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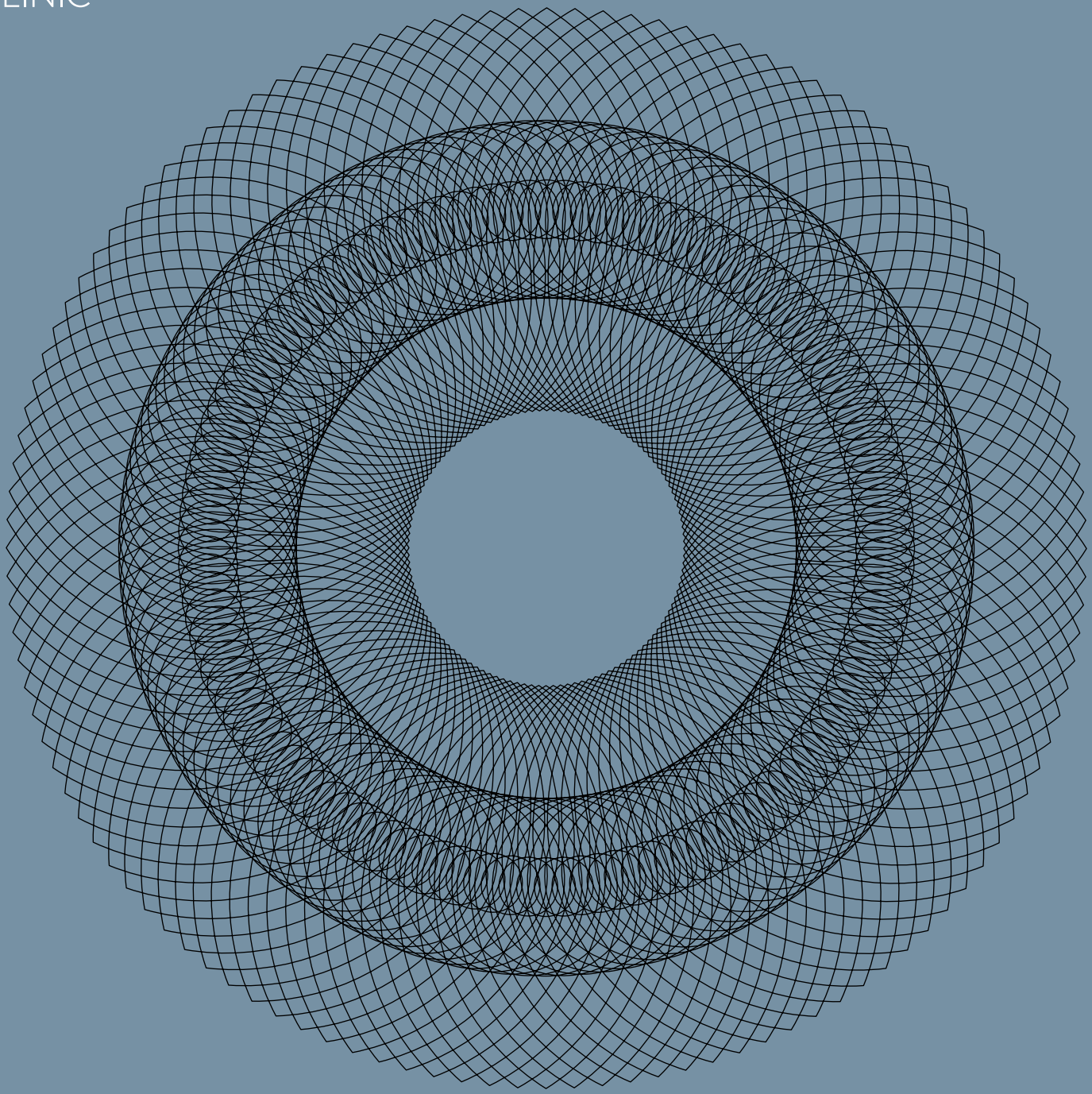
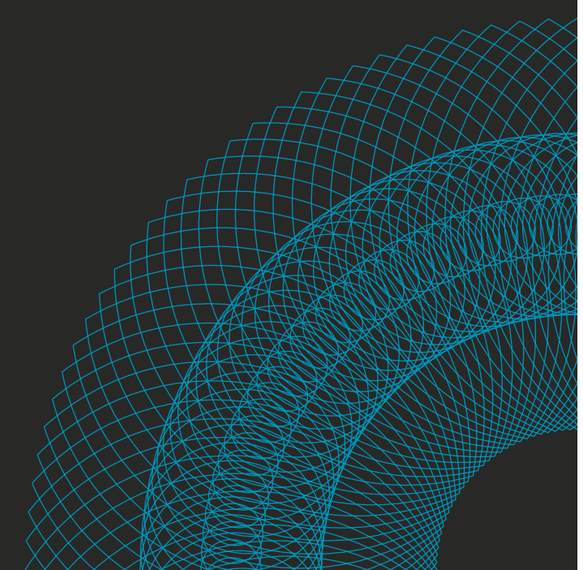


The UK Guide to Laser Eye Surgery

Your eye is like a camera



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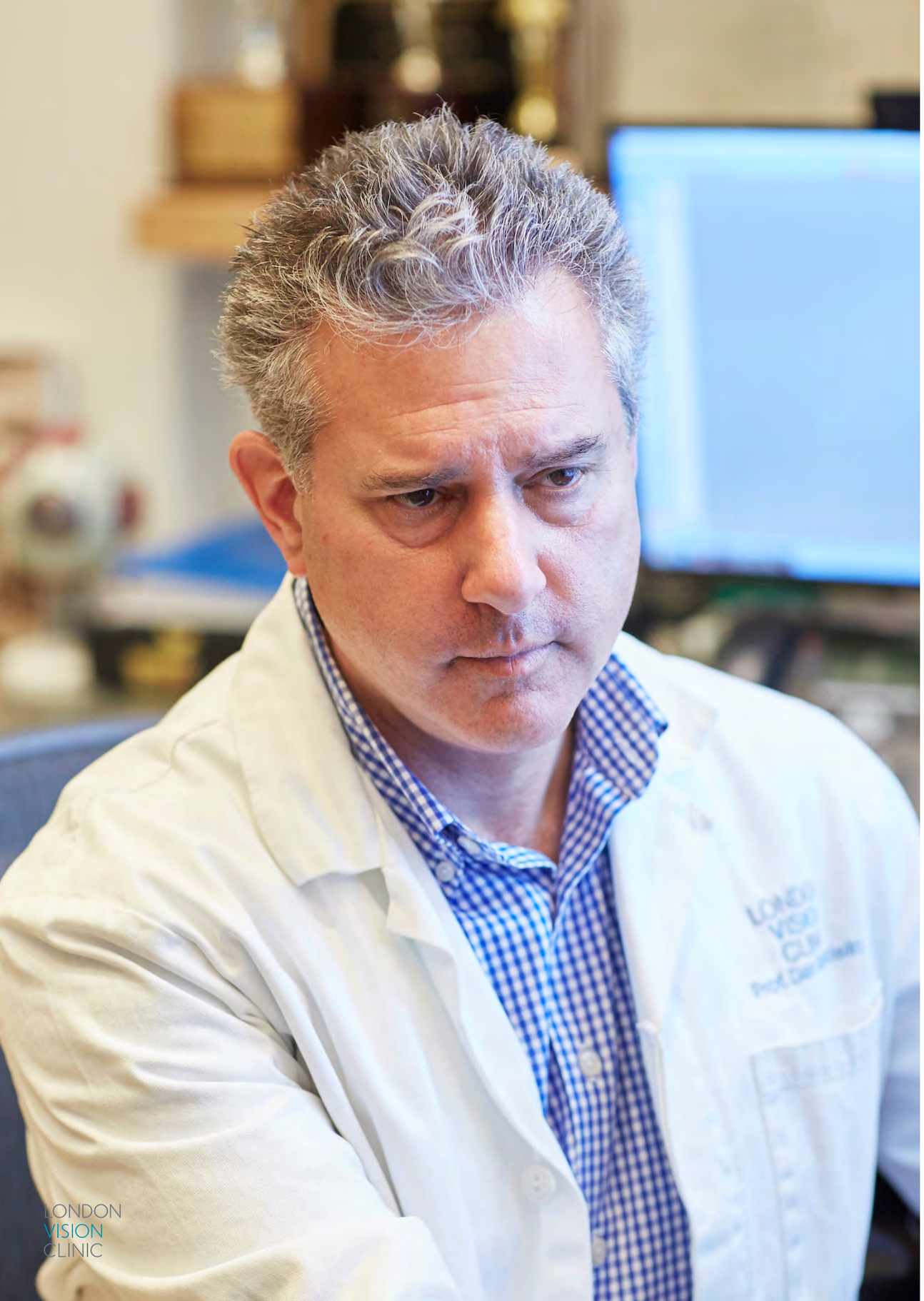

Professor Dan Reinstein

MD MA(Cantab) FRCS(C) DABO FRCOphth FEBO, PGDip CRS, CertLRS

Professor Reinstein is a recognised international expert in laser refractive surgery

Professor Reinstein is the founder of London Vision Clinic. He is internationally renowned for his expertise in laser eye surgery, and is one of the few full-time Ophthalmic Surgeons in the UK to have dedicated his entire professional life to the field of refractive surgery.

Professor Reinstein completed his undergraduate education at Cambridge (1981 to 1984) and went on to earn his medical degree from Cambridge University - an M.B. B.Chir (1989). He has received extensive post-doctorate fellowship sub-specialty training, first in corneal surgery and then in laser eye surgery, including:

- **1991:** Research Fellowship in Ophthalmic Epidemiology (Institute of Ophthalmology, London)
- **1994:** Fellowship in Ophthalmology (The Weill Medical College, Cornell University, New York)
- **1996:** Residency in Ophthalmology (Mount Sinai School of Medicine, New York)
- **1997:** Refractive Surgical Fellowship under laser eye surgeons Zaldivar, Arbelaez, Chacon, and Barraquer (Clinica Barraquer, Bogota, Colombia)
- **1999:** Fellowship in Cornea, External Disease and Refractive Surgery (University of British Columbia, Canada)

Professor Reinstein is recognised as one of the world's preeminent laser eye surgeons. A pioneer in his field, he is the co-inventor of the Artemis Insight 100 - the world's most accurate corneal scanner, which allows London Vision Clinic to safely treat even very high prescriptions. He was also instrumental in the development of PRESBYOND® Laser Blended Vision and ReLEx SMILE - two treatments which have dramatically increased the range of prescriptions that can be treated, and brought the benefits of laser eye surgery to thousands of patients who would previously have been found unsuitable.

Continued on the next page

Professor Reinstein is on the General Medical Council's Specialist Register in the UK and is a board-certified ophthalmologist in the USA and Canada. He holds professorships in New York (Columbia University Medical Center), Paris (Centre Hospitalier National d'Ophtalmologie des QuinzeVingts, Université de Paris VI) and Ulster (Biomedical Science Research Institute, University of Ulster). He is recognised world-wide as an expert in therapeutic refractive surgery, and is frequently approached by other surgeons regarding his knowledge in this area.

Professor Reinstein is an experienced research scientist and has made major contributions to the field. To date, he:

- Has published over 175 articles in peer reviewed medical journals and over 180 articles for the ophthalmic press
- Has written or contributed to over 40 book chapters
- Has delivered over 550 lectures at professional meetings on five continents
- Has presented or published over 280 scientific papers or abstracts
- Is the editor for the Therapeutic Refractive Surgery section for the Journal of Refractive Surgery
- Has published the textbook The Surgeon's Guide to Small Incision Lenticule Extraction (SMILE)
- Is the course director for the biannual 4-day training course on Forefront Refractive Surgery
- Has trained 13 refractive surgery fellows

Professor Reinstein has appeared frequently in the media as a laser eye surgery specialist

Professor Reinstein is the former Chief Medical Officer of a group of 60 laser eye surgeons across 30 clinics throughout North America. During his tenure, the group grew to become the largest provider of laser vision correction in the world (performing over 100,000 procedures per year).

He later joined the team at Carl Zeiss Meditec, where he helped to develop the MEL 80 excimer laser – this was a revolutionary technological development, and became the benchmark for the industry as a whole. Professor Reinstein remains the lead medical consultant to Carl Zeiss and, more recently, was a major contributor to the development of the VisuMax femtosecond laser and the MEL 90 excimer laser.

Professor Reinstein has appeared frequently in the media as a laser eye surgery specialist. His television appearances have included This Morning, BBC Breakfast, and SKY News. He has also been featured in publications ranging from The Times and The Sunday Times to GQ and Harper's Bazaar.

Professor Reinstein had PRESBYOND® Laser Blended Vision LASIK with Mr Carp in 2016.

Mr Glenn Carp

MBBCh (WITS), FC Ophth (SA) (WITS), PGDip CRS, CertLRS

Mr Carp has undergone one of the most rigorous training programs for any laser eye surgeon in the UK

Mr Glenn Carp is a distinguished and extremely skilled ophthalmic surgeon, who has undergone one of the most extensive training programs of any laser eye surgeon in the UK. Born and educated in South Africa, he qualified as a doctor in 1996 in Johannesburg; he began his career in Ophthalmology as an Ophthalmic Senior House Officer, followed by a year spent as a Research Officer in Ophthalmology at the University of the Witwatersrand in South Africa.

Mr Carp is on the General Medical Council's Specialist Register in the UK, and is also a fellow of the College of Surgeons in Ophthalmology (South Africa). In 2000, he began his specialist registrar training at the St John Eye Hospital in Johannesburg - Africa's largest eye hospital. He has won several awards for excellence in his field including the Tetski Patterson Award for clinical research and the Elli Dahan Registrar of the Year Award, which recognised outstanding performance over his specialist training program.

On completion of his training, Mr Carp continued as a consultant ophthalmologist at the St John Eye Hospital in Johannesburg. His areas of specialist interest included glaucoma and retinal surgery, and he also held a part time post at the Johannesburg Eye Hospital as a private consultant. Following this tenure, Mr Carp left South Africa to develop his expertise in the United Kingdom, through fellowship training in corneal and refractive surgery.

Since moving to the UK, Mr Carp has practised at several leading hospitals, including the Western Eye Hospital, Maidstone General Hospital, Preston Royal Hospital, and Worcester Royal Hospital. He was selected for a prestigious one year fellowship in Cornea and Anterior Segment Pathology and Surgery at London's Western Eye Hospital under the guidance of Miss Melanie Corbett, and later undertook an 18-month fellowship in Laser Refractive Surgery at London Vision Clinic under the guidance of our founder, Professor Dan Reinstein.

Continued on the next page

Mr Carp is a member of many professional organisations including:

- The European Society of Cataract and Refractive Surgery (ESCRS)
- The British Society for Refractive Surgery (BSRS)
- The Medical Contact Lens and Ocular Surface Association (MCLOSA) (Council member)
- The Ophthalmological Society of South Africa (OSSA)
- The South African Society of Cataract and Refractive Surgeons (SASCRS)
- The South African Society for the Prevention of Blindness - providing cataract surgery to poor communities
- United Kingdom & Ireland Society of Cataract & Refractive Surgeons (UKISCRS)

Mr Carp is a regular attendee at both national and international congresses around the world. He has been delivering presentations at the ESCRS congress for over a decade, and is regularly invited to give lectures on ophthalmology to medical students, optometrists, and ophthalmic nursing teams. Mr Carp is also a Zeiss appointed expert and speaker for both congress symposia and training courses.
He has also been responsible - alongside Professor Reinstein - for the training of five other clinical fellows at London Vision Clinic in refractive surgery.
As well as being a talented and dedicated refractive laser eye surgeon, Mr Carp is recognised internationally as an expert on keratoconus and corneal cross-linking.
Mr Carp had his own laser eye surgery with Professor Reinstein in 2006, and recently returned the favour in April 2016.

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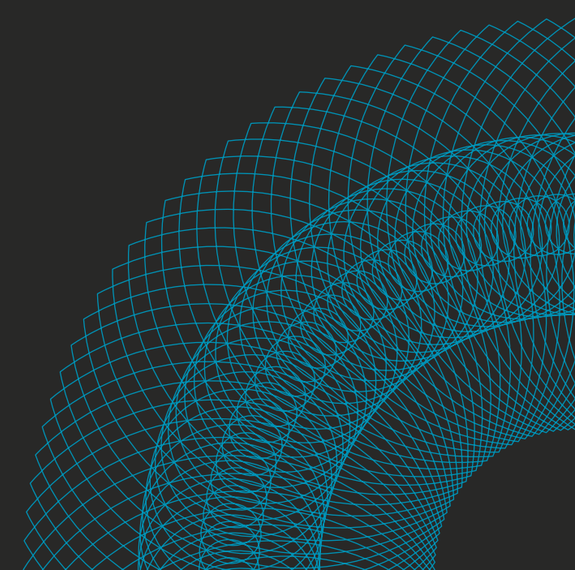
Interpret image as vision



Mr Darshak Patel

BMedSci Hons, BMBS, PGDip CRS, Cert LRS

With 14 years of training including 3 sub-speciality fellowships, Mr Patel is one of a handful of surgeons to have completed formal refractive surgery training in addition to multiple corneal surgery fellowships.

Mr Darshak Patel is a highly regarded and accomplished ophthalmic surgeon committed to providing the best possible visual outcomes for his patients.

He completed his medical training at University College London, graduating with a distinction in clinical science in addition to multiple medical school awards. He went on to undertake a Masters at the UCL Institute of Ophthalmology where he again graduated with distinction.

Mr Patel was selected for a 7 year Ophthalmology training programme in London where he refined his surgical skills in major ophthalmic units including St Thomas' hospital, where both modern cataract and refractive laser surgery were pioneered.

He has won several awards for excellence in his field including:

- 2010: Duke Elder Ophthalmology prize, rank 22/427
- 2010-2015: Distinctions in MBBS, MSc and PGCert Healthcare Leadership
- 2012-2016: Distinction in Clinical Ophthalmology Masters, UCL Institute of Ophthalmology
- 2017: Southern Ophthalmological Society, 1st prize presentation
- 2019: Moorfields Alumni Association Bursary
- 2023: Distinction in Diploma of Cataract and Refractive Surgery, Ulster University

Following completion of his general ophthalmic training, Mr Patel was appointed to prestigious subspecialty training fellowships across 2 years in complex lens, refractive laser and corneal transplant surgery, at the world-renowned Western Eye and Moorfields Eye Hospitals, London.

Continued on the next page

After completing a one year fellowship in refractive surgery at the London Vision Clinic, he was then appointment by Professor Reinstein and Mr Carp as a surgeon, and holds the Certificate in Laser Refractive Surgery from the Royal College of Ophthalmologists.

Mr Patel is registered as a specialist in Ophthalmology with the General Medical Council, and is a fellow of the Royal College of Ophthalmologists.

Mr Patel regularly publishes his research in high impact journals, presents his work internationally and has co-authored several book chapters in ophthalmic textbooks. He enjoys the privilege of delivering ophthalmic care in low-resource settings having previously visited Zanzibar and Cambodia, operating on particularly complex cataract cases.

He is passionate about training future eye surgeons in his capacity as a surgical skills tutor at the Royal College of Ophthalmologists and in his previous role as the College representative for regional trainees. He has also set up surgical skills courses for medical students pursuing careers in Ophthalmology.

Together with Professor Reinstein and Mr Glenn Carp, they deliver a four-day teaching programme on laser refractive surgery, which has been attended by over 300 clinicians from over 50 countries.

Committed to excellence

How the eye works

Your eye is like a camera

Your eye is like a camera. Your eye has:

- A variable opening called the pupil;
- A lens system, which includes a transparent covering (the cornea, which does most of the focusing) and a spherical lens inside the eye behind the iris;
- A reusable 'film' called the retina - a complex layer of cells at the back of the eye;
- Various sets of muscles, which control the size of the pupil, the shape of the lens system (to control the 'zoom' function of the eye) and the movements of the eye.

When you look at something, light passes through the cornea and the pupil at the front of the eye. The light is refracted by the cornea and the lens. The lens- which is inside the eye, between the pupil and the retina - refracts (bends) this light, focusing it onto the retina. The retina is full of sensory cells called 'rods' and 'cones', which change the photons of light into electrical signals. Our nerves transmit these signals to the brain, and the brain interprets this as an image.

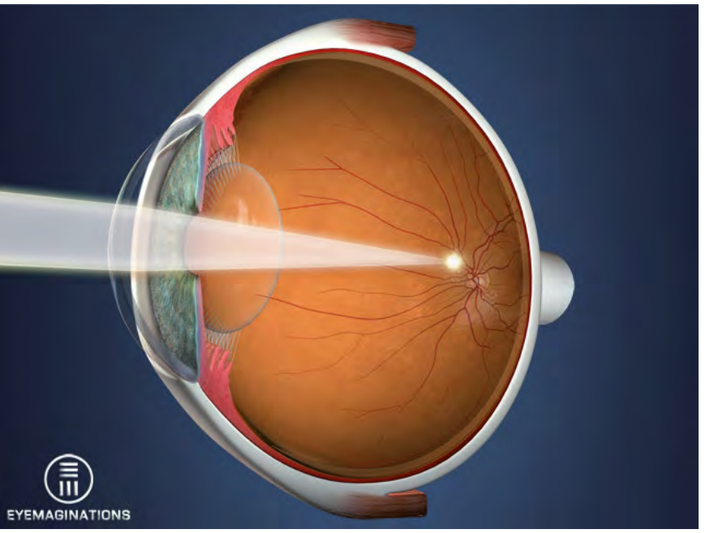
When you look at something, four things must happen:

- The image must 'reduce' to fit on to the retina;
- The scattered light must focus at the surface of the retina;
- The image must curve, to match the curve of the retina;
- The brain must interpret the image as vision.

In order for this to occur, muscles attached to the lens contract and relax to change the shape of the lens system and keep the object focused on the retina, even when your eyes move. Your nervous system controls this complex set of muscle movements.

Most vision problems occur when the eye cannot focus images onto the retina. The most common problems are to do with the shape of the cornea, the length of the eye, and/or the stretchiness ('elasticity') of the lens. These common issues are known as short-sightedness (myopia), long-sightedness (hyperopia), ageing eyes (presbyopia) and astigmatism. In the vast majority of cases, these issues can be corrected with laser eye surgery.

Myopia
Short-sightedness



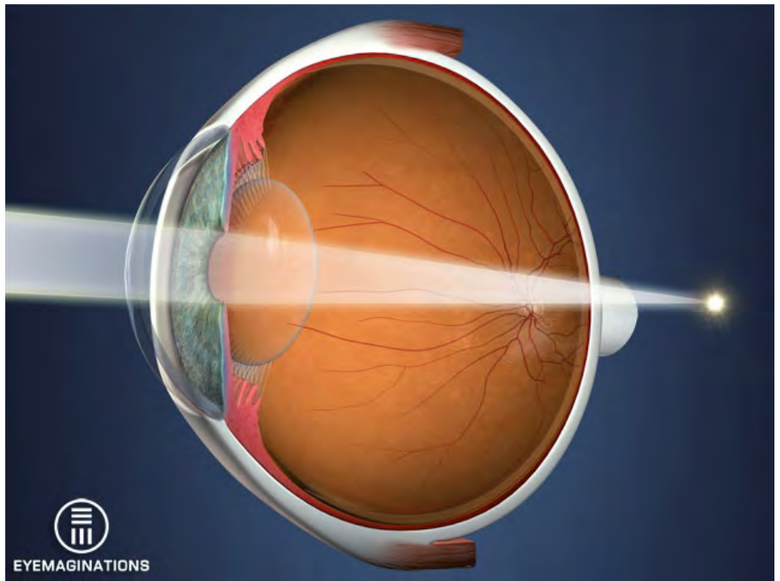
Myopia occurs when your eyeball is slightly longer or your cornea is more curved than required for clear vision. This means that when the light rays come together (focus), they do so slightly in front of rather than on the retina, meaning that the image becomes blurred. The effect of this is that you cannot see distant objects clearly (for example, the numbers on the front of buses) although your close vision may be very good as your eye is naturally focused at this distance. Laser eye surgery can correct myopia by changing the shape of the cornea so that its focusing power is matched to the length of the eye.

Hyperopia
Long-sightedness

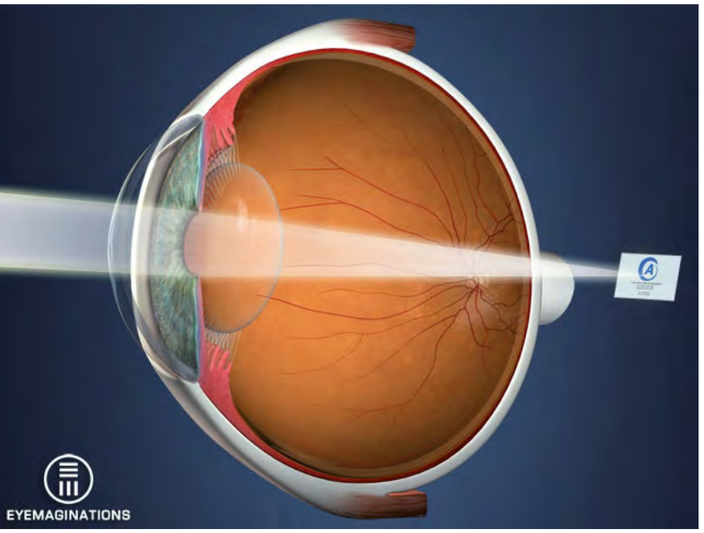
Long-sightedness can also be treated with laser eye surgery

Hyperopia occurs when your eyeball is slightly shorter or your cornea is flatter than required for clear vision. In contrast to myopia, this means that light focuses behind the retina, and the close vision can appear blurry. In younger people, many hyperopic eyes can self-focus by utilising the 'zoom' intended for reading to compensate for the blurring.

As the eye ages, however, this 'zoom' gets weaker, so near vision becomes blurred. Later, distance vision becomes blurred as well. This means that people with hyperopia often require reading glasses before their 40s, and then require both reading and distance glasses (or bifocals) from their 40s or 50s and onwards. As with myopia, laser eye surgery can correct hyperopia by changing the shape of the cornea so that its focusing power is matched to the length of the eye. Laser eye surgery can also correct ageing eyes (presbyopia). See next page

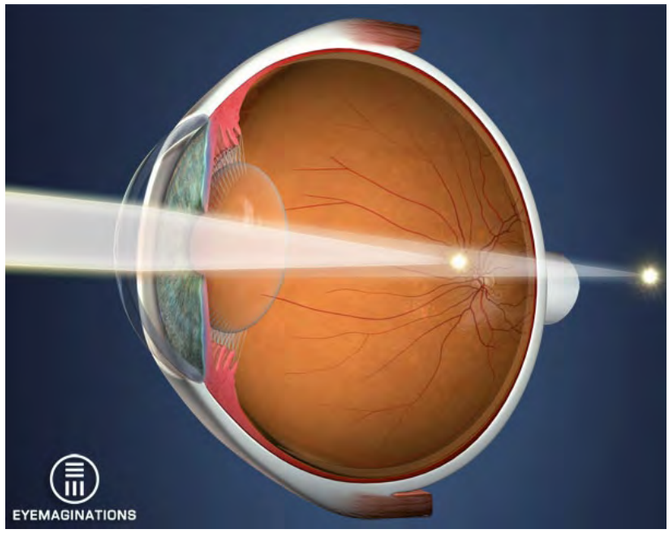


Presbyopia
Ageing eyes



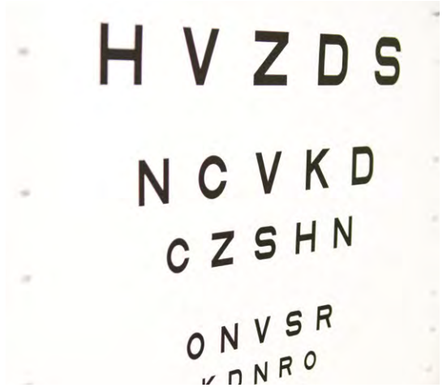
Everyone develops presbyopia during their lifetime. Most people, whether they have previously worn glasses or not, experience the symptoms of presbyopia in their 40s - although some people do not experience it until their mid-50s. As we age, the lens inside the eye loses its ability to change shape and shift the focus of the eye from distance to near. Effectively, the 'zoom' system in the eye becomes weaker. This means that your ability to read small print (e.g. newspapers) diminishes and you require different lenses for focusing on close and distant objects. Traditionally, people have used reading glasses, bifocals or varifocal lenses to correct presbyopia, or have resorted to undergoing a Clear Lens Exchange procedure (replacing the lens inside the eye with an artificial one). However, London Vision Clinic has been using PRESBYOND® Laser Blended Vision to correct the symptoms of presbyopia for over ten years; this is a much safer and less invasive procedure than Clear Lens Exchange, as it does not require the surgeon to 'go inside' the eye to remove the lens.

Astigmatism



A normal eye is spherical, like a football. Astigmatism occurs when your eye is more oval shaped (like a rugby ball), meaning that the curvature of the cornea (the transparent covering at the front of the eye) is not the same horizontally as it is vertically. The result of this is that, when light enters the eye, it is focused at two different planes rather than at a single point. Images appear blurred or distorted, and you may experience 'ghosting'. Approximately half of all people with myopia or hyperopia have some astigmatism as well. Laser eye surgery can correct astigmatism, whether it is accompanied by myopia or hyperopia, or present alone.

Understanding visual acuity
What does 20/20 mean?



It is possible to see better than the norm - better than 20/20

'Visual acuity' is the standard measure of a person's ability to see clearly. When your visual acuity is measured, your optometrist is testing your central vision – your ability to distinguish the details and shapes of objects from a certain distance away.
In the most common visual acuity test, an optometrist places an eye chart at a standard distance (twenty feet or six metres, depending on the customary unit of measurement). The patient is then asked to read letters on lines across the eye chart. Towards the bottom of the chart is a line known as the '20/20 line' – this is the smallest line that a person with 'normal' visual acuity can read from twenty feet away. Therefore, having '20/20 vision' simply means that you have normal visual acuity.

Three lines above the normal (20/20) line is the 20/40 line. The letters on the 20/40 line are twice as large as those on the 20/20 line, so a person with normal visual acuity could read from twice as far away - forty feet. If the smallest letters that a person can read from twenty feet away are those on the 20/40 line, that person would be said to have 20/40 vision. (This means that the person needs to approach to a distance of twenty feet to read letters that a person with normal acuity could read at forty feet.)

It is also possible to have better than 20/20 vision. For example, some patients are able to read the 20/16 line (the line below the 20/20 line) during their visual acuity test. They would be said to have a visual acuity of 20/16, which means that from twenty feet away, they can read a line that a person with normal visual acuity would need to approach to a distance of sixteen feet to read.

The biggest letter, at the top of the eye chart, is the 20/200 line. Many people believe that they have "bad vision" because they "can't even read the E at the top of the chart without glasses." However, importantly, visual acuity tests measure not only a person's uncorrected vision (their vision without glasses or contact lenses) but also their best corrected vision – the best vision that they are able to achieve with glasses or contact lenses. Many people with moderate myopia (short-sightedness) cannot read the 'E' without glasses, but have no problem reading the 20/20 line or even the 20/16 line with glasses.

In most situations where visual acuity ratios are mentioned, they refer to best corrected visual acuity. For example, the legal driving standard in the UK is 20/40, which means that a person's visual acuity is considered good enough to drive if they can read the 20/40 line from twenty feet away, with glasses on if necessary.
In laser eye surgery, the surgeon's goal is to get your visual acuity without glasses to the same level as your best corrected visual acuity (i.e. your vision with glasses or contact lenses) before surgery. Occasionally, patients achieve even better vision than this.

Understanding prescriptions

Optometrists measure refractive errors - myopia, hyperopia, presbyopia and astigmatism - in units called dioptres. Dioptres are a measure of the amount of refractive correction you need in order to see normally. One dioptre is the equivalent of a lens that can focus on an object one metre away.

The more short-sighted, long-sighted or astigmatic you are, the higher your prescription will be in dioptres.
A typical prescription has three numbers - for example: -5.00 / -1.50 x 180.

- The first number (-5.00) identifies your degree of short-sightedness or long-sightedness. The minus sign in front of the number identifies you as short-sighted, whereas a plus sign means you are long-sighted;
- The second number (-1.50) identifies the amount of astigmatism you have. This is written with either a plus sign or a minus sign (usually minus in the UK);
- The third number (180) indicates the axis in degrees, communicating the orientation of your astigmatism. An axis of 180 degrees, for example, means the astigmatism is horizontal.

So, a prescription of -5.00 / -1.50 x 180 indicates that the patient is moderately short-sighted, with a moderate degree of astigmatism in a horizontal direction.

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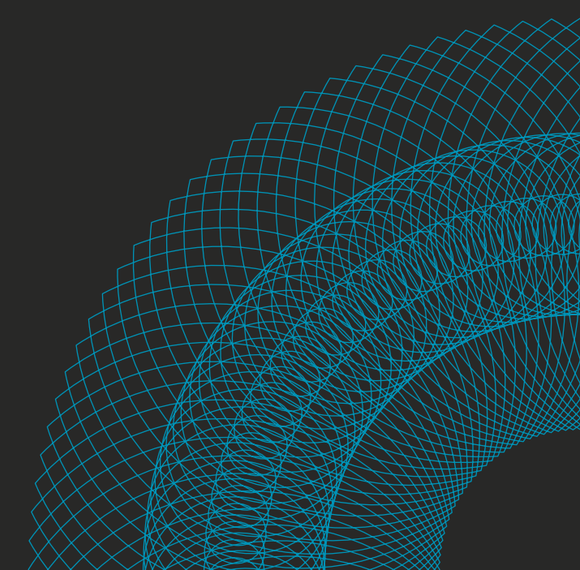
Optometrists measure refractive errors



How does laser eye surgery work?

Laser eye surgery uses a beam of ultraviolet light to reshape your cornea

Any operation that corrects the focusing of the eye is called refractive surgery. Laser eye surgery is simply a form of refractive surgery that uses a laser to reshape your cornea - the transparent, curved window at the front of the eye. Adjusting the curvature of your cornea allows light to be focused correctly onto the retina at the back of the eye. Refractive surgery is the world's most common elective surgical procedure.

The most popular form of laser eye surgery is LASIK (laser in-situ keratomileusis). During LASIK, the surgeon uses either a femtosecond laser or, rarely, a mechanical device called a microkeratome to create a very thin corneal flap, about a tenth of a millimetre thick. The surgeon then lifts this corneal flap, and uses a second (excimer) laser to sculpt the bed of the cornea. This procedure can be used to flatten the cornea (to correct short-sightedness), make it steeper (to correct long-sightedness), and make it more symmetrical (to correct astigmatism). When the surgeon puts the corneal flap back, the cornea takes on this new shape.

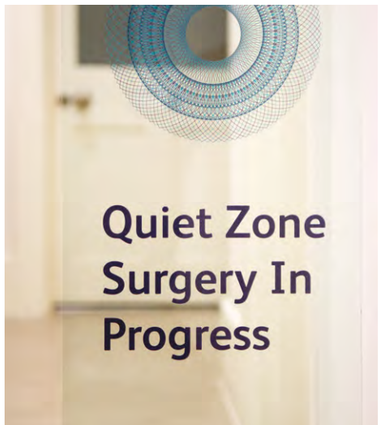
ReLEx SMILE is a keyhole form of LASIK laser eye surgery. SMILE (which stands for small incision lenticule extraction) differs from LASIK in that the surgeon does not need to create a flap in the cornea. Instead, a femtosecond laser is used to create a tiny tunnel, through which the surgeon draws out a minuscule amount of corneal tissue (less than 1/100th of the width of a human hair). The main advantage of SMILE over other forms of laser eye surgery is that it is even less invasive than LASIK, as no flap is created. SMILE can be used to treat even higher prescriptions than was previously deemed possible, and is often a preferred option for patients with drier eyes or thinner corneas.

Continued on the next page

With LASIK and SMILE laser eye surgery, the healing process is surprisingly short. In almost all patients, the flap (in LASIK) or the tiny tunnel (in SMILE) heals within a matter of hours after surgery. Anaesthetic drops are used to numb the eyes during surgery, so the procedure itself is totally painless. It is normal to experience a small amount of discomfort on the evening after surgery as the anaesthetic wears off, but this is rarely troublesome and painkillers are provided for use if necessary.

Most patients notice a significant vision improvement immediately after surgery, and vision continues to improve over the next 24 - 48 hours. The rapid visual recovery time means that the vast majority of patients can return to work within 24 hours of surgery, although it will take about 3 months before the final visual outcome will be realised.

For the small minority of patients who are unsuitable for either LASIK or SMILE laser eye surgery, there are alternative 'surface' procedures known as PRK (photorefractive keratectomy), LASEK (laser sub-epithelial keratomileusis) and Epi-LASIK (epithelial laser in-situ keratomileusis). These procedures all involve removing the surface layer of the cornea (the epithelium), and then treating the exposed area underneath with a laser. To the patient, the main difference between LASIK or SMILE and these surface procedures is the healing time. After a surface procedure, it takes approximately 5 - 7 days for the eyes to heal, and for vision to stabilise.



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With LASIK and SMILE laser eye surgery, the healing process is surprisingly short

Common misconceptions about laser eye surgery

Laser eye surgery itself is quick, and pain-free

Complications are common and serious
Laser eye surgery is very safe. Of course, no procedure is entirely without some level of risk - the point is that the relative risk of laser eye surgery is extremely low when compared to the relative benefits. In the hands of an expert surgeon using the best technology, the chances of even a small compromise to the vision is in the order of 0.1% for the majority of patients. For those with higher prescriptions, the risk may be higher, and this will be indicated at your screening appointment if it applies to you.

Laser eye surgery is painful
Laser eye surgery itself is quick, and pain-free. With LASIK and ReLEx SMILE, you may feel a moment's pressure early in the procedure. You may also experience some mild discomfort or irritation for up to 24 hours after the surgery, but this is usually relieved with artificial tears and pain-relief eye drops (which any good clinic should provide free of charge).

Laser eye surgery is only for short-sighted people
With today's technology, patients who are short or long-sighted, presbyopic or astigmatic can be treated.

Laser eye surgery cannot help people aged 40+ who need reading glasses
For over a decade, PRESBYOND® Laser Blended Vision laser eye surgery has been used to correct presbyopia (ageing eyes). No procedure is able to fully restore the eye's zooming mechanisms to enable perfect distance and perfect near vision in both eyes simultaneously. PRESBYOND® Laser Blended Vision is a form of LASIK laser eye surgery, where one eye is corrected mainly for distance vision and a little up close, while the other eye is corrected mainly for close vision and a little at distance. The brain learns to combine the two images, giving clear vision at near, intermediate and far distances. PRESBYOND® Laser Blended Vision is not to be confused with monovision (which uses contact lenses or older laser systems to correct one eye for distance and the other for near, and which some patients find difficult to tolerate). Studies have shown that over 97% of presbyopic patients are suitable for PRESBYOND® Laser Blended Vision treatment. The aim of PRESBYOND® Laser Blended Vision is to maximise independence from glasses, but you may still need to use glasses in some situations.

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The treatment is not permanent

Long-term follow-up studies have demonstrated that once the shape of your cornea is changed to correct your vision, the change is permanent. Of course, your eye is a living organ and alters over the years, just as the rest of your body does. Everyone's eyes change to some degree, even if they have never needed glasses. However, studies have shown that changes after surgery tend to be very small, and develop very slowly. Once you reach the age of 50, your prescription will only change by an average of half a dioptre every decade.

You can be too old for laser eye surgery

Technically, there is no upper age limit for laser eye surgery as long as the eye is healthy.

You can go blind

This is practically impossible. Realistically, the chance of going blind from laser eye surgery in the hands of an expert surgeon using the best technology is almost too small to measure - probably in the region of 1 in 5 million.

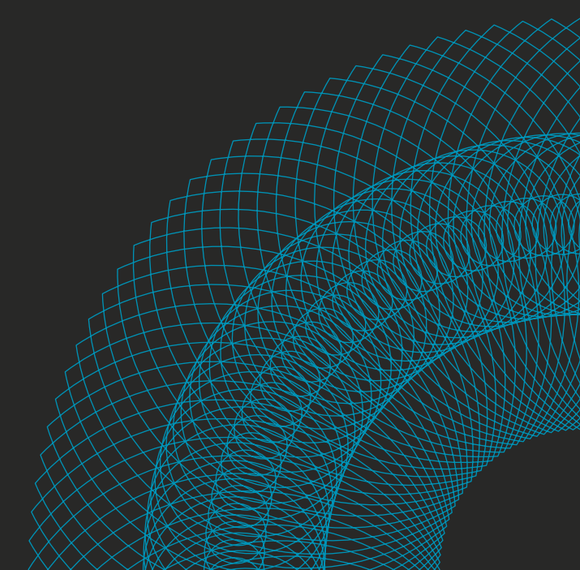
You could end up with worse vision than you started with

This question deals with two issues:

Vision without glasses – uncorrected vision loss: There is virtually no chance that your vision without glasses after laser eye surgery would be worse than without glasses for the specific tasks that you needed them before surgery.

Vision with glasses – loss of corrected distance visual acuity: Your maximum clarity with glasses before surgery is known as your 'corrected distance visual acuity' (CDVA). In expert hands, the chance of your CDVA being reduced by even a small amount is around 1 in 1,000 (0.1%) per eye for the majority of patients. For those with higher prescriptions, the risk may be higher, and this will be indicated at your screening appointment if it applies to you.

There is no age limit



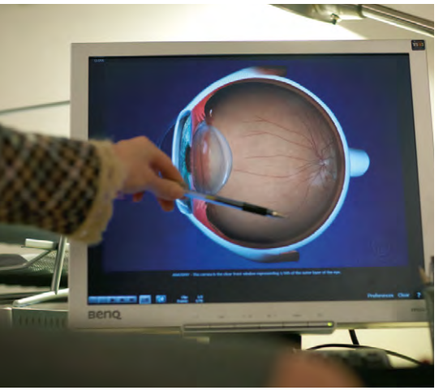
Safety considerations of laser eye surgery

Laser eye surgery is safe and efficacious for use in appropriately selected patients

How safe is laser eye surgery?

Laser eye surgery in the right hands, with the right technology and aftercare, is extremely safe. The National Institute for Health and Clinical Excellence (NICE) is the official body that produces guidance for UK doctors on the effectiveness of medical treatments. In 2006, NICE completed a two-year, in-depth study of laser eye surgery. It concluded that laser eye surgery "is safe and efficacious for use in appropriately selected patients." Numerous review articles of the published literature on laser eye surgery have demonstrated excellent patient satisfaction, clinical outcomes, and safety.

All surgery carries some risk of complications (a complication is defined as an unexpected occurrence). In laser eye surgery, complications are very rare, and advances in technology and surgical expertise mean that almost all complications can now be corrected. In fact, the chance of an expert being faced with a situation of marked permanently reduced vision or quality of vision that he or she could not correct satisfactorily is about 1 in 30,000.



How is safety measured?

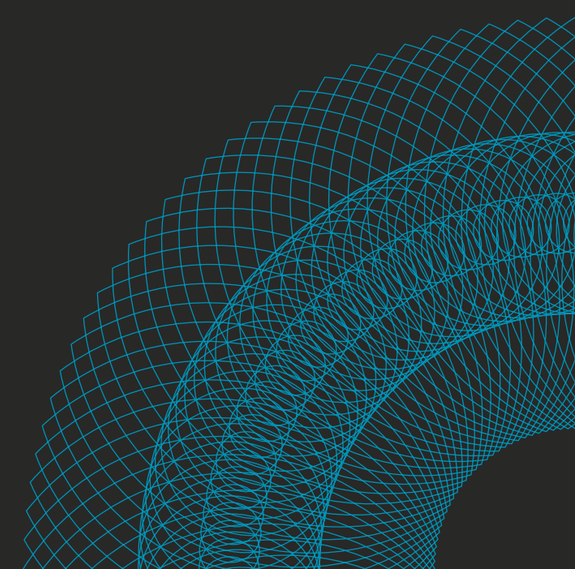
Measures of safety take into account any risk of 'compromise' to your vision. Visual compromise is defined as blurring, doubling or other distortion that cannot be corrected by glasses to achieve the same level of vision you had before surgery with glasses (your CDVA). This is different from a situation in which vision is improved after surgery but there is some blurring, which can be corrected with glasses. In this case the vision is not compromised, it is simply not fully focused (and can be corrected by glasses or, more usually, by a simple enhancement procedure).

In terms of measuring the extent of visual compromise, the standard method is to measure blurring by the number of lines on the eye chart that the patient is no longer able to read. For example, if before surgery you were able to see the 20/16 line with glasses, and after surgery your vision - even with glasses - is 20/25, this would be classified as a loss of two lines of CDVA.

The 2006 NICE report looked at the results of studies published in medical journals and found that, on average, less than 1% of LASIK patients lost more than two lines of best corrected vision after laser eye surgery. However, for expert surgeons, the likelihood of an eye losing two lines of best corrected vision is even less. The level of risk varies slightly depending on your prescription, but on average the risk of an eye losing two lines of best corrected vision is around 1 in 1,000. For those with higher prescriptions, the risk may be higher, and this will be indicated at your screening appointment if it applies to you.

The best way to ensure that your treatment is as safe as possible is to have treatment with an expert surgeon, who chooses to operate with the best technology and insists upon very thorough testing before surgery and regular follow-up appointments after surgery.

Laser eye surgery is safe and efficacious for use in appropriately selected patients



Questions to ask when considering laser eye surgery

You are looking for a surgeon who can show you statistics that reflect individual surgeon outcomes

No-one should undergo any form of elective surgery without feeling fully informed, safe and comfortable. You should **ask as many questions as you feel are necessary** to help you make a decision. **However, here are some essential starting points:**

How experienced is my surgeon?

To become a laser eye surgeon, you must be registered as a doctor with the General Medical Council (GMC). There is also a recommendation that laser eye surgeons obtain the certificate in Laser Refractive Surgery from the Royal College of Ophthalmologists, but this is not a legal requirement. Also, the availability of refractive surgery fellowship specialist training is very limited in the UK, so many surgeons learn refractive surgery 'on the job'. Because of this, standards - unfortunately - vary within the field: it is important to ask whether your surgeon has undergone formal refractive surgery training and for how long, and whether he or she is a corneal specialist. Specifically, you should choose a surgeon with the following credentials as a minimum:

- A Fellow of the Royal College of Surgeons /Ophthalmologists or equivalent
- Fellowship specialty training in corneal surgery
- Fellowship sub-specialty training in refractive (laser eye) surgery
- On the General Medical Council's Specialist Register
- Postgraduate Diploma in Cataract and Refractive Surgery from Ulster University (or similar postgraduate qualification)
- Certificate in Laser and Refractive Surgery from the Royal College of Ophthalmologists

As a patient, you should seek a laser eye surgeon who has experience in the specific procedure you are interested in (for example, LASIK, SMILE, PRESBYOND® Laser Blended Vision, etc.) You should also check what range of prescriptions your chosen clinic can safely treat. If you have a more unusual prescription, you may find that some surgeons will refuse to treat you; this usually does not mean that your prescription cannot be treated anywhere, but rather that your chosen clinic lacks the experience or technology to treat your particular condition.

While more experienced surgeons will have performed a higher number of procedures, it is important not to assume that high turnover equates to a high quality surgeon. Likewise, you should be cautious about basing your decision on advertised complication rates - since what one surgeon or clinic officially classes as a 'complication' may be quite different to another.

Will the clinic conduct all of the necessary pre-operative tests to ensure my suitability for laser eye surgery?

The pre-operative examination is an excellent opportunity to examine the eye fully. **This should ideally include the following tests (some of which are not routinely carried out in laser eye surgery assessments):**

- Refractions, including manifest refraction, cycloplegic refraction, and CDVA
- Slit-lamp examination
- Dilated eye examination
- Intraocular pressure
- Contrast sensitivity
- PRESBYOND® Laser Blended Vision assessment (if you are presbyopic)
- Night vision simulation
- Corneal topography (including back surface, i.e. tomography)
- Dry eye exam
- Pupil size
- Corneal thickness
- Wavefront analysis
- Very high-frequency digital ultrasound (if necessary)
- Keratoconus screening

After conducting all of the necessary tests, the clinic should provide you with a clear assessment of your suitability. If your clinician determines that you are not suitable for treatment, they should provide you with a comprehensive explanation for this. You may want to ask if there is another provider that may have the technology or expertise necessary to treat you safely, even if it may not be possible at your chosen clinic (for example some lasers are much better at treating hyperopia than others, whilst some other practices will not treat patients over 40 years of age, or may offer correction of distance vision only).

How much time will you spend with me before my surgery?

While there is no official guideline for how long a pre-operative assessment for laser eye surgery must be, you should feel that you've been given enough time to have all of your questions answered, and you should have received a full eye health exam (including dilation of the pupils, which is essential to evaluating the health of the whole of the eye).

You should be asked to come in for a one-on-one consent appointment with your surgeon on a separate day from your initial consultation. Based on the updated guidelines from The Royal College of Ophthalmology, published April 2017, a minimum cooling off period of one week is recommended between the procedure recommendation and surgery. In exceptional circumstances, where a one week cooling off period is impractical for you, the reasons for this should be agreed between you and your surgeon and documented in the medical record. We require a minimum of one day prior to the surgery. Even if this seems like an inconvenience, it is very important as it gives you a chance to fully digest the information you have been given during your initial appointment, note down any concerns you wish to address with your surgeon, and make an informed decision as to whether to proceed. It is also important that you are given the opportunity to meet your surgeon before surgery, as they are the person ultimately responsible for your outcome.

Can I see your results for patients with a similar prescription to me?

A good clinic should publish their results in clearly labelled detail, so that you can examine the results that are most relevant to you. For example, results for patients with short-sightedness between -1.00 D and -3.00 D will have less relevance to you if you have -6.00 D of short-sightedness, or if you are long-sighted. You will need to ensure that you are looking at the right group of patients in order to evaluate surgical results properly.

On top of this, some clinics do not publish surgical results relating to near vision after laser eye surgery. If you are over 40 and considering laser eye surgery for presbyopia, you should ask to look at surgical results for near vision as well as distance vision. Ideally, the clinic would have published their results in a scientific journal (known as 'peer-reviewed literature').

At London Vision Clinic, we have published results for the full range of prescriptions including myopia up to -14.00 D, hyperopia up to +7.00 D, and cylinder up to 6.00 D.

What percentage of patients are charged your advertised price? Are there any hidden 'extras'?

In general, you should be cautious about choosing a laser eye surgery clinic based on a cheap offer. It's possible that you will be eligible for the advertised price, but some clinics are known to 'up-sell', advertising a very low price that is only applicable to a small percentage of patients. You should also check what is included in your treatment fee, and whether you will be asked to pay extra for eye drops and aftercare (charges which can quickly add up!).

Above all, you should feel comfortable questioning why laser eye surgery is being offered at a discount price. None of the technology and expertise required for world-class laser eye surgery comes cheaply, so if laser eye surgery costs less, you should ask why - what is being cut out to make it cheaper?

What aftercare regime is provided for my treatment plan?

In terms of follow-up, a good clinic should follow patients for one year after surgery. This is to give the patient's eyes time to settle fully, and to ensure that they have achieved the desired outcome (or to offer them an enhancement procedure, if the surgeon feels there is more that can be done for them).

The amount of aftercare appointments needed will depend on the procedure - for example, patients who have had surface treatments (PRK, LASEK or Epi-LASIK) should be closely monitored during the first five days after surgery. However, for LASIK and SMILE procedures, most patients should have follow-up appointments at:

- 1 day after surgery
- 1-4 weeks after surgery
- 3 months after surgery
- 12 months after surgery

Will I have access to my surgeon after treatment?

This is important. A surgeon is directly responsible for the care of their patients, even if he or she has delegated some aspects of the aftercare to an optometrist. You should always be told how you can contact your surgeon if necessary, and ideally your surgeon should be the person who conducts your appointment the day after surgery.

You will also be given your surgeon's personal mobile phone number on the day of surgery so that you can get in touch immediately if you have any concerns.

Alternative treatment options

While over 97% of patients have a prescription that is within the treatment range for corneal laser refractive surgery, there will be a small number that do not qualify due to their prescription, the shape of the eye or the health of the cornea. If you fall in to this category, there are alternative options available to you including phakic intraocular lens implantation, clear lens exchange, or, of course, to continue with glasses and/or contact lenses.

Phakic intraocular lens implantation

The eye possesses a crystalline lens inside, which serves to add variable power to the focusing of the eye in addition to the focusing power produced by the cornea. The Greek word for lens is 'phacos'. Therefore, inserting a synthetic lens into the eye while leaving the natural crystalline lens of the eye intact is referred to as phakic intraocular lens implantation. There are two types of phakic intraocular lens clinically available: the iris-claw lens and the implantable collamer (or contact) lens (ICL).

The Iris-Claw Lens: The 'Artisan'

The Artisan lens possesses two clips which grip onto the front of the iris, so the lens sits inside the eye behind the cornea. While this lens was more popular in the early 2000s due to a lower risk of inducing cataract formation compared to the ICL, long term problems related to the health of the cornea have emerged. In the meantime, several improvements made to ICL technology have greatly reduced the likelihood of cataract formation. The Artisan lens is now much less commonly used than the ICL.

The Implantable Collamer Lens (ICL)

Phakic intraocular lens implantation is most commonly performed using the ICL made by Staar Surgical. The ICL is an extremely small and thin lens that is implanted inside the eye. The lens sits behind the iris and in front of the natural crystalline lens. ICLs have the ability to treat nearly every possible prescription; in the UK, the lens is available to treat nearsightedness from -0.50 to -18.00 D, far-sightedness from +0.50 D to +10.00 D and astigmatism up to 6.00 D. The lens comes in 4 different sizes to accommodate patients with small, medium or large eyes.

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The Implantable Collamer Lens (ICL)

In 1997 the V4 ICL model was approved for use in the UK, and quickly became the go-to treatment option for patients who were not candidates for corneal laser treatment. A few years ago, an updated model of the lens was introduced, the EVO Visian ICL, which has further improved the safety of these lenses, particularly with respect to the risk of cataract formation by introducing a tiny hole in the centre of the lens. This hole – the aquaport – allows for better flow of aqueous and nutrients around the crystalline lens and it is believed to be the reason for the significant reduction in ICL induced cataract. The second very significant improvement made to ICL technology is in the size selection. Previously, various formulae were used to estimate the size of the lens need to be implanted. At the London Vision Clinic, Professor Reinstein and his team have been involved in optimising this element of the procedure using the Artemis Insight 100 very high-frequency digital ultrasound. To date, over 1 million ICLs have been implanted worldwide.

Patient selection

Patients who are interested in pursuing ICLs undergo the same extensive examination as all laser patients. One important note is that many people who are candidates for ICL have high near-sightedness due to an elongated eye. Therefore, it is very important that a full and thorough examination of the vitreous and retina be performed through a dilated pupil. It is prudent to document the health of the peripheral retina with state-of-the-art wide-field imaging as certain retinal pathology can affect the success rate of phakic intraocular lens surgery. It may be necessary to be evaluated by a retinal specialist to ensure the stability and health of the retina. Treatment of asymptomatic retinal holes or tears may sometimes be required before ICL surgery.

Surgery

The power of the lens that will be implanted determines the surgical course and number of clinic visits that is required. ICLs used to correct myopia have a small hole in the center of the lens to allow for fluid flow around the lens inside the eye but ICLs used to correct hyperopia do not. Therefore, farsighted patients will need to have a very short laser procedure a few days before the ICL procedure to create a small hole in the iris for the fluid to flow through. This is done in an exam room and takes only 1 minute for each eye.

ICL surgery is typically performed 1 eye at a time with 1 to 3 days between eyes. The surgery takes approximately 10 minutes. After treatment you will remain at the clinic for anywhere between 30-60 minutes before receiving a final check which includes eye pressure and lens position review. You will use drops for approximately 2-3 weeks after surgery.

After the procedure

You can return to most normal daily activities the morning after surgery with a few restrictions (e.g. no eye rubbing, swimming, intense physical activity, and avoid dusty or dirty environments). If the eye is stable at 1 week, all restrictions are lifted. You will return for monitoring visits on a similar schedule to laser eye surgery for the first year. After the 1 year visit it is important to continue with an eye care provider for annual check-ups including a dilated retinal exam to monitor the positioning of the lens inside the eye and the health of the eye including the back of the cornea (endothelium), iris, lens, and back of the eye (retina).

As with laser eye surgery, there may sometimes be a small prescription remaining after the ICL is implanted. Residual refractive error tends to be very small but can be addressed in a number of ways. After ICL surgery there are no restrictions on the type of glasses or contact lenses a patient can wear. You can also explore laser refractive surgery to treat any residual prescription (assuming you have no corneal conditions which precluded you from laser treatment in the first place).

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After the procedure

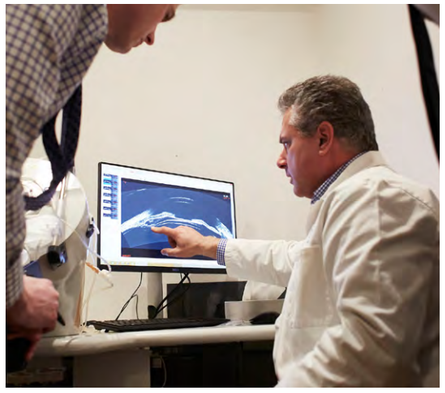
Most patients experience a small amount of glare and halo in the early postoperative period but this tends to go away within a few weeks to months. In some cases, a mild eye drop can be used to constrict the pupil and decrease glare and halo.

It is extremely rare to remove a lens because of subjective complaints, but since an ICL does not alter the natural state of the eye it can be taken out and you can go back to wearing glasses or contact lenses.

Risks and complications

Risks of ICL include pupillary block, cataract formation, increased eye pressure, and glaucoma. While these risks are low, the majority are associated with choosing the correct size lens.

As previously mentioned, the lens is available in 4 sizes. The size is chosen based on measurements taken during the preoperative evaluation. The majority of providers, both in the UK and internationally, still use measurements of the outside of the eye to estimate the dimensions inside the eye, which in turn determine the lens size that should be implanted. However, the anatomy inside the eye where the lens will sit, does not always correlate sufficiently with the external measurements. The most advanced method for ICL sizing is to use the Artemis Insight 100 VHF digital ultrasound scanner to directly measure the area inside the eye behind the iris where the lens will be sitting.



Risks and complications

It seems intuitively obvious that direct measurement of this space inside the eye will provide better information as to which ICL size to choose, than estimating this size from external measurements. It is important that patients be aware of the different sizing methods and ensure that surgeons are using this most advanced method to minimize the chance of complications or needing an ICL lens exchange surgery.

Clear lens exchange

Clear lens exchange (CLE), also known as refractive lens exchange (RLE), is exactly the same procedure that is used for cataract surgery, but in eyes where there is no cataract in the lens. As with ICLs, CLE can be used to correct almost any prescription.

In CLE, your own internal crystalline lens is removed and a synthetic implant is placed inside the capsular bag that contained the natural lens. The implanted lens is similar to an ICL, but it is placed inside the capsular bag, whereas an ICL is placed in front of the natural lens. Because the natural lens is removed, and the implanted lens has a fixed focus, CLE also removes any remaining function of the eye's ability to change focus. Therefore, an ICL is usually preferred when treating patients under the age of 65, whereas CLE is usually used for presbyopic patients with little near focus reserves. In some patients with high hyperopia outside the range for laser eye surgery, there may also not be enough space inside the eye to place an ICL, so CLE would be the only surgical option available for such patients.

There are several inaccuracies in the information often provided to patients regarding CLE. The first is the often-cited advantage that CLE provides permanent vision correction. While the change in refraction due to the procedure is permanent, the cornea reshapes continuously from the age of 40, and this change affects the prescription in about a third of all individuals, usually by changing the astigmatism. Therefore, it is possible for the refraction to shift slightly after CLE due to natural changes to the cornea.

Another proposed advantage of CLE is that it removes the need for future cataract surgery as the natural lens has been removed during the CLE procedure. This is as opposed to undergoing a corneal refractive laser procedure that leaves the natural lens intact, but cataract surgery may be required later in life. However, only 30% of individuals in the UK, a predominantly Anglo-Saxon population, actually go on to have visually significant cataracts that require surgery.

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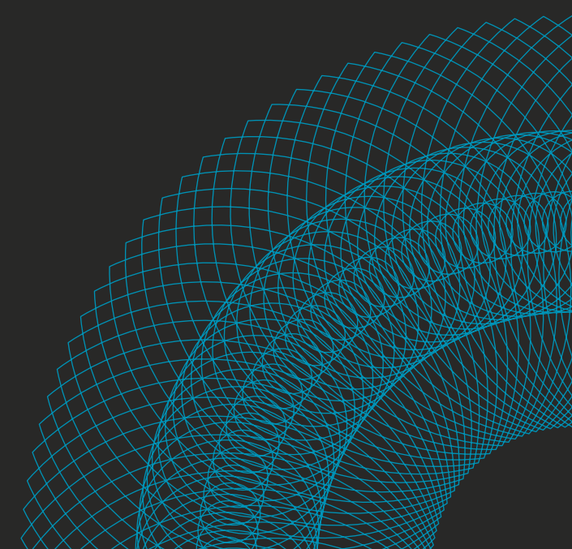
It is important that patients be aware of the different sizing methods



Therefore, the future possible need for cataract surgery should be weighed up against the comparatively higher risks of intraocular surgery, particularly for patients younger than 60. Although it is intuitive to most people that going inside the eye to replace a lens that is still transmitting light (not a cataract) is more invasive and less safe than performing a laser procedure on the surface of the eye, this point is often overlooked or minimized. Catastrophic risks such as bleeding or infection are indeed very rare. However, CLE patients are generally younger than those undergoing normal age-related visually significant cataract surgery so it is important to understand there is a higher risk for retinal detachment or swelling in the back of the eye.

The last point to consider is evolving IOL technology. While the current IOL technology is very good and can provide a range of vision after surgery, there are still limitations that include, glare, halos, and decreased contrast sensitivity. As IOL technology improves, it is expected that new designs will evolve over time that decrease the side effects and provide a more natural range of vision.

With all of that being said, it is very important to measure if, or to what extent, any natural lens changes are happening before making a decision about lens surgery. Changes to the lens begin as early as 40 years old so it is normal for someone to have "yellowing" of the crystalline lens far before it affects the vision. Normal aging changes to the lens are sometimes referred to as "a little bit of cataract" or "early cataract" or "dysfunctional lens syndrome." As mentioned, these changes are completely normal. Using a microscope, providers can visualize the crystalline lens but it is extremely important to objectively quantify the changes. As part of a normal lens evaluation, and before making any surgery decision, a number of instruments should be used to help quantify the changes. These include the HDA Optical Scatter Index (OSI), Oculus C-QUANT, and Tracey iTrace.

In conclusion, CLE is a vision correction option for patients but must be discussed thoroughly and weighed against all other options. As stated in The Royal College of Ophthalmology Guidelines, all alternative interventions need to be discussed that could meet the vision correction needs with less risk, including from other practitioners.

Questions about technology

There are six technologies that most laser eye surgeons use. **These are:**

- Topography and tomography
- Pachymetry
- Pupillometry
- Wavefront aberrometry
- Excimer laser
- Femtosecond laser

Below is some more information about these technologies, as well as some others. We will explain how they measure your eyes, the readings they produce, how accurate they are, and the effect they have on your treatment.

Topography and tomography

What is it for?

Topography and tomography are for measuring the shape of your corneal surfaces. The topographer captures an image of your eye to create a topographic map of the front surface of the cornea. Tomography can also capture the shape of the back surface of the cornea.

What actually happens?

You rest your chin on a padded support and stare straight into the examining instrument. The clinician sits in front of you and aligns the instrument by having you focus on a visual target. They will ask you to open your eyes widely to take a number of multi-coloured pictures that are printed and added to your medical record. The pictures are like maps, where the different colours show the different elevations of your corneal surface(s) and the thickness profile of your cornea.

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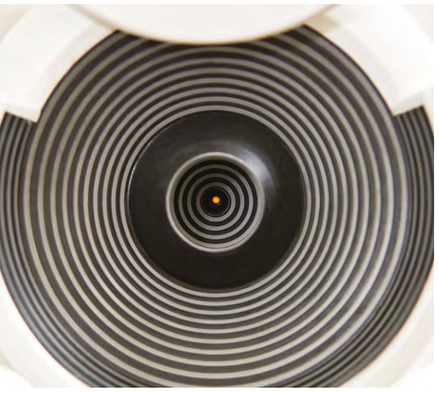


Topography and tomography

How does it feel?
You feel nothing as the instrument does not make contact with your eye.

How does it benefit you?
Topography and tomography are some of the most important safety factors in determining your suitability for laser eye surgery. It is important that both topography and tomography be performed at your pre-operative screening. Topography (measured using instruments such as the Atlas or Keratron) provides the most accurate measurement of the front surface of your eye, while tomography (measured using instruments such as the MS-39, Pentacam, Orbscan and Galilei) measures the shape of both the front and back surfaces of the cornea, and the thickness profile of your cornea. The information provided by this 3D map of your cornea is essential for determining whether there are any corneal abnormalities or if it is too thin for surgery to be safe. In patients with very irregular corneas, topography-guided treatments can be performed to achieve a more regular corneal shape.

Pachymetry

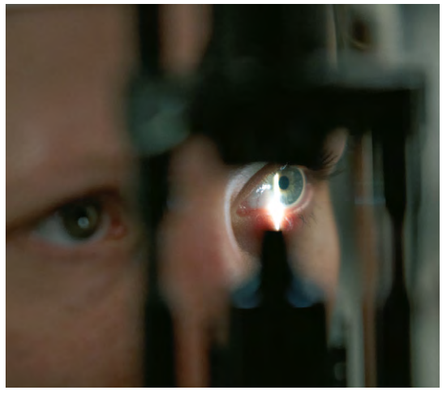
What is it for?
Pachymetry is for measuring corneal thickness - specifically, a pachymeter measures the depth of the thinnest point of your cornea.

Hand-held pachymetry is traditionally used primarily to measure the central area of the cornea where the cornea is thinnest. It takes single point measurements of the corneal thickness.

Corneal pachymetry can also be mapped using optical devices such as the tomography scanners described above (MS-39, Pentacam, etc). The gold standard for pachymetry measurement by optical devices is an optical coherence tomography (OCT) scanner.

Very high-frequency (VHF) digital ultrasound is the most precise way to measure the thickness of the cornea. In addition, it provides 3D thickness profiles of the individual layers of the cornea, allowing improved diagnostic capabilities for both pre-operative and post-operative analysis.

Both tomography and VHF digital ultrasound provide important information about the shape of the cornea that is used to screen for abnormalities such as keratoconus.



Pachymetry

What actually happens?
There are three main types of pachymetry:

Hand-held ultrasound probes:
A topical anaesthetic drop is placed in each eye to numb the surface of the eye for approximately 15 minutes. The optometrist then sits or stands in front of you and gently holds open your eyelid. They will then gently touch a hand-held probe onto the surface of the eye to take readings of the thickness of the cornea.

Very high-frequency ultrasound 3D scanning:
In VHF digital ultrasound, you have your eyes numbed with anaesthetic drops, and have your eye positioned over a watertight rubber eyepiece. The eyepiece is then filled with warm saline solution (like artificial tears). Several arc-scans of the entire cornea are made to generate the thickness profile of each individual layer within the cornea, most importantly the front layer of skin on the cornea (the epithelium). This scan can also be used to measure the thickness of the corneal flap following LASIK.

Optical pachymetry devices:
You rest your chin on a padded support and stare straight into the examining instrument. The clinician sits in front of you and aligns the instrument by having you focus on a visual target. They will ask you to open your eyes widely to take a number of multi-coloured pictures that are printed and added to your medical record. The pictures are like maps, where the different colours show the thickness profile of your cornea and some optical devices can also measure the epithelium.

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Pachymetry

How does it feel?

Hand-held ultrasonic pachymetry is not painful - anaesthetic eye drops are used, so you will not feel the probe touching the eye.

During VHF digital ultrasound scanning, the eye is comfortable in the warm eye bath. The measurements are taken through sound waves that travel through the saline solution - so no instruments will touch the eye.

In optical pachymetry scans, the patient feels nothing (as in a topography/ tomography scan).

How does it benefit you?

Along with front and back surface tomography, measuring the thickness of your cornea and epithelium is one of the most important safety factors in laser eye surgery. Using a pachymeter together with a topography device provides very accurate data and ensures that the thickness of your cornea is within safety limits. Your surgeon uses these measurements to determine whether you are suitable for surgery and which type of treatment is the safest option for you.

VHF digital ultrasound scanning is also one of the most sensitive ways of diagnosing keratoconus - an eye condition that prevents patients from having laser eye surgery.

The most advanced and accurate pachymetry device is the Artemis Insight 100 VHF digital ultrasound scanner. This measures corneal thickness more accurately than OCT, tomography or hand-held ultrasound machines. It produces a 3D image that displays the thinnest point of the cornea with great accuracy, and shows a profile of the depth of your cornea. This technology is currently only available in a handful of clinics around the world.

Very high-frequency digital ultrasound

What is it for?

Ultrasound is used to provide extremely precise measurements of the front surface of the eye (cornea and epithelium) as well as structures inside the eye (iris, ciliary body, and crystalline lens).

What actually happens?

Very high-frequency digital ultrasound (VHFU) with the ArcScan Insight 100 imaging takes approximately 3-5 minutes. While sitting, you will lean forward and rest your head on a chin-rest, as with most eye tests. The eye is then placed against a soft goggle (like a swimming goggle) which is then filled with saline solution. While you are looking at a fixation light, the ultrasound device, without touching the eye, scans in front of the eye. The soundwaves produce a detailed cross-sectional image of the cornea and structures inside the eye.

How does it feel?

The surface of the eye is anesthetized before the exam with an eye drop. The eye is then gently rested in a "water bath" which can initially feel a little cool. There is no other sensation throughout the exam. Most patients describe the experience as soothing.

How does it benefit you?

VHFU is the most accurate way of measuring most internal structures of the eye, particularly the cornea and structures behind the iris. Before surgery VHFU allows for earlier diagnosis of conditions which can affect the outcome and safety of corneal refractive surgery. For example, micronic changes to the epithelial cells (front layer of skin on the cornea) can be detected using VHFU that can indicate the first signs of keratoconus (a corneal condition in which modifications to the standard corneal laser refractive surgery, or other options, must be made). After surgery VHFU allows for the most accurate monitoring of the healing response as well as improved decision making and management of further care.

VHFU is also used in phakic IOL surgery, such as ICL sizing. VHFU is the most accurate way to measure the structures inside the eye that affect the outcome of surgery, particularly the parts of the eye behind the iris that can only be imaged by ultrasound. The high resolution imaging accurately measures specific landmarks inside the eye including the sulcus, ciliary body, and crystalline lens position. Accurate measurements of these structures can help better predict the final position of the phakic IOL and therefore decrease the risk of complications (see phakic IOL section).

Pupillometry

What is it for?
Measuring your pupil size. The pupillometer measures the average pupil size, variation in pupil size over a fixed time frame, and difference in pupil size between the two eyes in three different light levels.

What actually happens?
You are positioned with both eyes viewing a spot light through padded eyepieces. The clinician then measures the size of each pupil in three different light levels, using an infrared camera.

How does it feel?
You feel nothing as the instrument does not make contact with your eye.

How does it benefit you?
Accurate pupillometry is crucial for successful laser eye surgery, because lasers are only capable of treating a defined area of the eye. Typically, this is a circle with a diameter of 6 mm to 8 mm, depending on the laser used. If your pupils were larger than the area that can be treated by the laser, you would be left with an untreated ring around the smaller circle corrected by the laser. It would be like looking through a clear patch in the middle of a smeared window. Some people with large pupils can only be treated by specific lasers that are capable of covering larger areas.

Secondly, some patients have an increased risk of experiencing night vision changes (such as halos and 'starbursts' around lights) after surgery. Accurate pupil size measurements for dark and dim lighting conditions allow your surgeon to optimise your treatment plan to minimise the risk of this occurring.

Wavefront aberrometry

What is it for?
Measuring the optical imperfections of your eye that are not correctable with glasses alone (these are known as the 'higher order aberrations' in your visual system). These irregularities of your cornea and optical system affect the finer quality aspects of your vision (beyond the normal refractive errors of short-sightedness, long-sightedness, presbyopia and astigmatism).

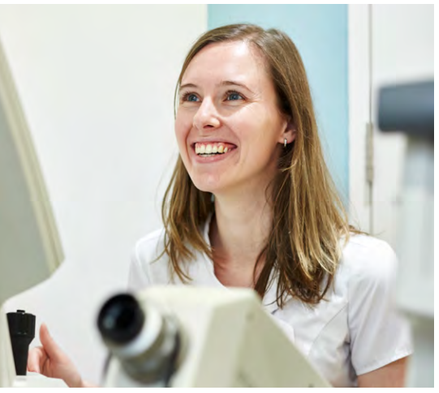
A wavefront aberrometer records data from the light passing through your eye's optical system (the lens and cornea). A map of the imperfections in your eye is then produced, as well as a visual system analysis.

Different aberrometers measure different resolution with the number of spots (measurement points) ranging from as low as 60 to as high as 1200. Recently, a new device has been introduced that uses a different measurement method and has increased the resolution to 40,000 points. A low resolution aberrometer is like a watercolour painting. It provides a general impression of the landscape, measuring just a few points and using a mathematical formula to work out an approximate image of the rest. A high resolution aberrometer is more like a photograph – it records much more data, giving a more accurate map of the number and location of imperfections. This means the surgeon can plan your treatment precisely to incorporate these irregularities.

What actually happens?
You rest your chin on a padded support and stare straight into the examining instrument. The clinician sits in front of you and aligns the instrument by having you focus on a visual target. You will be asked to open your eyes widely. The clinician will then take one or more readings of the 'wavefront' of each eye.

How does it feel?
You feel nothing as the instrument does not make contact with your eye.

How does it benefit you?
The information mapped by a wavefront aberrometer can be fed into the laser to achieve better results. Using wavefront aberrometry allows your surgeon to decide if you would likely benefit from a 'Wavefront Guided' laser eye surgery treatment (which aims to improve on the optical imperfections of your eye, beyond what glasses alone can correct). Wavefront technology can also detect certain eye conditions that would preclude you from getting an optimal laser eye surgery result.



Tonometry

What is it for?

Measuring the pressure inside your eyes. Optometrists and ophthalmologists measure eye pressure (also known as 'intraocular pressure', or IOP) as part of a routine eye examination, to screen for eye diseases such as glaucoma.

One method of tonometry is the 'air-puff' method. In this test, you rest your forehead on a padded support and stare straight into the examining instrument. The instrument then blows a small puff of air onto your eye. The tonometry instrument estimates the pressure inside your eye by measuring the change in the light reflected off the cornea as it is temporarily indented by the air-puff. The clinician may perform the procedure several times for each eye.

Alternatively (or additionally) your optometrist may perform Goldmann tonometry (or a similar 'applanation method'). In applanation methods, anaesthetic drops containing a fluorescein dye are placed in the eyes to numb the surface. Your optometrist will ask you to stare straight ahead whilst resting your chin and forehead against special supports on an instrument called a slit lamp.

A slit lamp is a special microscope with a light source, to which a tonometer is attached. The optometrist will direct a broad beam of blue light from the slit lamp into your eye while they gently move the slit lamp forward until the tonometer probe lightly touches your eye. Your optometrist can directly measure your intraocular pressure by adjusting a tension dial on the tonometer.

How does it feel?

In air-puff tonometry, nothing but air directly touches the eye. You will hear the puffing sound and feel a coolness or mild pressure on your eye. This may make you flinch, but it is not uncomfortable or painful.

Goldmann tonometry is not painful. The optometrist will use anaesthetic eye drops to numb the surface of your eyes so that you will not feel the instrument touching your cornea during the test.

Tonometry

How does it benefit you?

The inside of the eye is nourished by the production of fluid, which drains out of the eye; if there is an imbalance between the rate at which the fluid is produced and the rate at which it is drained away, the intraocular pressure may increase or decrease from its normal level. Measuring changes to the IOP is important, as these changes can affect other structures in the eye such as the optic nerve. Increased pressure inside the eye is often associated with glaucoma. Glaucoma is a treatable condition but, if left untreated, it can be devastating - which is why early diagnosis is so important.

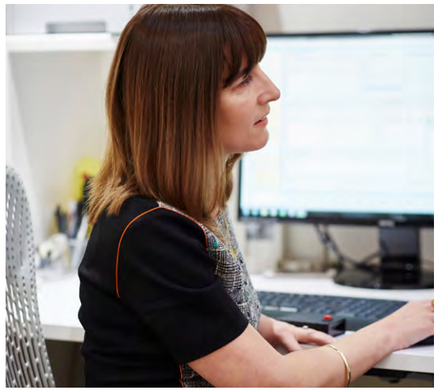
Quality of vision measurement

What is it for?

Vision can be thought of being made up of two elements – the quantity and the quality. Vision 'quantity' is the visual acuity (see earlier section), measured by reading letters on a standard vision chart and is recorded as 20/20, for example. However, it is possible to have 20/20 vision, but still not be satisfied with your vision due to quality of vision symptoms, such as halos, glare, starbursts, double images, or reduced contrast sensitivity. Therefore, it is important to measure the quality of vision in addition to quantity of vision. A number of different devices are available to measure different aspects of quality of vision.

What actually happens?

You rest your chin on a padded support and stare straight into the examining instrument. The clinician sits in front of you and aligns the instrument by having you focus on a visual target. Depending on the device, you may be asked to provide feedback to what you can see by clicking a button.



Quality of vision measurement

How does it feel?

You feel nothing as the instrument does not make contact with your eye.

How does it benefit you?

Measuring the quality of vision in addition to quantity of vision provides your surgeon with a complete picture of what you see. This information can then be correlated with the other scans and tests to make a confident and informed diagnosis, and consequently make an appropriate treatment recommendation. For example, these can be used to assess the visual significance of early cataract formation.

Examples of devices that measure quality of vision include the following. The HD Analyzer evaluates how light is scattered by the eye (known as the objective scatter index), providing a picture of what a point light source looks like for the patient. For example, this picture would be a small circle in a normal eye, whereas the picture becomes larger and more distorted in an eye with a cataract. The C-quant also evaluates light scatter, known as straylight, and works using feedback from the patient when viewing different image patterns.

The light distortion analysis system is a method for measuring the size and shape of halos and starbursts, based on patient feedback when looking at a point light source.

The highest standard of care includes measurement of at least contrast sensitivity before and after treatment to ensure that visual quality has been maintained. It is uncommon for laser refractive surgery to significantly reduce quality of vision, and such changes are manageable with further treatment in the majority of cases. These devices are found at only a few refractive surgery clinics, but are integral to the management of patients who are not satisfied with their quality of vision.

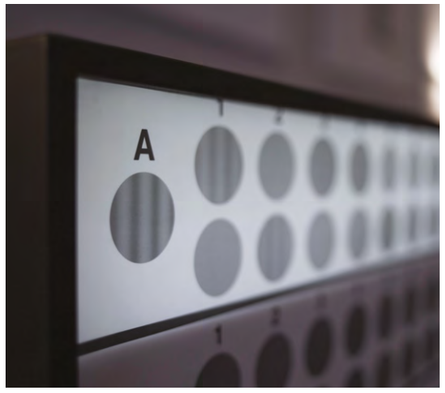
Night vision simulation

What is it for?
Measuring your night vision disturbances. This test provides your surgeon with a picture of how your vision is affected by glare at night, so that they can design a customised treatment plan to maintain or enhance your night vision after surgery.

What actually happens?
The optometrist asks you to look at a computer simulation of common night vision disturbances, such as halos and 'starbursts' around light-emitting objects (e.g. oncoming car headlamps and street lights). They then vary the size and brightness of these disturbances to try to simulate how you see at night.

How does it feel?
You feel nothing.

How does it benefit you?
This test provides your surgeon with subjective feedback which they then match with the objective measurements that have been taken of your wavefront, refraction and topography, allowing them to custom design the optimal treatment for you.



Contrast sensitivity testing

What is it for?
Measuring your ability to distinguish objects in low contrast situations. Assessing your ability to see contrast between images in low lighting conditions provides an important measure of your visual function at night. It gives your surgeon an understanding of how you see things in the real world as opposed to just black-on-white (100% contrast) letters on a chart. Occasionally, people complain of poor vision in dim lighting conditions yet have normal or very near normal black-on-white visual acuity. This is often because they have reduced contrast vision.

What actually happens?
You are shown images of grey stripes, shapes or letters. The images are shown in sequences, and the contrast (the difference between the colour of the image and the colour of the background) reduces each time, so that it becomes more difficult to distinguish the image. You are challenged to recognise the stripes and letters as the contrast decreases, until it is so faint that you can no longer recognise whether there are stripes, or what the letters are.

How does it feel?
You feel nothing.

How does it benefit you?
Night vision disturbances may be induced by laser eye surgery. This is more likely in patients with high prescriptions or large pupils. Measuring your contrast sensitivity provides your surgeon with a further measure of how well you already see at night, giving an indication of how best to plan your treatment in order to avoid night vision disturbances.

In general, lasers using 'aspheric treatment profiles' will be safer with respect to night vision. Some laser systems are so well designed that they can even improve contrast sensitivity and night vision in some patients.

Ocular dominance and tolerance assessment

What is it for?
Assessing your tolerance for PRESBYOND® Laser Blended Vision and enabling your surgeon to design a customised treatment plan that will correct both your distance and near vision at the same time.

What actually happens?
Your optometrist focuses your non-dominant eye for near vision while leaving your dominant eye focused for distance. They will then measure your binocular vision at distance and close up to determine whether you are likely to be suitable for a Blended Vision correction.

How does it feel?
You feel nothing.

How does it benefit you?
If you are over 40 years old, PRESBYOND® Laser Blended Vision can significantly reduce or even eliminate your dependency on reading glasses, bifocals or varifocals.

Microkeratome

What is it for?
The microkeratome is a high-precision, computer-controlled instrument that the surgeon uses to help create the corneal flap in LASIK.

What actually happens?
You lie down on the laser bed facing up. After anaesthetising your eyes with eye drops, the surgeon holds your eye open using a lid holder. The microkeratome holds your eye steady by creating suction between it and your cornea and is then used to make a circular corneal flap with a hinge. The surgeon folds the flap back to expose the inner surface of the cornea, which is then ready for reshaping. In many clinics, the flap creation is done using a femtosecond laser.

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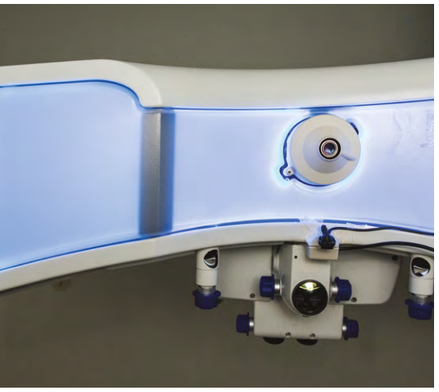
How does it feel?
During this part of the procedure, you may feel a small amount of pressure. This may feel a little strange, but it is not painful. As this happens, your vision will dim or go dark for a few seconds.

How does it benefit you?
The main benefit of a flap in LASIK is that the healing and recovery time is much shorter than with surface procedures (PRK, LASEK and Epi-LASIK). The flap heals within hours, and the vast majority of patients can return to work the day after surgery.



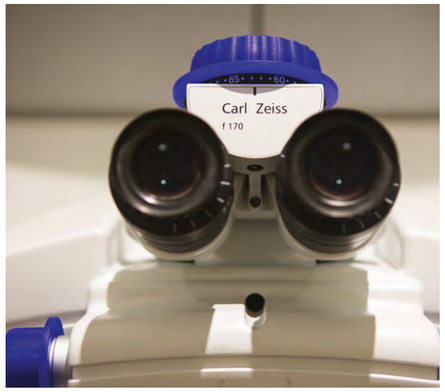
Femtosecond laser

What is it for?
Today, the majority of surgeons use a femtosecond laser instead of a mechanical microkeratome when creating a LASIK flap. A femtosecond laser is also the type of laser used to perform a SMILE treatment. Common brand names of this technology include IntraLase, ZLASIK and VisuMax.

What actually happens?
You lie down on the laser bed facing up. After anaesthetising your eyes with eye drops, the surgeon holds your eye open using a lid holder. Your eye is held steady by creating suction between it and the laser. A femtosecond laser beam is then used to create a bubble layer within the cornea to delineate a circular corneal flap with a hinge in LASIK, or a refractive lenticule in SMILE. In LASIK, the surgeon folds the flap back to expose the inner surface of the cornea, which is then ready for reshaping. In SMILE, the surgeon manually removes the lenticule in one piece through a small 2-mm keyhole opening.

How does it feel?
You may feel some light pressure and gentle pushing and pulling but no discomfort. This may feel a little strange, but it is not painful. While the suction is applied, your vision will go fuzzy.

How does it benefit you?
Femtosecond lasers allow the surgeon to create a thinner flap than is possible using a microkeratome. The femtosecond laser has also enabled the SMILE procedure to be possible.



Excimer laser

What is it for?
Laser refractive surgery for the correction of refractive error. In short-sighted patients, the laser flattens the cornea in the central zone. In long-sighted patients, the laser steepens the central cornea by removing tissue in the periphery. In astigmatic patients, the laser flattens or steepens the cornea in one meridian (direction), in order to make the cornea more spherical (round instead of oval).

The laser beam will be a certain size and a certain shape. The point where the laser touches the eye is called a spot. The smaller the spot, the more focused it is, creating a higher intensity beam that moves around the eye at a faster rate. This means the laser only removes the material it needs to, providing a more precise treatment.

What actually happens?
You lie back on a bed and look into a flashing light. In the space of seconds, the laser removes a tiny, precise amount of corneal tissue to alter the optical focusing properties of the eye.

How does it benefit you?
The excimer laser is an extremely high-precision sculpting tool that changes the focusing of the eye. It enables specialist eye surgeons to reduce or eliminate the need for glasses or contact lenses.

There have been significant strides made in laser technology over the last two decades, but finding a surgeon who has the experience and expertise to use the technology to best effect is critical to successful treatment. Some excimer laser brands are Alcon, Bausch and Lomb, Nidek, Schwind, VISX, WaveLight and Carl Zeiss.

Excimer laser

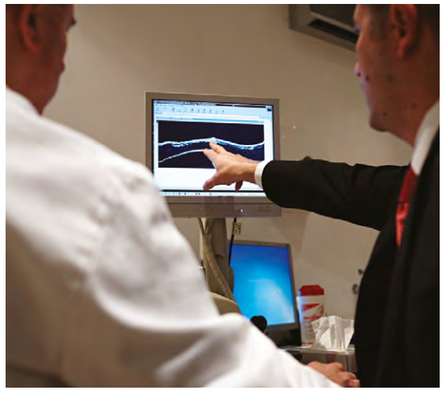
How does it feel?
You will hear the buzzing sounds from the laser, and some patients report seeing a ‘kaleidoscopic’ light. However, you will not feel anything during the treatment. Some patients also report smelling a ‘burning’ odour (similar to the scent sometimes emitted from a hair dryer). This is not actually a burning smell; it comes from the breaking of carbon bonds in the tissues of the cornea.

Active eye tracking

What is it for?
Tracking and compensating for your eye movements during surgery. The purpose of the eye tracker is to enable the laser spot to be delivered to the right position on the cornea.

What actually happens?
The eye tracker monitors your eye’s natural micro-movements and calculates positional corrections needed to place the laser spots in the right place on the cornea. In addition, should your eye move outside of the treatment zone, the eye tracker ‘pauses’ the laser until the eye is back in position (this is called passive tracking).

How does it feel?
You do not feel the eye tracker.



Wavefront guided treatment

What is it for?
Trying to improve on the optical imperfections of your eye beyond that which glasses alone can correct.

Wavefront Guided treatments usually result in better outcomes. However, it is worth noting that this is still an evolving field – in fact, some Wavefront Guided treatments actually are actually less effective than the standard treatments on the same laser. Asking your surgeon to provide data on the relative benefit of Wavefront Guided treatment is recommended, as some clinics will charge extra for this.

What actually happens?
The measurement obtained from Wavefront Aberrometry (see page 46) is combined with the prescription in your glasses, using software that delivers a customised shape change to the cornea.

How does it feel?
Please see excimer laser section.

How does it benefit you?
A small percentage of patients may benefit from a Wavefront Guided treatment. In general, most patients would benefit more from a wavefront optimised or customised tissue removal ablation profile (the shape of tissue removed by the laser).

Customised wavefront optimised treatment

What is it for?

Tailoring the treatment to your eyes, accounting for more than just the prescription in your glasses. Customised Wavefront Optimised treatment planning software enables the highest level of customisation for each individual eye, based on night vision simulations, contrast sensitivity and other corneal and ocular parameters.

What actually happens?

Customised Wavefront Optimised treatment software goes beyond 'generic' Wavefront Guided treatments (see above). In simple terms this is like the difference between a standard 'off the peg' suit that you would find on the High Street and a bespoke suit that has been custom-tailored. Using specialised bespoke software, your surgeon can change the parameters of your treatment based on the wavefront measurement to create an even better result than that obtained by simple Wavefront Guided treatment.

Customised wavefront optimised treatment

How does it feel?

Please see excimer laser section.

How does it benefit you?

Customised treatment planning increases your chance of achieving the best possible visual result. It reduces your risk of night vision changes such as glare, halos and starbursts to the absolute minimum, and maximises the depth of focus achievable by PRESBYOND® Laser Blended Vision.

Frequently Asked Questions

Q: Can laser eye surgery treat the loss of reading vision?

Yes. The loss of reading vision occurs due to ageing, as the eye begins to lose its ability to 'zoom' from distance to near. This means that the close vision deteriorates. Some clinics choose to treat presbyopia by removing the natural lens inside the eye and replacing it with an artificial one.

However, there is also a laser eye surgery procedure called PRESBYOND® Laser Blended Vision, which is highly effective and much less invasive than lens replacement. With this technique, one eye is treated to view objects mainly at distance and a little up close, while the other is treated to view objects mainly up close and a little at distance. The brain learns to combine the two images, enabling the individual to see far and intermediate distances and up close, without effort. Studies have shown that 97% of people are suitable for PRESBYOND® Laser Blended Vision, and almost all are able to read normal newsprint without glasses after surgery.

Q: Which procedure will I be suitable for?

The vast majority of patients undergoing laser eye surgery worldwide are suitable for LASIK, and most short-sighted patients are also candidates for SMILE. In the past, patients with thin corneas tended to be recommended for surface procedures (PRK, LASIK and Epi-LASIK) as these do not require the creation of a corneal flap.

Many of these patients can now be treated with SMILE - a totally 'flap-less', keyhole procedure, which was first introduced in the UK at London Vision Clinic in 2011. However, a small minority remain candidates for surface treatments only, and some patients may only be suitable for an intraocular lens procedure, either an ICL or CLE.

Q: How long should I be out of contact lenses before the consultation with my surgeon ('surgeon consultation appointment')?

Contact lens type		Length of time lenses need to be out before the consent appointment with the surgeon
All soft contact lenses (including toric and extended wear)		At least 1 week before
Rigid gas permeable (RGP)	worn for 0-10 years	At least 4 weeks before
	worn for 10-20 years	At least 8 weeks before
	worn for 20-30 years	At least 12 weeks before
True hard lenses (polymethyl methacrylate)		At least 12 weeks before

Q: Are both eyes treated at the same time?

Yes. Large scale studies conducted over a decade ago demonstrated that there was no difference in safety between single-eye surgery and bilateral surgery. In fact, some evidence suggests that it is actually safer to treat the second eye immediately following the first eye. There are, of course, certain situations where your surgeon may suggest treating one eye at a time, but this would generally be due to specific medical issues.

Q: What will I feel during and after the laser eye surgery procedure?

There is no pain involved during laser eye surgery. You will be given a topical anaesthetic to numb your eyes - most patients report feeling some pressure on the eye (which can be a strange sensation) but not pain. Many LASIK and SMILE patients do not experience any discomfort after surgery - although it is normal to experience some grittiness, light sensitivity and eye watering for the first 24 hours. After surface procedures (PRK, LASEK and Epi-LASIK), the eyes take a few days to heal. However, patients should not find the healing process painful, as they are given pain-relief medication and fitted with bandage contact lenses.

Q: How long does laser eye surgery take?

The treatment takes only minutes and the laser itself is only active for seconds.

Q: What happens if I look away, blink, cough or sneeze during the procedure?

Nothing. Although your eye will move during surgery, eye tracking technology ensures your safety when this happens - the laser tracks your eye hundreds of times every second, and compensates for any movements. In the SMILE procedure, the eye is immobilised by the vacuum connection to the laser.

Q: What is the risk of a complication during laser eye surgery?

Laser eye surgery is safe, but no surgery is entirely without some level of risk. Thankfully, an expert surgeon will have the knowledge to manage complications properly, and will usually be able to correct any complications that do occur. In the hands of an expert surgeon, the chance of something going noticeably wrong is around one in 1,000 procedures. The chance that such a surgeon would be faced with a situation he or she would not be able to correct satisfactorily is about one in 30,000.

Q: Can I take a tranquiliser or sedative (e.g. Valium) prior to the procedure?

Rules about this will vary between clinics. Generally it is better to not use sedatives, as these can alter patient cooperation during the procedure. However, patients who suffer from anxiety disorders such as panic attacks, claustrophobia etc. may benefit from judicial use of sedatives. If this applies to you, your surgeon should discuss the risks and benefits of sedatives thoroughly with you, before surgery. Never self-medicate. Your medical team should provide the necessary required medical dose.

Q: Do laser eye surgery results differ between prescriptions?

Yes. In general, results decrease as prescriptions increase. Results also differ between short-sightedness and long-sightedness. Therefore, when reviewing a clinic's results, it is important to look at results for prescriptions that are similar to yours as these will provide you with a more accurate picture of your chosen clinic's success rates.

Q: What is wavefront?

Wavefront treatment has received a lot of publicity. However, it is important to remember that not all wavefront systems are as good as each other (see Technology section earlier). Wavefront sensors measure the unique optical imperfections of your eye, called 'higher order aberrations'. These irregularities of your optical system affect the finer quality of your vision, beyond what glasses are able to correct. The most advanced wavefront technology can be used to customise your treatment to account for these higher order aberrations, meaning a safer and more accurate treatment.

Q: I have astigmatism, can I still have laser eye surgery?

Yes. Laser eye surgery can treat astigmatism at the same time as it corrects short or long-sightedness. No extra procedure is needed.

Q: Is my prescription too high?

In most cases, having a very high prescription will not stop you having laser eye surgery. The range that any surgeon can treat depends on their technology and experience, but technology and expertise in the field is now so advanced that the vast majority of patients with very high prescriptions are now suitable for a 'full correction' and, for those patients with extremely high prescriptions, laser eye surgery can still be used to achieve a significant improvement in the vision, or an intraocular lens procedure could achieve a full correction, either an ICL or CLE.

If you are turned away by a clinic, it is important to remember that this often does not mean that you are not suitable - it may simply mean that your chosen clinic does not have the technology or experience necessary to treat you safely.

Q: What range of prescriptions can be treated?

The majority of laser eye surgery is performed on patients with:
- Myopia up to -8.00 D
- Hyperopia up to +3.00 D
- Astigmatism up to -4.00 D.

However, some surgeons have the expertise and technology that allows them to safely treat much higher prescriptions – a full correction is sometimes possible on prescriptions of:
- Myopia up to -14.00 D
- Hyperopia up to +6.50 D
- Astigmatism up to -6.00 D.

If your prescription is higher than this, you should not be disheartened as it may be possible to significantly improve your vision with a partial correction. Alternatively, you can consider intraocular procedures such as an ICL or CLE, which can be used to correct almost any prescription.

Q: Am I too old / too young?

Laser eye surgery patients must be at least 18 years old; there is no upper age limit.

Q: Does everyone get presbyopia?

Yes. Presbyopia typically develops during the 40s (although some patients do not begin to lose their reading vision until their mid-50s). When presbyopia develops, people begin to need glasses for reading even if they have never worn glasses before. People who previously wore glasses will need a different prescription for reading than for distance (e.g. bifocals).

Q: What are the risks of laser eye surgery?

Laser eye surgery is, by any medical standard, a safe procedure. However, as with all surgical procedures, there are some risks to consider. Fewer than 3% of LASIK procedures result in any complications. The chance of having a serious complication is much less than 1% generally and probably less than 0.3% with an expert surgeon. The most common complications and side-effects of laser eye surgery are as follows:

- In about 1 in 1,000 LASIK cases, the flap is too short, thin or uneven. If this occurs, the flap is put back in place to heal. The surgeon will not use a laser on your eye and your vision will likely be unaffected, but you can try surgery again in a few months.

- Wrinkles in the flap (striations) occur in about 1 in every 1,000 LASIK procedures. Striations can cause astigmatism. The most likely causes are either rubbing your eyes before they are fully healed, or the surgeon not lining up the flap properly when it is replaced. If the wrinkles are causing astigmatism, a second procedure can be done to lift and smooth out the flap. If they are not causing any problems they can be left untreated.

- In about 1 in every 5,000 cases, patients develop irregular astigmatism after surgery. Contact lenses can usually correct this form of astigmatism (glasses will not). People who have very high prescriptions have a higher risk of this complication. Irregular astigmatism can happen even if the surgery is perfect, but your risk is increased if you have an inexperienced surgeon or one who does not use the best equipment.

- Epithelial ingrowth is a potential complication of LASIK that occurs in less than 1% of cases, in which epithelial cells begin to grow and multiply under the corneal flap. The most common treatment is lifting the corneal flap, removing the cells, irrigating the interface and repositioning the flap. Most cases, if managed appropriately, have a good outcome.

- Ectasia, which occurs in about 4 in 10,000 cases, is a progressive deformity that makes the cornea thinner and steeper. It can be treated with corneal cross-linking (CXL), by suturing (stitching) the flap to the underlying cornea, or in rare circumstances with a corneal transplant. When identified early, it is very unlikely to lead to further visual degradation with appropriate treatment. Ectasia is more likely to occur in eyes with a condition known as keratoconus. Therefore, it is important to undergo intensive and detailed screening for keratoconus before surgery. Currently, the most sensitive method for detecting keratoconus is to use thickness maps of the epithelium in combination with topography and tomography (see the sections on technology). This method was pioneered by Professor Reinstein and has become accepted by ectasia experts around the world as an important component to keratoconus screening.

As with any surgical procedure, there is a risk of infection after laser eye surgery. The risk of a corneal infection is approximately the same as one year of soft contact lens wear (about 5 in 10,000 patients). As with any ophthalmic procedure there is a very remote risk, estimated as less than 1 in 4,000,000, of the loss of an eye, with partial or total blindness.

- Most laser eye surgery patients experience some temporary dryness after treatment. In certain people, the condition is long-lasting. Eye drops can provide relief, but up to 5% of patients have persistent dry eye symptoms up to 1 year, and 1% longer than 1 year.

- Glare and halos are probably the most common side-effect of laser eye surgery. Most patients indeed experience some level of glare and halos at first, but this generally goes away over a period of a few weeks to a few months. Those who do have lasting effects usually only experience symptoms at night, and most do not find them troublesome. Symptoms can usually be improved by further surgery. The causes are below.

Q: What causes glare and halos and can it be treated?

There are several reasons why a patient might develop glare and / or halos after laser eye surgery:

If you have been 'under-corrected' (i.e. if the shape of your cornea has not been changed enough during your procedure), you may still be slightly short or long-sighted and/or still have a minor astigmatism.

A minor enhancement procedure can usually address this. For the small minority of patients who are not candidates for an enhancement, wearing glasses can generally get rid of any troublesome symptoms.

The size of your pupils can be another cause of glare and halos. If a patient's pupils dilate (open) beyond the area of the cornea that has been treated during laser eye surgery, this can cause glare and halos in low light conditions. The risk of this can be mitigated by accurately measuring your dilated pupil size before surgery. The surgeon can determine whether or not they can effectively treat a large enough area of your cornea with the laser, and if this is not possible then the surgeon should decide not to treat you.

If you do have glare and halos at night because of your pupil size, there are a few techniques that can help. Some patients find that keeping the overhead light on inside their car when driving stops their pupils dilating so much that it affects their vision. There are also medicated eye drops that stop the pupil from dilating fully, and some patients find that these fully alleviate the problem. Alternatively, clinics with access to an excimer laser that includes a topography-guided treatment option can perform a second treatment that can reduce these symptoms.

Finally, glare and halos can be caused if the area of your cornea treated by the laser is off to one side (known as 'off-centred ablation' or 'decentration'). Choosing a properly qualified and experienced surgeon can help to minimise the risk of this serious complication. Specialist clinics will be able to perform a topography-guided treatment to re-center the treated zone and improve the quality of vision.

In general, using advanced wavefront technology can significantly reduce the risk of glare, halos and night vision difficulties resulting from surgery (see Technology section for further detail).

Q: How does the flap stay in place in LASIK?

Initially, the flap is kept in position by a vacuum effect. The cells lining the inner surface of your cornea - known as endothelial cells - pump water out to the inner part of the eye. This creates suction, which holds the flap in place. During the first few hours after surgery, the outer surface of the cornea - known as the epithelium - seals the edges of the flap. Over the ensuing weeks, natural substances inside your cornea bond the flap to the underlying tissue.

Laser Eye Surgery is suitable for 98% of patients

Q: What conditions may prevent me from having laser eye surgery?

The following list includes conditions or circumstances that prospective patients commonly ask about when discussing suitability for laser eye surgery.

Condition or Circumstance	Can the person have laser eye surgery at the London Vision Clinic?
Older than 60?	Yes. There is no upper age limit for laser eye surgery, as long as your eyes are healthy. Some older patients experience a longer healing period after laser eye surgery, but this can be discussed at your initial screening if it is likely to apply to you.
Pregnant or breastfeeding?	No. Laser eye surgery is not recommended until 2 months after breastfeeding is complete. Increased hormonal activity during pregnancy and breastfeeding can affect visual outcomes and, while this is not dangerous, it increases your likelihood of being under- or over-corrected and therefore requiring an enhancement procedure. The medications used before, during and after laser eye surgery could also be transmitted to your unborn baby - this should be avoided.
Taking prescription drugs?	Yes, probably. You should indicate which drugs you are taking (prescription or otherwise) during your initial screening. Occasionally, certain medications can prevent you from having laser eye surgery - however, this is rare.

Continued on the next page

Condition or Circumstance	Can the person have laser eye surgery at the London Vision Clinic?
Younger than 18?	No. All laser eye surgery patients must be at least 18 years old before treatment.
Have amblyopia (lazy eye)?	Yes. The aim of laser eye surgery is to achieve the same level of vision as you had with glasses before surgery. Having a lazy eye does not mean that you are unsuitable for laser eye surgery, and many patients with a lazy eye have had very successful overall outcomes - i.e. the surgery achieved the same level of vision as with glasses before surgery, but can also improve the peripheral vision. If you have ever been told that you have a lazy eye (also known as amblyopia) you should mention this at your initial screening, so that your options can be discussed in detail with your optometrist.
Have astigmatism?	Yes. Laser eye surgery has been used to treat astigmatism since 1994.
Have a cataract?	Yes. Whilst laser eye surgery does not 'cure' a cataract, a mild cataract (which is not significantly affecting the vision) should not prevent you from having laser eye surgery. Should the cataract worsen, you can still have successful cataract surgery after laser eye surgery (although you should be aware that cataract surgery after laser eye surgery is a specialist field, which may limit your choice of surgeon for your cataract procedure). In cases of cataracts that are already affecting the vision, you would usually be recommended to have cataract surgery (lens replacement), combined with a laser 'top-up' procedure to fully focus the vision if required.
Have a collagen vascular disease?	Yes. You should indicate this when you are having an initial screening.
Have a compromised immune system?	Perhaps. We assess this on a case-by-case basis and will provide you with an answer at your initial screening.
Have a connective tissue disorder (i.e. rheumatoid arthritis)?	Perhaps. These conditions can be associated with altered healing responses by the body and therefore present a slightly higher risk of complications after laser treatment. However, if the connective tissue disorder is controlled, it is likely that you will be suitable. We assess this on a case-by-case basis and will provide you with an answer at your initial screening.
Have had a detached retina?	Yes. However, it depends on the severity of your condition. Laser eye surgery does not treat a detached retina itself.
Have dry eyes?	Probably. Your suitability for laser eye surgery will depend on the cause and severity of the dry eye, and it is likely that you would be recommended for SMILE rather than LASIK surgery (or occasionally for a surface procedure, if the dry eye is especially severe). To ensure optimum safety, serious dry eye conditions are sometimes monitored for several months (or even years) before surgery.
Have epilepsy?	Yes.
Have glaucoma?	Yes. Laser refractive surgery is not a treatment for glaucoma, but your surgeon will work in conjunction with your glaucoma specialist to ensure that your glaucoma management is not affected by your laser eye surgery.
Have hepatitis C?	Yes. You should indicate this when you have your initial screening.
Have HIV?	Yes. You should indicate this when you have your initial screening.
Have (or have ever had) herpes infection of the eye?	Only if there has not been a reoccurrence of the infection for at least 12 months prior to having the procedure.

Continued on the next page

Condition or Circumstance	Can the person have laser eye surgery at the London Vision Clinic?
Have diabetes?	Yes, if the diabetes is controlled and you don't have any signs of active diabetic retinopathy. To be sure, you'll need to be examined for this at your initial screening. Patients with uncontrolled diabetes are not suitable for laser eye surgery.
Have ever had iritis?	Only if there has not been a reoccurrence of the condition for at least 12 months prior to having the procedure.
Have keloid scarring?	Yes.
Have keratoconus?	No. Keratoconus is a progressive disease that results in the thinning of the cornea. Therefore, removing corneal tissue with laser treatment is inadvisable as it will further destabilise the shape of the cornea. However, London Vision Clinic can successfully stabilise keratoconus - or protect patients from further progression - through a treatment called cross-linking. If you have ever been told that you may have keratoconus, please mention this as early as possible so that we can conduct the necessary investigations and direct you to the right treatment pathway.
Have large pupils?	Yes. With our custom programmed treatments, we have successfully treated patients with very large pupils without inducing night vision disturbances.
Have macular degeneration?	Yes. However, it should be noted that laser eye surgery does not treat macular degeneration itself. If your central vision is significantly reduced as a result of macular degeneration, laser eye surgery may provide little improvement to your uncorrected central vision (although it is likely to improve your uncorrected peripheral vision).
Have night vision disturbances?	Yes.
Have nystagmus (involuntary eye movements)?	Yes. Laser eye surgery will not treat the nystagmus, but can be safely performed with the use of sensitive eye tracking systems (which are now fitted to most modern lasers).
Have only one good eye?	Yes. But have to consider the greater risk.
Have prism?	Yes. However, you may still need prism glasses if you have double vision with contact lenses or without the prism in your spectacles.
Have strabismus (squint)?	Yes. However, laser eye surgery techniques alone will not resolve a strabismus problem, unless the strabismus is a fully accommodative squint (this is seen in some long-sighted people whose eye turns in without their glasses or contact lenses but is perfectly straight with glasses or contact lenses). In general, laser eye surgery is unlikely to be able to restore vision beyond that which is attainable with glasses or contact lenses.
Have systemic lupus erythematosus?	Yes, if it is well controlled. Your surgeon will assess your suitability on a case-by-case basis.
Have thin corneas?	Perhaps. If you have been turned down for laser surgery due to corneal thickness, it is worth having a complete preoperative assessment with us, including a VHF digital ultrasound examination with the Artemis, to rule out keratoconus. If you have thin corneas but do not have keratoconus, you will likely still be a candidate for laser eye surgery using SMILE or a surface procedure.

Glossary

A

Ablation
The removal of organic material from the cornea by an excimer laser in laser eye surgery.

Accommodation
The automatic adjustment of the eye for seeing at different distances, usually via changes in the convexity of the lens inside the eye.

Acuity
The sharpness or clarity of vision. The most common measure of visual acuity is the Snellen acuity chart used by optometrists and ophthalmologists. Normal visual acuity is known as '20/20 vision'.

Amblyopia
Amblyopia, also known as 'lazy eye', is a condition where the vision in one eye is not fully developed, often due to lack of use in early childhood.

Artemis / Insight
A trade name for a very high-frequency (VHF) digital ultrasound scanner manufactured by ArcScan Inc, which measures corneal thickness to the accuracy of 1 micron. It produces a 3D image, which means it can detect the overall depth and thinnest point of the cornea with great accuracy.

Astigmatism
A condition in which the surface of the cornea is not spherical, but shaped like a rugby ball. An astigmatic cornea focuses incoming images on two separate points in the eye, creating a distorted image. The second number on your glasses prescription refers to your degree of astigmatism.

B

Bifocals
Corrective lenses that have two powers of correction. Typically, most of the lens is used for distance vision while a smaller area is for near vision. Bifocals and varifocals are normally prescribed for individuals with presbyopia (ageing eyes).

Binocular vision
The blending of images seen individually by each eye into a single image.

C

Cataract
A condition caused by the clouding of the natural lens inside the eye.

Clear Lens Exchange (CLE)
A surgical procedure, similar to cataract surgery, in which a surgeon removes the crystalline lens from the eye and replaces it with a clear plastic intraocular lens (IOL).

Contrast sensitivity
The ability to perceive differences between an object and its background, i.e. the ability to distinguish a grey object on a grey background.

Cornea
The transparent covering at the front of the eye. Most laser eye surgery procedures work by changing the curvature of the cornea.

Corrected distance visual acuity (CDVA)
A measure of a patient's best possible visual clarity whilst wearing corrective lenses, such as glasses or contact lenses.

Crystalline lens
See 'Lens'.

Cross-linking (CXL)
Corneal cross-linking is a procedure where riboflavin drops are put on the eye and illuminated with UV light. This causes a chemical reaction to occur within the cornea to create bonds between corneal layers and increase the overal strength of the cornea. Cross-linking is used to treat patients with keratoconus or ectasia.

D

Decentration
A potential complication of laser eye surgery. In perfect centration, the centre of the corneal ablation exactly coincides with the centre of the visual axis. This allows for sharp, focused vision – like looking through the very centre of your spectacle lens. If the area of your cornea treated by the laser is off to one side, this is known as decentration (or 'off-centred ablation'). Decentration can cause various symptoms, including edge glare or even monocular double vision. Other factors, such as the size of the pupil, the amount of light in your surroundings, and the size of the ablation zone will affect the severity or presence of symptoms.

Dilation
The process by which the pupil enlarges, usually in low light conditions. Alternatively dilation can be induced artificially by special eye drops, which is necessary to examine the health of the back of the eye.

Dioptre (D)
A unit of measurement of the refractive power of a lens.

Double vision
Also called 'ghosting', this means seeing double images. For example, looking at a clock and finding that some of the numbers appear to have a lighter image repeated next to them.

Dry eye
The term 'dry eye' is used to describe a variety of disorders with similar symptoms: discomfort, a feeling of dryness, burning or stinging, grittiness, foreign body sensation and photophobia.

E

Ectasia
An outward bulging and thinning of the cornea due to raised internal eye pressure and/or a weakened cornea.

Endothelium
The inner layer of cells on the inside surface of the cornea.

Enhancement
A secondary laser eye surgery treatment or retreatment, performed to refine or improve the original visual result.

Epi-LASIK
See Laser Assisted Epithelial Keratomileusis.

Epithelial ingrowth
A potential complication of LASIK, in which epithelial cells under the corneal flap begin to grow and multiply. The most common treatment is lifting the corneal flap, removing the cells, irrigating the interface and repositioning the flap. Most cases, if managed appropriately, have a good outcome.

Epithelium
The outer surface layer of the cornea – the skin. Measurement of the thickness profile of the epithelium is one of the most sensitive methods for detecting a condition called keratoconus.

Excimer laser
An argon-fluoride laser that emits ultraviolet light in pulses, at a wavelength of 193nm. The term excimer comes from the concept of 'an energised molecule with two identical components'. Each pulse of this cool laser removes 1/4000th of a millimetre of tissue from the targeted surface, by breaking the bonds between the molecules of collagen. It would take about 200 pulses from an excimer laser to cut a human hair in half.

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F

Far-sightedness
See ‘Hyperopia’.

Femtosecond laser
A femtosecond laser is a laser that emits optical pulses with a duration of 1/4000th of a second. Femtosecond laser technology is used for the SMILE laser eye surgery procedure, and to create a corneal flap in LASIK.

Focusing power
The cornea is responsible for about two-thirds of the focusing power of the eye. As light enters the eye, it is focused by the cornea. Then, as the light passes through the pupil, the lens adjusts the focus, depending on the distance of the object being viewed. Close objects, such as a book or computer screen, require more power than distant objects, such as traffic signs.

G

Ghosting
See ‘Double vision’.

H

Halos
Images from light sources look blurred with circles radiating outward from the centre. Halos can appear as a complication of refractive surgery but they also occur naturally.

Hyperopia
Also known as far-sightedness or long-sightedness. Hyperopia occurs when the eyeball is too short from front to back or the focusing mechanism is too weak. This causes light rays to be focused behind, rather than on, the retina. People with hyperopia have difficulty seeing objects that are close by.

I

Intraocular
Inside the eye.

Intraocular lens (IOL)
Silicone, acrylic or plastic lens used to replace the natural crystalline lens of the eye. See also ‘Clear Lens Exchange’.

Intraocular pressure (IOP)
Pressure inside the eye.

J

Joules
Joules is the unit of measurement of energy.

K

Keratectomy
Surgical removal of corneal tissue.

Keratoconus
A disorder that causes thinning and asymmetry of the cornea. The normally symmetrical shape of the cornea becomes distorted. A cone-shaped bulge develops, and this can result in significant visual impairment. Laser eye surgery is not recommended for patients with keratoconus. These patients may consider cross-linking to strengthen the cornea.

Keratomileusis
A refractive surgical technique in which a thin, circular flap of the cornea is removed, frozen, reshaped on a lathe and replaced upon the cornea.

L

Laser
LASER stands for Light Amplification by the Stimulated Emission of Radiation. Laser light is composed of one colour (wavelength), travelling in one direction, and each light wave is in step with the next. This makes laser light millions of times more powerful than ordinary daylight.

Laser in-situ keratomileusis (LASIK)
A surgical procedure to reshape the central cornea, decreasing or eliminating myopia, hyperopia, and astigmatism. The surgeon creates a flap in the cornea, and the exposed eye surface below is reshaped using an excimer laser. After altering the corneal curvature, the flap is replaced. It adheres quickly, without stitches.

Laser assisted sub-epithelium keratectomy (LASEK)
A surgical procedure to reshape the cornea by detaching the epithelium with an alcohol solution that softens it and allows it to be rolled back into a flap. After excimer ablation to correct the vision, the flap of epithelium is repositioned over the cornea.

PRESBYOND® Laser Blended Vision
A laser eye surgery technique for the correction of presbyopia, in which one eye is treated to view objects mainly at distance, but a little up close and the other is treated to view objects mainly up close, but a little at distance. The brain combines the images and enables the individual to clearly at all distance.

Lens (also called crystalline lens)
The natural lens of the eye is located behind the iris. It helps rays of light to focus on the retina. The lens is transparent, but with age, it can become cloudy (this is known as a cataract). The lens has the ability to ‘zoom’ its focus from distance to near; however, this reduces with age (this is known as presbyopia).

Long-sightedness
See ‘Hyperopia’.

M

Micron (µm)
A unit of length equal to one-millionth of a metre.

Microkeratome
A surgical device for creating a flap of corneal tissue, used in older forms of LASIK. Most modern laser eye surgeons now use a femtosecond laser to create corneal flaps, instead of a microkeratome.

Monovision
A technique using contact lenses (or older laser systems) to overcome the effects of presbyopia by correcting one eye for near vision and the other for distance vision – not to be confused with PRESBYOND® Laser Blended Vision, which is a more sophisticated procedure.

Myopia
Also known as near-sightedness or short-sightedness. Myopia occurs when the eyeball is too deep from front to back or the eye’s focusing mechanism is too strong. This causes light rays to be focused in front of, rather than on, the retina. People with myopia have difficulty seeing distant objects.

N

Near-sightedness
See ‘Myopia’.

O

Off-centred ablation
See ‘Decentration’.

Ophthalmic
To do with the eye.

Ophthalmologist
A medical doctor who specialises in the diagnosis and medical or surgical treatment of eye diseases. Ophthalmologists have medical degrees and further specialist training. Ophthalmologists are usually trained as surgeons, but some choose not to perform surgery and work as medical ophthalmologists. An ophthalmologist may also prescribe glasses and contact lenses.

Optic nerve
The optic nerve is a bundle of nerve fibres, about the diameter of pencil, which passes through the back of the eyeball and connects the retina to the brain. The optic nerve carries visual messages from the photoreceptors of the retina to the brain.

Optical zone
The area within which the corneal shape is changed by the surgery.

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Optician
An expert in making and fitting glasses. An optician may also be qualified to dispense and/or fit contact lenses.

Optometrist
An optometrist is a non-medical eye health provider, who specialises in the examination, diagnosis, treatment, management and prevention of diseases and disorders of the visual system. In the UK, optometrists complete a three year degree at University. Many optometrists dispense glasses and contact lenses. Optometrists may not prescribe medicine, as they are not medical doctors.

Over-correction
An outcome of refractive surgery in which the resulting amount of correction is more than desired. Over-correction occurs most frequently when healing does not occur as predicted. It can usually be treated easily, with an enhancement procedure.

P

Pachymeter
A device that measures the thickness of the cornea.

Peripheral vision
The ability to see objects and movement outside the direct line of vision.

Photorefractive keratectomy (PRK)
A surgical procedure using an excimer laser to reshape the central cornea, to give a flattened shape for people who are myopic or a more curved surface for people who are hyperopic.

Plano
No refractive error.

Presbyopia
Part of the normal process of ageing. As we become older, the crystalline lens begins to lose its ability to zoom from distance to near vision. To compensate for this, people wear reading glasses such as bifocals.

Pupil
The small black circular space in the centre of the iris. The pupil changes its diameter in response to different light levels, becoming bigger in the dark and smaller in bright light. The pupil controls the amount of light reaching the retina and the depth of focus of the eye.

Pupillometry
A diagnostic test to measure the size of your pupils.

R

Refraction
A test to determine the best glasses or contact lenses to correct a refractive error (myopia, hyperopia, presbyopia or astigmatism). 'Refraction' also refers to the bending of light by the use of a lens or other material.

Refractive error
A measurement of visual imperfection. The degree to which images received by the eyes are not focused on the retina (causing myopia, hyperopia, presbyopia or astigmatism), measured in dioptres.

Refractive lens exchange
See 'Clear lens exchange'.

Refractive surgery
Any surgical procedure that alters the focusing power of the eye (including, but not limited to, the laser eye surgery and intraocular procedures covered by the guide).

ReLEx SMILE
Often known simply as SMILE (small incision lenticule extraction). SMILE is an evolution of LASIK laser eye surgery, in which a tiny amount of corneal tissue is removed through a 'keyhole' incision – no flap is created.

Retina
The light sensitive layer of cells (rods and cones) on the inner, back surface of the eye that converts light images into nerve impulses. These are then sent along the optic nerve for transmission to the brain.

Retreatment
See 'Enhancement'.

S

Snellen visual acuity test
The Snellen test is the most common test used to determine visual acuity. It uses a white chart with the big black letter E at the top, followed by lines of letters that descend in size. The test gives a result such as 20/40, which means that the person can see an item 20 feet away with the same clarity as a normally sighted person can see at 40 feet. See also 'Acuity'.

SMILE
See 'ReLEx SMILE'.

Starbursts
Images from light sources blur, with spikes radiating out from the centre. Starbursts can be a complication of refractive surgery, but may also occur naturally.

T

Topography / Tomography
A technology used to determine the shape of the front and back surfaces of the cornea. This is used to detect any abnormalities in the shape of the cornea, most importantly to detect eyes with keratoconus, in which laser eye surgery should not be performed. Topography data can also be used by some laser systems to plan a topography-guided treatment, which can be used to smooth the shape of the cornea if it is irregular.

V

Visual acuity
See 'Acuity'.

Visual field
The extent of an area seen by the eye in a given position of the gaze. The central visual field is directly in front of the object at which we are looking. The peripheral visual field is 'side vision'. The fields in each eye partly overlap.

W

Wavefront
A technology used to determine and measure higher order aberrations. These aberrations affect the finer quality of the vision. While conventional eye examinations can detect two types of error on the cornea: spherical (myopia and hyperopia) and cylindrical (astigmatism), wavefront diagnostics can detect an infinite set of ocular aberrations – this information can then be used to create a customised treatment plan.

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