure involves removal of tissue in a way that steepens the dome of the cornea. For astigmatism, the surface of the cornea is smoothed out.

Other relatively new techniques for correcting refractive errors include implants of phakic intraocular lenses (IOLs), placed into the eye, near the eye's lens, to correct nearsightedness or farsightedness. Manufacturers say that the advantages of IOLs, in comparison with laser surgery, include less risk of side effects such as glare or the appearance of "halos" around lights; in addition, in case of problems with an IOL, it can be removed. Risks include the possibility of damage to the eye's lens and an increase in intraocular pressure (pressure within the eye), which can be remedied with medication or surgery.[5]

Farsightedness and astigmatism — but not nearsightedness — also have been treated with conductive keratoplasty (CK), in which a thin probe is used to release radio-frequency energy to reshape the cornea.[6]

Another procedure, originally performed on patients with cataracts, is refractive lens exchange, also called clear lens extraction; it replaces the eye's natural lens with an artificial one. Risks are similar to those experienced by patients undergoing cataract surgery and include slightly increased chances of a detached retina.[7]

Corneal implants — clear, partial-ring-shaped pieces of the same kind of plastic used in IOLs — can be surgically implanted in the cornea to flatten it and thereby improve vision for people with nearsightedness. Side effects may include eye irritation, abnormal growth of blood vessels and glare. The implants can be removed if patients are not satisfied with the results.[8]

Monovision

In the past, eye specialists believed that presbyopia could not be corrected by surgery, but in recent years, techniques have been developed to treat presbyopia by using LASIK, LASEK, PRK or CK. The treatments are designed to produce monovision — a condition in which one eye is corrected for optimal distant vision and the other eye is corrected for optimal near vision. Because some people have difficulty adjusting to this correction, specialists typically recommend that they be fitted with monovision contact lenses for a time before deciding to undergo refractive surgery.[9]

After a pilot undergoes a monovision procedure, he or she needs time to adjust to the change in perceived visual cues involving depth perception, said Dr. Anthony Evans, chief of the International Civil Aviation Organization (ICAO) Aviation Medicine Section.

In addition, the FAA, which recently modified its policies to allow pilots to undergo monovision refractive surgery, said in an informational brochure for pilots that those who have blurred vision and difficulty performing visual tasks in low-light conditions, such as night driving, typically are not good candidates for monovision procedures.[10]

Other procedures also are available, including implantation of multifocal IOLs or corneal inlays and a procedure called anterior ciliary sclerotomy, in which incisions are made in the sclera — the white part of the eye — to create more room for the ciliary muscles, which help the eyes focus. One relatively new theory about presbyopia is that it begins when the eye's lens grows into the space used by the ciliary muscles, preventing muscle contraction that would help the lens change its shape and focus.[11]

'Rarely Any Reason'

ICAO, noting the considerable experience worldwide with refractive surgery, the infrequent complications and the success rates for some procedures of more than 95 percent, allows all of the surgical procedures and says that a pilot who has undergone any of them can be considered fit for flight duties "as long as there has been a good recovery," Evans said.

A draft version of the "refractive surgery" section of the upcoming edition of ICAO's *Manual of Civil Aviation Medicine* says, "Applicants who have had refractive surgery and are being considered for medical certification or recertification should meet the following criteria: The surgery is uncomplicated; vision is stable; there is no corneal haze and no complaints of glare, halos or 'ghosting'; the [applicant] meets the visual requirements of Annex 1 [*Personnel Licensing*] and the assessment must be based on measurements made by a qualified vision care specialist; [and] there should be follow-up examinations by a qualified vision care specialist six months after return."[12]

Some civil aviation authorities have stricter rules. For example, European requirements do not allow for medical certification of pilots whose uncorrected vision was very poor before they underwent the procedure.

The ICAO draft says that, despite the increasing use of refractive surgery, "there is … rarely any reason for an applicant to submit to refractive surgery in order to meet the visual requirement, and it is important that applicants understand this."

In addition, the draft says, "Individuals contemplating refractive surgery must

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be made aware of the risks involved and should be told that having the surgery might result in a delay in return to duties as aircrew or air traffic controller or, if complications occur, in the permanent loss of medical certification."

Monaco agreed, and said that when pilots consult him about the advisability of refractive surgery, he urges them to consider all possible outcomes.

"By regulation, these procedures are all acceptable for pilots, but they're not appropriate for every pilot," he said. "A small percentage of LASIK patients have had complications, very severe complications. … I would want my patients to know what the downsides are before they consider having surgery, and … if there are less invasive ways of dealing with a [pilot's vision] problem, that's what I'd recommend."

The FAA said that pilots considering LASIK should know that, although "the majority of patients do experience dramatic improvement in vision after laser refractive surgery, there is no guarantee that perfect [uncorrected visual acuity] will be the final outcome. …

"While the risk of serious vision-threatening complications after having LASIK is low (less than 1 percent), some complications could have a significant impact on visual performance in a cockpit environment."[13]

Those complications include an extended healing period of three months or longer; a one in 50 chance of experiencing glare, halos or other distortions of light at night; a one in 100 chance of over-correction or under-correction of vision, or a degradation of best visual acuity; and a one in 100 chance of a dislocated corneal flap or other related problem, the FAA said.

Overall, Evans said, aeromedical specialists have become increasingly comfortable with the concept of refractive surgery.

"Refractive surgery is more acceptable now than 10 years ago because RK is no longer the treatment of choice, and there were significant problems with it," he said, "and the aviation medicine community — and the medical community in general — has gained more experience of individuals that have had very successful refractive surgery." ●

Notes

1. LASIK of Sacramento. *What Is Refractive Surgery?* <www.eyeinfo.com/lasikwhatisrefsurg.html>.
2. Nakagawara, Van B.; Wood, Kathryn J.; Montgomery, Ron W. *New Refractive Surgery Procedures and Their Implications for Aviation Safety*, DOT/FAA/AM-06/9. April 2006.
3. Ibid.
4. Mayo Clinic. *LASIK Eye Surgery: Alternative to Corrective Lenses.* <www.mayoclinic.com/health/lasik-eye-surgery/EY00002>.
5. STAAR Surgical Co. *Potential Risks of Refractive Surgery*. <www.visianinfo.com/html/safety-icl.html>.
6. Cleveland Eye Clinic. *Patient Information: CK.* <www.clevelandeyeclinic.com/ck.cfm>.
7. AllAboutVision. *Refractive Lens Exchange (Clear Lens Extraction).* <www.allaboutvision.com/vision-surgery/refractive-lens-exchange.htm>.
8. AllAboutVision. *Intacs Corneal Inserts or Implants: A Proven Treatment for Keratoconus.* <www.allaboutvision.com/conditions/inserts.htm>.
9. Mayo Clinic. *Presbyopia.* <www.mayoclinic.com/health/presbyopia/DS00589>.
10. Nakagawara, Van B.; Wood, Kathryn J.; Montgomery, Ron W. *Information for Pilots Considering Laser Eye Surgery*, U.S. Federal Aviation Administration (FAA) Pilot Safety Brochures. <www.faa.gov/pilots/safety/pilotsafetybrochures>.
11. An older theory is that presbyopia is a result of the age-related loss of elasticity of the lens.
12. International Civil Aviation Organization (ICAO). "Refractive Surgery," an excerpt from an unpublished draft of ophthalmology guidelines to be included in an upcoming revision of the ICAO *Manual of Civil Aviation Medicine*. March 2007.
13. Nakagawara; Wood; Montgomery. *Information for Pilots Considering Laser Eye Surgery.*

Further Reading From FSF Publications

Mohler, Stanley R. "Early Diagnosis Is Key to Correcting Age-Related Vision Problems Among Pilots." *Human Factors & Aviation Medicine* Volume 47 (September–October 2000).