

Laser vision correction where are we in 2005?

Which patients are suitable for the correction of refractive errors by laser or other surgery, what procedures are available and what should patients expect on the day of a laser surgery operation and afterwards, including the possible complications?

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Laser vision correction for refractive errors has become commonplace since its introduction to Australia in 1991. No matter what type of medical practice you are involved in, you will have patients who have either had or are thinking of having laser vision correction, or who know people who have had it. Medical practitioners should understand which patients are suitable for treatment, the procedures available, and what these procedures can and can't do.

Causes of blurred vision

While the cornea provides most of the eye's focusing power, some is provided by the crystalline lens. If the optical system of the eye works correctly then the image formed on the retina is sharp, and a normal patient would see 6/6 without the need for glasses. The optical system is, however, rarely perfect, and if imperfect enough, the image formed on the retina results in blurred vision. This is most commonly due to myopia (short sightedness), hypermetropia (long sightedness) or astigmatism. Astigmatism can also occur in conjunction with either myopia or hypermetropia. The patient handout on page 34 summarises these conditions, describing what patients

see, explaining the anatomical reasons and listing the degrees of severity.

Surgical treatment of refractive errors

Refractive surgery is any surgical procedure aimed at correcting a refractive error. The correction is achieved by altering the curvature of the cornea or by implanting a lens inside the eye.

Laser vision correction is the best known refractive surgery. The most common laser vision correction procedure is LASIK (laser in situ keratomileusis), in which laser sculpting of the cornea is performed beneath a resected cap of corneal tissue. Surface laser ablation is performed in about 5 to 10% of cases, particularly if the cornea is too thin or not structurally suitable for LASIK.

Nonlaser refractive surgery procedures include conductive keratoplasty, implantation of phakic intraocular lenses and refractive lensectomy. Cataract and lens surgery are considered forms of refractive surgery as the lens power selected enables the surgeon to alter the optical error of the eye, although this may not be the primary purpose of the operation. Recent developments in refractive surgery are discussed in the box on page 35.

IN SUMMARY

- Patients seek refractive surgery in order to function better, rather than for cosmetic reasons.
- Laser vision correction works well as an alternative to glasses or contact lenses.
- The most common laser vision correction procedure is LASIK (laser in situ keratomileusis).
- Not everyone is suitable for laser vision correction; the decision to proceed is an individual choice with advice from the ophthalmologist.
- Lens surgery is a better choice than laser refractive surgery in some patients.

continued

Some causes of blurred vision

The cornea is the transparent window-like structure at the front of the eye that focuses light rays on the retina at the back of the eye. The cornea provides most of the eye’s focusing power but the lens inside the eye also helps. If the optical system of the eye works correctly then the image formed on the retina is sharp. However, the optical system of the eye is rarely perfect, and if imperfect enough, the image formed on the retina results in blurred vision. This is most often due to short sightedness (myopia), long sightedness (hypermetropia) or astigmatism (see below). Astigmatism can also occur in conjunction with either short sightedness or long sightedness. These conditions are termed refractive errors of the eye, and simply mean that the refracting (focusing) system of the eye is imperfect.

Short sightedness - myopia

- You have blurry distance vision
- You see near objects clearly
- Your distance vision seems clearer if you squint your eyes

Causes

Eye is too long (elongated from front to rear), or the cornea has too much curvature – light focuses in front of the retina instead of directly on it.

Degrees of severity

- Mild: less than -3.00 diopters*
- Moderate: -3.00 to -6.00 diopters
- Severe: -6.00 to -9.00 diopters
- Extreme: greater than -9.00 diopters

Long sightedness - hypermetropia

- You have trouble seeing near objects
- Your distance vision is relatively clear, but it becomes less clear as you get older
- You may notice eye fatigue when reading

Causes

Eye is too short from front to rear, or the cornea has insufficient curvature – light focuses ‘behind’ the retina, instead of directly on it

Degrees of severity

- Mild: less than +2.00 diopters
- Moderate: +2.00 to +4.00 diopters
- Severe: +4.00 to +6.00 diopters
- Extreme: greater than +6.00 diopters

Astigmatism

- You see objects as doubled or distorted, or with a shadow next to them, at distance and near
- You may also be short sighted or long sighted

Causes

The cornea has two distinct curvatures, not one, due to an oval shape – there is unequal focusing of light rays entering the eye.

Degrees of severity

- Mild: less than 1.00 diopter.
- Moderate: 1.00 to 2.00 diopters
- Severe: 2.00 to 3.00 diopters
- Extreme: greater than 3.00 diopters

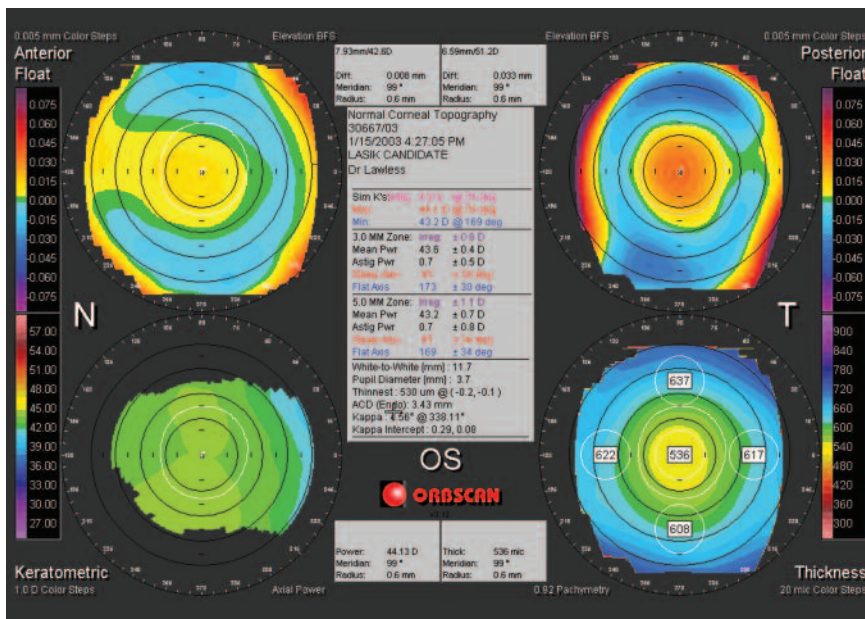


Figure 1. Scan showing normal preoperative corneal topography.

Laser vision correction

Laser vision correction is for people who want to reduce their dependence on glasses or contact lenses. Generally, it can be beneficial to patients with eye conditions that can be corrected by wearing glasses or contact lenses. It is not likely to benefit those with eye conditions in which glasses cannot improve vision, such as cataracts or age-related macular degeneration.

Refractive errors outside the range for treatment with current available technology are considered to be: myopia over -10 diopters, hypermetropia over +5 diopters and astigmatism higher than 5 diopters.

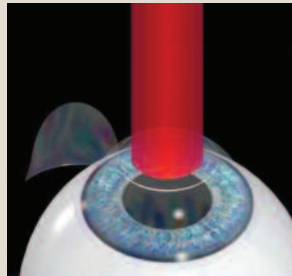
Suitable patients

The main criteria for a good candidate for laser vision correction are listed below:

Refractive surgery options: laser and nonlaser procedures

LASIK

LASIK (laser in situ keratomileusis) is a two-step procedure with a corneal cap created with a microkeratome and then the exposed cornea reprofiled by a laser. It is now possible to create the cap with a laser (IntraLase technology), rather than a mechanical microkeratome.



LASIK surgery.

Surface laser ablation (PRK, ASLA, LASEK)

Surface laser ablation involves removal of the epithelium and reprofiling of the exposed stromal layer by a laser. In PRK (photo-reactive keratectomy), sometimes now called ASLA (advanced surface laser ablation), the epithelium is discarded, and in LASEK (laser assisted subepithelial keratomileusis) it is placed back over the stroma following the ablation.

Surface ablation is generally performed if LASIK is contraindicated because of unusual corneal shape, or if the cornea is at risk of weakening (ectasia) if a flap were created. It is generally reserved for smaller corrections because of the possibility of introducing haze or scarring if treatments for moderate or higher corrections are performed.

Mitomycin C applied topically at the time of surgery seems to limit the frequency and severity of haze or scarring following surface ablation; it is also useful in treating haze or scarring if it does occur.

Although the long term (greater than five years) effects of topical mitomycin C on the cornea or on ocular health are unknown, studies in the peer review literature to date suggest that, in a controlled low dose as a single application, it appears to be safe and effective.

Wavefront-based laser vision correction

Customised treatment is possible with both LASIK and surface ablation. Wavefront sensors measure the optical properties of the eye, allowing a more sophisticated analysis of the subtleties of an optical error. This information can be used to create an ablation pattern individualised to the patient's eye.

Wavefront-based treatments provide improved quality of vision, particularly under low light conditions, and are becoming the standard of care.

Conductive keratoplasty

Conductive keratoplasty is a radiofrequency heat treatment to the peripheral cornea, and is used to treat small amounts of hypermetropia or to induce myopia to improve reading vision in one eye of a presbyopic patient. It is a very safe procedure, but has a limited place with a small range of effectiveness. It can be appropriate for presbyopic patients who are concerned about the risks of laser vision correction but would like better reading vision in one eye.

Phakic intraocular lens implantation

Phakic intraocular lenses – implanted lenses used in addition to the natural crystalline lenses rather than replacing them – are usually reserved for patients with high myopia (greater than -8 diopters). They have a limited place in high hypermetropia because generally there is not enough room inside the eye to place them safely.

The use of these lenses is appealing because the full correction for a high myope can be built into the power of the lens, and the accuracy is not dependent on corneal wound healing or on reshaping or removal of corneal tissue. Implantation of these does, however, present immediate surgical risks because the eye has to be opened. They also carry some risk of causing cataract, and also unknown long term risks related to movement of the lens, inflammation and glaucoma. It is certain that some of these lenses will need to be removed and/or replaced over time. They have a small but definite place within refractive surgery, and this role will increase over the next few years, particularly in patients with high myopia who are aged less than 50 years and still have accommodative power.

Refractive lensectomy

Refractive lensectomy is essentially cataract surgery without the presence of a cataract. The patient's crystalline lens is removed and an intraocular lens placed to deal with the refractive error. This procedure is mainly used in older (above 50 years) presbyopic patients with hypermetropia outside the accurate range for laser vision correction surgery (that is, greater than +5 diopters). It carries the general risks of intraocular surgery but in selected cases can provide the best optical outcome.

Refractive lensectomy will become an increasing feature of refractive surgery because of recently approved multifocal intraocular lenses. It is here that cataract surgery and refractive surgery merge, as cataract surgery has become safer and more precise, and intraocular lenses have become better suited to patient's visual needs.

- the patient is at least 18 years of age – suitability for treatment requires that there is some sense that the refractive error is stable; this may not occur until the patient is aged in the mid-twenties, and in some never occurs, with a progressive increase in their error (this is particularly so in those with high myopia). A prescription for glasses or contact lenses that has remained stable for at least 12 months is some indication of stability.

Essential points to understand before laser vision correction

Laser vision correction, most often LASIK, is a surgical treatment for people who want to reduce their dependence on glasses or contact lenses. Generally, it can be beneficial to patients with any eye condition that can be corrected by wearing glasses or contact lenses, whether it be short sightedness (myopia) or long sightedness (hypermetropia), both with or without astigmatism. The surgery is not likely to benefit people who have an eye condition in which vision cannot be improved by the wearing of glasses, e.g. cataracts or age-related macular degeneration.

Laser vision correction entails some risk and may only reduce dependence on glasses rather than eliminate it. Your doctor will discuss the impact of possible complications with you, but it is important that you try to evaluate the effects these complications could have on your lifestyle. Some points for consideration are listed below.

Reduced vision

It is possible that laser vision correction could affect your best corrected vision. If so, your best vision (that is, with glasses or contact lenses) may not be as good after surgery as it was before surgery. Fewer than 1% of patients will suffer a significant reduction in sharpness of vision.

Need for spectacles

Refractive surgery is usually not as accurate at correcting vision as the use of a perfect pair of glasses or contact lenses. However, 99% of patients in the common ranges of myopia, hypermetropia or astigmatism will be able to legally drive a car without spectacles following the procedure.

Your vision may be under- or overcorrected and you might need to wear spectacles for activities such as night driving; alternatively, further refractive surgery is possible in most cases.

Presbyopia, the condition that reduces the ability to focus on near work, is age related, and will occur whether you have laser surgery or not. It means that following surgery you will probably need glasses for reading from the age of the mid-forties.

Monovision option for people aged over 40

As mentioned above, reading vision becomes affected from your mid-forties due to natural changes within the eye. You can often overcome this difficulty by having one eye deliberately left a little short sighted – this is termed monovision. It can take a while to adjust to having monovision, usually some weeks and, rarely, some months. The effect can be demonstrated for you before surgery, to allow you to decide if monovision is right for you.

Infection

In any operation there is always a slight chance of getting an infection. An infection may lead to severe scarring, and in extreme cases corneal transplantation surgery, or possibly blindness.

Eye pressure

Corneal refractive surgery results in your measured (not real) intra-ocular pressure decreasing slightly after surgery. It will not influence whether you develop high intraocular pressure or glaucoma, nor will it influence the treatment of these conditions if they occur over time.

Tear production

Laser vision correction always reduces tear production. Some patients may experience dry eye symptoms for a few weeks to a few months, and may need to use tear replacement drops. Rarely, tear disturbance can be more serious and long term.

Ectasia after LASIK

If the cornea becomes too thin, a protrusion (or ectasia) may develop in the months after LASIK surgery. Rarely, this can lead to a significant distortion in the vision, to the point that glasses or contact lenses do not improve the situation and a corneal transplant may be required.

Night vision

Night vision problems are common immediately following refractive surgery. They decrease over the first four to six weeks, and are rarely significant problems.

Corneal flap complications

Although corneal flap problems in LASIK are uncommon, a serious flap-related complication may result in loss of best corrected vision.

Visual quality

Rarely, patients may notice a reduction in quality of vision, with ghosting or variations under different light conditions.

Retina

Retinal problems following laser vision correction, while extremely rare, may lead to permanent loss of vision and blindness.

- a vision problem that can be treated by this type of refractive surgery – other intraocular diseases should be excluded
- a cornea that is thick enough to allow tissue removal and reprofiling
- a cornea that has normal characteristics in terms of curvature, both front and back surfaces – this is only detectable with corneal imaging equipment (Figure 1)
- the patient should not be pregnant or breastfeeding – hormones affect corneal hydration and therefore refractive error, and surgery performed during pregnancy and the early stages of breastfeeding may be limited in accuracy of correction

continued

Table. Laser vision correction: complications and treatment options

Complication	Possible treatment
<p>Undercorrection or overcorrection – blurry vision still persists (incidence, 1 to 2%) After undergoing laser eye surgery, some patients may still need to use glasses. The chances of this occurring for a particular patient will depend largely on the magnitude of the error treated.</p>	<p>Glasses or contact lenses. It may be possible for patients to undergo refractive surgery again, but there needs to be enough tissue remaining to perform this safely.</p>
<p>Reduced ‘best visual acuity’ – less crisp vision than with glasses or contact lenses (up to 10%) A patient’s best vision (with glasses or contacts) may not be as good after surgery as it was before. This means that the ‘best-aided visual acuity’ – the highest level of vision achievable with glasses or contact lenses – may be diminished after surgery. The likelihood of this is greater when larger errors are treated.</p>	<p>Further surgery may be beneficial.</p>
<p>Corneal flap complications (1%) Flap subluxation or trapping of epithelial cells beneath the flap during LASIK may occur in the early postoperative period.</p>	<p>A second procedure may be beneficial, either the day following initial surgery or some weeks later .</p>
<p>Glare and light sensitivity (common) Patients may experience greater sensitivity to sunlight and glare than usual.</p>	<p>Patients should be advised to wait for their eyes to settle and adjust – usually a few days.</p>
<p>Starburst or night haloes (common) Patients may experience seeing a halo effect, or rings, around street lights and car lights at night.</p>	<p>Patients should be advised to wait for their eyes to settle and adjust. The starbursts or night haloes will decrease with time, although they may not disappear completely.</p>
<p>Discomfort, dryness, and fluctuation in vision (common) Patients may feel some pain initially after the procedure, although this is unusual. In the first few weeks, the eyes may feel some dryness sensation. Patients may experience fluctuation in vision – this is normal during the first month of the healing process.</p>	<p>Patients should be advised to wait for their eyes to settle and adjust. Lubricant eye drops (artificial tears) reduce dryness sensation.</p>
<p>Infection – red, oozing, or painful eyes (up to 0.1%) The risk of infection is highest in the first 48 hours after surgery. A severe infection may cause scarring and, in extreme cases, marked loss of vision or blindness, requiring a corneal transplant.</p>	<p>Antibiotic drops during surgery and for the first week after surgery reduces the risk of infection.</p>
<p>Ectasia Weakening of the cornea with irregular astigmatism and visual loss can occur, albeit rarely, years after the surgery. Although it is more likely if patients are selected inappropriately (e.g. they have keratoconus) or if the cornea is made too thin after surgery, it may occur even in well selected patients.</p>	<p>Hard contact lenses or possibly a corneal transplant.</p>
<p>Presbyopia – need for reading glasses or bifocals This condition occurs around age 45 years regardless of whether laser surgery is performed.</p>	<p>Reading glasses or bifocals, unless monovision correction is performed.</p>

- the patient must have realistic expectations and understand that refractive surgery entails some risk, and in some cases may only reduce rather than eliminate dependence on

glasses or contact lenses. The patient handout on page 36 details some of the points that could form the basis of an informed consent discussion with the ophthalmologist.

Complications

Some of the complications from laser vision correction and their incidence, significance and possible treatment options are listed in the Table.

Contraindications

Relative and absolute contraindications to laser vision correction surgery include the following:

- severe dry eye disease – laser vision correction surgery reduces tear production as a consequence of reducing corneal sensation. This recovers by about six months after surgery. The reduction in tear volume in a patient with mild dry eye may tip the balance so that the patient has significant dry eye after surgery, which in turn will influence corneal healing. The accuracy and safety of corneal refractive surgery is based on predictable corneal wound healing. Some patients with mild or moderate dry eye may be treated perioperatively with temporary or permanent punctal plugs and may still be able to undergo the procedure
- corneal scarring and keratoconus, as they influence corneal healing – keratoconus should be identified on a screening examination by analysing corneal shape
- autoimmune disorders that are uncontrolled or require significant systemic immunosuppression, as they slow healing
- ocular herpes simplex herpes keratitis – if attacks are frequent, are difficult to control or have resulted in corneal scarring and vascularisation, ocular herpes is generally considered an absolute contraindication; if attacks are very infrequent and involve only the corneal epithelium with no corneal scarring than the condition may be regarded as a relative contraindication
- prescription medications that slow healing or increase the risk of infection, such as corticosteroids or immunosuppressants.

The day of LASIK surgery and postoperative care

Patients are normally at the surgery centre for about two hours. Various eye drops will be used:

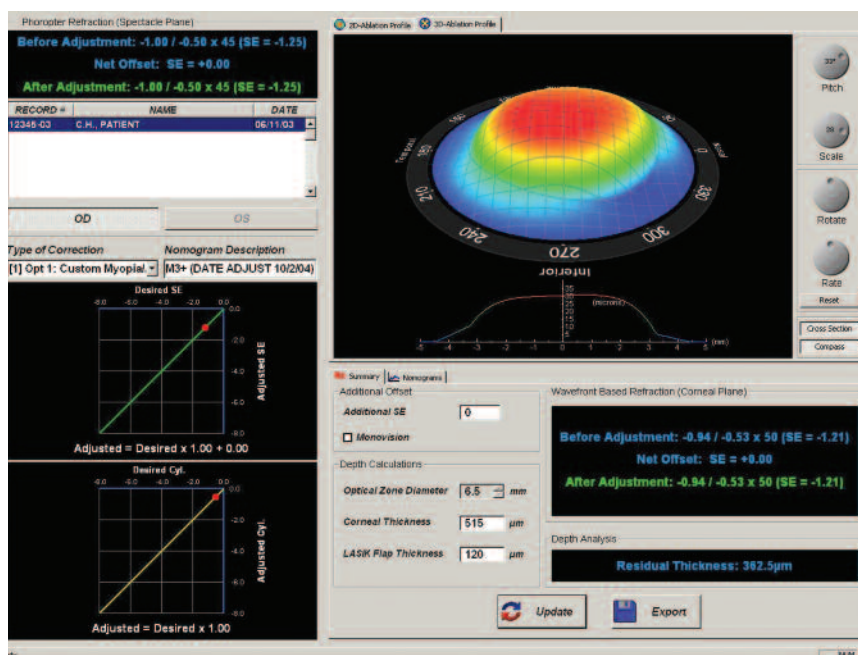


Figure 2. Preoperative wavefront analysis for customised laser vision correction surgery.

- antibiotics – such as the fluoro-quinolones ciprofloxacin (CiloQuin; Ciloxan) and ofloxacin (Ocuflax)
- anti-inflammatories – such as dexamethasone (Maxidex) and fluoro-metholone (Flarex, Flucon, FML)
- anaesthetics – such as amethocaine (Minims Local Anaesthetics [Amethocaine]) or oxybuprocaine (Minims Local Anaesthetics [Oxybuprocaine])
- mydriatics and cycloplegics – such as



Figure 3. LASIK surgery: repositioning the corneal flap back over the corneal bed after laser reprofiling. Stitches are not required.

continued

tropicamide (Minims Mydriatics and Cytoplegics [Tropicamide], Mydriacyl) and phenylephrine (Minims Mydriatics and Cytoplegics [Phenylephrine]).

Wavefront measurements will be taken (Figure 2), and patients are often given oral diazepam (Antenex, Ducene, Valium, Valpam). The surgery itself is performed under topical (drops) anaesthesia, and is generally pain-free, although patients may be troubled by lid pressure from the speculum or light sensitivity from the operating microscope (Figure 3).

The standard of care is to perform LASIK on both eyes at the same surgical setting. Sometimes the patient or surgeon may decide that this is not the appropriate course, and the eyes may be operated on at separate sessions. If the decision is made to perform bilateral surgery, then the second eye is only operated on if the

first procedure is complication free.

After the surgery, a shield is placed over the eye but it is not patched. Blinking is helpful in corneal recovery. Generally, patients feel their eyes are comfortable and they have about 90% of their final visual quality by the morning following surgery. Depending on the amount and complexity of the optical error treated, the final visual acuity is achieved over the next several days to weeks. Antibiotic and corticosteroid drops are used four times a day for one week, then artificial tears for a few weeks as required.

Patients are advised not to swim for one week, and to avoid rubbing the eyes and participating in body contact sports for a month. The wearing of an eyeshield at night is often recommended for a few nights to prevent eye rubbing, and the wearing of eye makeup is normally permitted after seven days. Most people have

vision meeting legal requirements for driving and are comfortable enough to drive 48 hours after bilateral LASIK.

Follow up visits are scheduled for day one postoperatively and then two to three weeks later. Follow up normally ceases at three to six months, by which time a stable visual result should have been obtained. As LASIK is dependent on corneal healing for its accuracy, some patients will be over- or undercorrected and may need retreatment. Miscorrection varies, depending on the amount and complexity of the error treated, and a decision is generally made concerning retreatment three months after initial surgery.

Surface laser ablation surgery

Recovery tends to be slower after surface laser ablation than after LASIK, and the patient tends to have more discomfort in the first four to five days. Generally with

surface ablation procedures, bandage contact lenses are placed on the eyes immediately following surgery, and are removed on day four. Apart from the slower recovery, the course is normally similar to that of patients undergoing LASIK.

Conclusion

Laser vision correction, predominantly LASIK, is a popular elective procedure to diminish or reduce dependency on glasses or contact lenses. Suitability for the procedure and the best operation for a patient is a decision based on an individual's optical error, age, corneal anatomy and visual needs. **MT**

Further reading

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Useful websites

- www.aao.org – American Academy of Ophthalmology. General information about eyes.
- www.nei.nih.gov – National Eye Institute (US National Institutes of Health). General information, statistics on ocular disease, images and publications for patients.
- www.ascrs.org – American Society of Cataract and Refractive Surgery. More specific refractive information, links to other refractive websites.
- www.ranzco.edu – Royal Australian and New Zealand College of Ophthalmology. General information regarding ocular conditions, local links.
- www.surgicaleyes.org – Patient-created site detailing possible adverse outcomes of refractive surgery.

DECLARATION OF INTEREST: Dr Lawless is a member of the medical advisory boards for Alcon and IntraLase. Mr Hodge: None.