

diving medicine

CORNEAL SURGERY AND DIVING

THERE ARE CURRENTLY SEVERAL DIFFERENT TYPES OF SURGERY BEING PERFORMED ON EYES TO CORRECT THEM SO THAT A PERSON DOES NOT HAVE TO WEAR GLASSES AND MORE PROCEDURES ARE BEING DEVELOPED. THIS DISCUSSION WILL BE LIMITED TO THE FOUR MOST COMMON; RADIAL KERATOTOMY (RK), SURFACE PHOTOREFRACTIVE KERATECTOMY (PRK), LASER IN SITU KERATOMILEUSIS (LASIK), AND INTRASTROMAL CORNEAL RING SEGMENTS (ICRS). PRK AND LASIK USE THE EXCIMER LASER AND ARE OFTEN REFERRED TO AS LASER EYE SURGERY. I HAD LASIK ON 18 DECEMBER 1996 AND AM PLEASED WITH THE RESULTS.

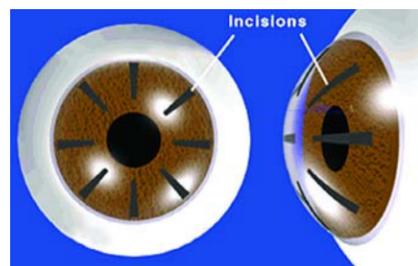
Radial Keratotomy (RK)

In radial keratotomy the surgeon attempts to make a series of radial cuts 90% of the way through the cornea to weaken the edges of the cornea and allow the centre of the cornea to flatten. This only works in near-sighted eyes where the power of the cornea is too strong (cornea too round).

This surgery has been available for decades but there are serious problems with this operation. The visual complications include a change in vision during different parts of the day, increased susceptibility to glare, and reduced night vision. A change in barometric pressure will cause a change in visual acuity (moving to a different altitude, flying, mountain climbing, etc.).

The cornea has a tendency to continue to flatten with time so that several years after the surgery the person is often far-sighted. The cuts in the cornea do not heal with anywhere near the original

strength of the cornea and a blow to the eye can result in rupture of the cornea. In the Canadian Forces, anyone who has

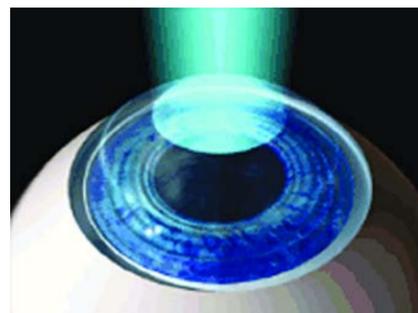


had RK is unfit diving, pilot, air traffic control, tactical helicopter observer and search and rescue technician duties, for life.

I know of recreational divers who dive after RK but more recent procedures are so much better than RK that it should no longer be performed.

Surface Photorefractive Keratectomy (PRK)

This was the original procedure where the excimer laser was used to change the shape of the cornea to correct near-sightedness and astigmatism. In this operation the front of the cornea is



removed by the laser (basically your glasses prescription is carved onto the surface of the cornea). The amount of corneal tissue removed is limited so that the cornea is not significantly weakened. PRK was first performed in 1987 and millions of eyes have been corrected. The

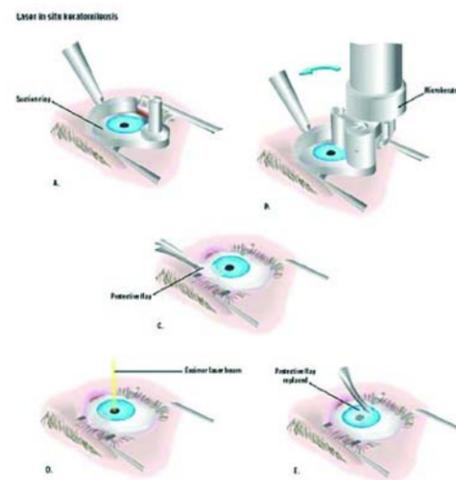
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basic problem with this procedure is that the epithelium (skin) on the surface of the cornea is removed by the laser and it takes several months for the cornea to heal and vision to stabilize. Another problem is that the cornea tries to repair the defect and the more successful the healing process, the worse the visual result. In some cases the procedure must be repeated to remove the repair tissue! It usually provides good correction for small amounts of near-sightedness (maximum three diopters) and astigmatism (maximum one diopter).

PRK has several disadvantages compared to LASIK including increased postoperative pain, delayed visual recovery, central visual haziness, repeat surgery more difficult, and each eye must be corrected separately. PRK has been almost completely replaced by LASIK. You should wait several months after PRK to allow your vision to stabilize, to allow the cornea to heal, and to ensure that complications do not occur before diving.

Laser in Situ Keratomileusis (LASIK)

The newest laser procedure is laser in situ keratomileusis (LASIK). In this procedure, a powered knife (microkeratome) is used to cut a three-sided flap on the surface of the cornea. The flap is folded out of the way and the laser is used to carve the center of the cornea to change the shape to correct the refraction. The flap is then unfolded to cover the surgical site. The surface of the cornea is not damaged and the basement membrane is left intact. Therefore, the only healing that has to take place is the cut. LASIK can be used to correct 0.5 to 12 diopters of near-sightedness, five diopters of astigmatism and six diopters of far-sightedness. There is less chance of scarring or blurring of the cornea, and the results are both more



predictable and better than with PRK. Both eyes are corrected on the same day and vision usually recovers in less than 48 hours.

Both laser procedures initially had problems with visual distortion because the area of correction was smaller than the diameter of the pupil at night. Third generation machines (like the one used on my eyes in 1996) corrected an area up to 9 millimetres in diameter so these problems became very rare. Fourth generation lasers are 'narrow beam or scanning' (the picture is of a third generation, broad beam, laser). Fourth generation lasers carve a one to two millimetre spot on the cornea and cycle up to 50 times a second. The end result is that the surface of the cornea is smoother and the cornea is less traumatized.

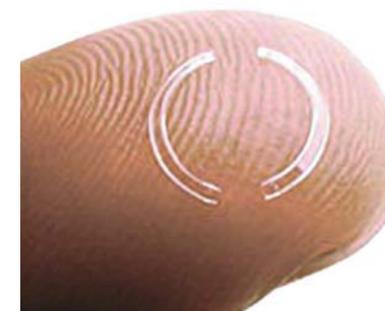
Current machines correct spots less than one millimetre (100 u) at a time (even smoother results) and corneal topography is usually done before the procedure so that the exact original shape of the cornea is known and factored into the correction to result in even better visual acuity. In addition, recent lasers use an eye tracking system to correct for eye movement during the surgery. There are potential complications with LASIK, but

they are very rare (the risk of a significant infection is less after LASIK than wearing contacts).

The maximum amount of near-sightedness that can be corrected is a function of the maximum diameter of the pupil and the thickness of the cornea. The larger the pupil, the larger the area of correction required. A larger area of correction requires a greater thickness of cornea to be removed and the cornea is thinner near the edges. Some people have thicker corneas than others. A specific amount of cornea must be left to ensure the strength and stability of the cornea. The practical result of all these variables is that some people who require more than eight diopters of correction for their near-sightedness can not be fully corrected. Never-the-less, if someone who is extremely near-sighted (legally blind) can be corrected to only two or three diopters of near-sightedness, the change in their lives will be amazing. You should wait approximately four weeks after LASIK before diving.

Intrastromal Corneal Ring Segments (ICRS or Intacs)

This is a relatively new procedure. Very small cuts are made in the outer edges of the cornea and Polymethylmethacrylate (PMMA) ring segments are inserted (an older procedure implanted one long ring). These ring segments stretch the cornea



and flatten the centre, thereby correcting one to three diopters of near-sightedness and up to one diopter of astigmatism.

The advantages of intra-corneal ring segments are that no part of the cornea is removed, the central part of the cornea where vision occurs is not involved, and the rings can be removed or replaced at any time in the future.

The disadvantages are that there are a limited number of rings available and the correction is NOT individualized. This is similar to going to the drugstore to get a

DAVID SAWATZKY, S.C., C.D., B.Med.Sc., M.D., M.Sc., is a diving medical specialist on contract at Defence Research and Development Toronto from 1998 to 2005. Previously he was the Canadian Forces Staff Officer in Hyperbaric Medicine at DCIEM (1986-1993) and later the Senior Medical



Officer at Garrison Support Unit Toronto (1993-1998). He's written a monthly column on diving medicine in Canada's *Diver Magazine* since 1993, has been on the Board of Advisors for the International

Association of Nitrox and Technical Divers (IANTD) since 2000, and is an active cave, trimix and closed circuit rebreather diver/instructor/instructor trainer. David's first love is cave diving exploration and he's been exploring and surveying underwater passages in Canada since 1985. David was responsible for the exploration and mapping of almost 11 kilometres of underwater passages in the Ottawa River Cave System. In 1995, he executed the first successful rescue of a missing trained cave diver. David received the Canadian Star of Courage for this rescue which took place in the chilly Canadian waters of Tobermory, Ontario. He still dives as much as possible, but admits his three year old son Lukas, two year old daughter Emeline and wife (Dr Debbie Pestell) are currently higher priorities than diving!

DR K DAVID SAWATZKY S.C., C.D., B.Med.Sc., M.D., M.Sc.

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pair of glasses. However, some people get excellent results and no permanent changes are made to the cornea. You should wait approximately four weeks after ICRS surgery before diving.

Conclusion

In conclusion, radial keratotomy (RK) should not be done and might make you permanently unfit for professional diving.

Surface photorefractive keratectomy (PRK) is a good procedure for small amounts of near-sightedness but it takes several months to heal and has largely been replaced by LASIK.

Laser in situ keratomileusis (LASIK) is an excellent procedure for up to 12 diopters of near-sightedness, five

diopters of astigmatism and six diopters of far-sightedness. The cost is slightly higher than PRK but the visual correction is almost immediate, the results far more predictable and better than with PRK.

Some LASIK centres now advertise that if you do not achieve 20/20 vision after the surgery the procedure is free.

After surface PRK you should not dive for several months. After LASIK or ICRS you should not dive for approximately one month.

If you have worn glasses your entire life, suddenly being able to go swimming, boating, sailing, skiing, climbing, caving, etc. without glasses must be experienced to be believed!

