S Afr Optom 2005 **64** (1) 5 – 10

Laser assisted *in-situ* keratomileusis - a literature review (Part 2)

R Hansraj*, AO Oduntan, TA Rasengane*****

* University of Kwazulu - Natal, Department of Optometry, Private Bag X54001, Durban, 4000 South Africa
<rhansraj@pixie.udw.ac.za>
** Optometry Programme, School of Health Science, Univerity of Limpopo, Private Bag X1106, Sovenga, 0727 South Africa
*** Department of Optometry, Free State Universary, PO Box 339, Bloemfontein, 9300 South Africa

Abstract

This is the second part of an article on the review of laser assisted in situ keratomileusis. This part deals with the contra-indications, risks and complications, as well as, possible side effects of the procedure.

Contra-indications of LASIK

The contra-indications of LASIK include the following:

Monocular patients:

Monocular patients are not good candidates for LASIK because any complications during the surgery could potentially blind the patient[1].

Uncontrolled vascular disease:

Uncontrolled vascular diseases, such as unstable diabetes, could affect the healing process and the long-term stability of the surgical outcome[2]. Therefore, patients with this type of conditions are not considered for the procedure.

Patients who are immuno-compromised:

Immuno-compromise, whether due to being on drugs or therapy that suppresses the immune system; or collagen, vascular and auto-immune diseases, has been found to be associated with marginal corneal ulceration following refractive surgery[3, 4], hence immuno-compromised patients are not considered for LASIK.

Abnormal corneal conditions:

Pre-operative keratoconus, corneal steepening and keratoglobus can potentially lead to post-operative complications and the loss of vision[1, 3, 5-10]. Patients with recurrent corneal erosion and corneal dystrophies should also be avoided or approached with caution, as these conditions affect wound healing and can lead to corneal ectasia[11-14]. The UV radiation from the excimer laser, as well as, the use of steroids post-operatively, can also trigger a recurrence of the viral infection in a patient with a history of herpetic corneal ulcers[1, 4].

Low pachymetry:

Central corneal thickness of less than 410 µm is inadequate for the LASIK operation as the patient will encounter induced irregular astigmatism, distortion and is at risk of corneal rupture[2, 15].

Pregnant or nursing patients:

LASIK is contra-indicated in patients who are pregnant or nursing, or those expecting to become pregnant within six months following the procedure. This is because of the possibility of fluctuating refractive error resulting from hormonal changes[4, 8, 16]. Furthermore, the healing process can be affected during pregnancy and some medications that may be needed, may pose a risk to the unborn or nursing child[8].

Glaucoma patients:

Eyes with glaucoma, or diagnosed with glaucomatous field losses, would be further compromised during the period of increased intra-ocular pressure induced by the suction ring during the LASIK procedure[1, 11, 16]. Therefore, patients with this condition cannot be considered for LASIK.

Progressive refractive error:

Patients with progressive myopia or hyperopia are contra-indicated[11].This is because of possible variation in refractive status following LASIK.

Amblyopia:

Cases of amblyopia are often excluded due to

Received February 2005; revised version accepted 26 February 2005

the risk of complications or infections setting in, which may consequently result in a loss of function of the non-amblyopic eye and thus leave the patient visually disabled[8, 17].

Narrow palpebral apertures and small or very deep set orbits:

Patients with narrow palpebral apertures and small or very deep set orbits are excluded because the positioning of the microkeratome and suction ring is compromised in these patients[1, 11].

Dry eyes:

Patients exhibiting dry eyes or abnormalities of the precorneal tear film are excluded due to the risk of the tear integrity being further compromised following LASIK[1, 18, 19].

Allergy to latex:

Latex gloves are used during the surgery and it comes into contact with delicate ocular tissue, thus patients allergic to latex, are excluded[20].

Risks and complications

Chisholm[18] reports that complications can occur in up to 5.3% of cases of LASIK correction. These complications can either occur intra-operatively or post-operatively as discussed below.

Intra-operative complications

Intra-operative complications have been attributed to the learning curve that is followed by any new technique, with the incidence of complications expected to decrease as the ophthalmologist becomes more proficient as more surgery is performed[2, 11]. The intra-operative complications of LASIK that have been reported include the following:

Pupil bisection:

Pupil bisection occurs if the microkeratome is stopped too early resulting in the hinge of the flap bisecting the pupil. Consequently, there is a very short flap and an inadequate ablation diameter. This complication is often related to poor gear advancement, which may be caused by residual debris on the microkeratome[21].

Free corneal flap:

Failure in hinge formation, resulting in a free cap, may be due to either the microkeratome not being properly set, or insufficient suction[1, 11, 21, 22]. Often patients with very flat corneas (less than 41 D), which protrude much less into the suction ring, are at a greater risk of developing free flaps[21].

Poor flaps:

Poor flaps include those that are perforated, thin or both. A perforated flap results from inadequate suction pressure, a malfunctioning microkeratome, blade imperfections or by buckling of steep corneas during the microkeratome pass[21-23].

Corneal perforation:

Corneal perforation is the most significant potential intra-operative complication, which may occur if the depth plate was improperly inserted or not in place at all[11, 24]. This complication can be very serious since the pressure in the eye is being maintained at 65 mmHg and may lead to lesions in the iris, lens or an explosive haemorrhage[24].

Bleeding of neovascular vessels:

Prior to surgery, many LASIK patients who were previous contact lenses wearers, could have developed superior, and sometimes inferior micropannus[11, 23]. If the area of neovascularization is involved in the flap formation, then it could lead to bleeding, which is difficult to control.

Decentration:

Decentration can occur because of poor fixation during surgery, often due to the patient looking down to look away from the surgeon, or squeezing his/her eyes shut, which induces Bell's phenomenon[1, 25]. Poor alignment of the optics within the laser delivery system can also result in decentration[26]. Decentration will result in the induction of irregular astigmatism and thus lead to ghosting, distortion and night glare[11]. Prismatic effect can also be induced and consequently there will be a reduction of the best corrected visual acuity.

Post-operative complications

Post-operative complications refer to those complications that occur during the healing period and include the following:

Displaced flaps:

A displaced flap usually occurs within the first 24 hours and is often related to significant ocular trauma post-operatively[27]. Flap dislocation can, however, occur later and thus open up the cornea to epithelial in-growth and infection[28]. Patients, therefore, need to be aware of the inherent risk of traumatic flap dislocation or loss. Fortunately, the flap remains hinged and very rarely becomes free. However, it could result in infection and in permanent striae formation.

Corneal infection:

Corneal infection can occur due to poor steril-

ity of the equipment, or compromise of the epithelium[3, 29-31]. In some cases, corneal infection has occurred when bandage contact lenses were used without antibiotic coverage[3].

Epithelial defects:

Epithelial defects can occur especially along the incision edge of the flap. Proliferation of the epithelium irregularly at the edge of the flap can lead to epithelial in-growth[32] being triggered off when there is a poor adherence of the flap to the underlying stroma and thus poor apposition of the flap[22]. Central epithelial defects may occur due to epitheliotoxicity to the topical anesthetic and/or because of dehydration[11]. Another reason could be the implantation of epithelial cells during the surgery secondary to the microkeratome mechanically dragging epithelial cells into the lamellar interface[33]. These defects can result in the patient being very photophobic and experiencing excessive tearing and pain. Further consequences of these epithelial defects may be infection, melting of the edge of the flap, astigmatism being induced and scarring, which will affect vision as the in-growth invades the visual axis[27, 33 ,34].

Diffuse Lamellar Keratitis:

Diffuse lamellar keratitis (DLK), usually referred to as "Sands of Sahara", seems to be caused by contaminants on the microkeratome blade, hence it is emphasised that the blades be cleaned thoroughly before the surgical procedure[35]. It occurs as a result of interface debris or bacterial toxins triggering off an inflammatory reaction, and thus anterior chamber activity[18]. DLK has also been linked to residue of cleaning solutions on the surgical instruments[36].

Corneal ectasia:

Corneal ectasia, which refers to progressive thinning and weakening of the central cornea, has been reported when the residual corneal thickness is less than 250 μm[27, 37-39]. Other risk factors have been identified as *forme fruste* keratoconus, a preoperatively thin cornea or due to a unexpectedly thick flap[40-42].

Flap wrinkles or folds:

Wrinkles or folds within the flap can occur with slight movements of the flap, and will result in distortions and irregular astigmatism if not corrected[18, 21].

Night glare:

Night glare is often experienced as a result of the pupil diameter exceeding the optical zone created. Patients complain of haloes, ghosting and decreased vision at night[11].

Retinal changes:

There have been cases of retinal haemorrhages or retinal detachment reported following LASIK[22, 43, 44]. However, it has been suggested that any retinal haemorrhage may be due to some pre-existing pathology[15]. Vitreo-retinal interface changes may, however, play a role in macular changes following LASIK[45].

Anisometropia:

Anisometropia and aniseikonia, can occur due to different refractive outcomes in both the eyes. This may result in the patient becoming amblyopic, experiencing diplopia and having poor depth perception[46].

Overcorrection:

Variations in the healing response in each patient, together with an incorrect evaluation of pre-operative refractive error, or incorrect set up of computer software, can limit the accuracy of the surgical outcome relative to the attempted correction[1]. This can result in the patient being overcorrected for example, a myope becoming hyperopic or a hyperope becoming more hyperopic. Early presbyopes and presbyopic patients will experience poor vision at near if they become mildly hyperopic from an originally myopic state. This may necessitate a hyperopic LASIK procedure, the use of some other refractive surgery e.g. laser thermokeratoplasty[1], or by optical means.

Undercorrection:

The cause of undercorrections following LASIK are similar to those of overcorrections and include spontaneous regression, inaccurate refractive error evaluation, incorrect interpretation of nomograms and the incorrect set up of the computer software[1, 18, 47]. Undercorrections occur frequently in patients with higher refractive errors[5]. These patients will complain of poor distance vision especially at night. Enhancements will thus be required and in some cases other types of refractive surgery may need to be considered[11, 18], or optical correction with spectacles or contact lenses.

Regression:

Regression refers to the post-operative refractive error slowly going back to the original refractive error. It occurs more often in the higher myopes and has been attributed to

irregular re-epithelialization and hyperepithelialization, particularly at the edge of the ablated area[48]. Regression has also been linked to a "remodelling" of the stroma, even though, the deeper stromal is supposed to be relatively inert in the process of wound healing[49]. An increase in 10 µm epithelial thickness will result in 1 D of regression[50]. When regression occurs it necessitates an enhancement depending on the residual corneal thickness[21].

Possible side-effects

Blurred vision:

Transient blurred vision may occur in the first 12 to 24 hours due to small epithelial defects or stromal oedema, but is expected to rarely last longer than about 48 hours[11]. This corneal haze, from the oedema, has been attributed to increased reflectivity of the anterior stromal keratocytes that are involved in the healing process[51].

Optical aberrations:

Corneal surface irregularities have been reported to induce significant optical aberrations[52]. Optical aberrations may be perceived as haloes, ghost images, shadows and slight distortions. These optical aberrations may or may not interfere with normal visual acuities, but will affect the optical quality of the post-operative image[51, 53].

Dry Eyes:

Patients who undergo LASIK, experience temporary post-operative dry eye symptoms which may last for about one month after the surgery[18, 19, 54-56]. It occurs due to damage to the conjunctival goblet cells and loss of corneal sensitivity, consequently decreasing reflex lacrimation[18, 56-58].

Discomfort:

Any discomfort will usually occur during the first 24 hours. The lack of pain has been attributed to the fact that neither the epithelium, nor the ciliary muscle, has been traumatized[1]. However, patients can experience a foreign body sensation and an orbital ache due to the use of the lid speculum. Pain may also sometimes be an indication of a displaced flap or an epithelial defect[37].

Photophobia:

Patients may be transiently more sensitive to sunlight following surgery, which has been attributed to scattering of light by the edematous or irregular cornea[11].

Conjunctival changes:

An occasional conjunctival haemorrhage following conjunctival edema and injection, may be seen initially in the first 12 to 24 hours[11].The haemorrhage occurs due to the application of the suction ring. This condition must be treated as it can affect visual performance following surgery, if it gets into the flap interface[59].

Loss of corneal sensitivity:

Loss of corneal sensitivity has been associated with various refractive surgical procedures including LASIK. During LASIK most of the stromal nerve trunks are cut, with only those in the hinge being spared[60]. Thus, the cornea is compromised when this sensory capability is drastically reduced. This is particularly important since normal corneal sensitivity is essential for normal corneal structure and function[61].

Conclusion

The goal of refractive surgery is to provide the patient with the best possible visual acuity with minimal surgery. Even though ophthalmologists are principally involved in performing it, the role of the optometrist with regards to refractive surgery includes unbiased advice, as well as pre- and post-operative care and research into the relevant procedures[62, 63]. It is acknowledged that the optometrist, equipped with facts provided by relevant research, will be capable of assisting the patient to make an educated decision with regards to refractive surgery. An optometrist can also be able to provide post-operative management and advise the patient on long-term implications. In this way, optometry can become actively involved in the growing field of refractive surgery to ensure the visual well-being of the patient.

Acknowledgement

The financial support provided by the South African Institute of Race Relations, during the course of this study, is greatly appreciated.

References

1. Buratto L, Ferrari M. Indications, techniques, results, limits, and complications of laser in-situ keratomileusis. *Curr Opin Ophthalmol* 1997 **8** 59-66.
2. Farah SG, Azar DT, Gurdal C, Wong J. Laser in situ keratomileusis: Literature review of a developing technique. *J Cataract Refract Surg* 1998 **24** 989-1006.
3. Slade SG, Doane JF, Ruiz LA. Laser Myopic Ker-

atomileusis. In: Elander R, Rich LF, Robin JA. *Principles and Practice of Refractive Surgery.* Philadelphia. WB Saunders and Company, 1997.
4. Whittaker G. Pre-assessment of prospective PRK patients by optometrists. *Optician* 1994 **208** 28-31.
5. Bores LD. *Refractive Eye Surgery.* 2nd ed. Boston: Blackwell Scientific Publications, 2001.
6. Korolkiewicz M. Preoperative assessment for LASIK – a case of sub-clinical keratoconus. *Optician* 2001 **222** 17-19.
7. Van Niekerk CJS. LASIK:"Hype"or healthcare. *Vision Magazine* 1997 August/September 9-12.
8. Naroo S. Refractive surgery in practice: Part 2 – pre-assessment. *Optician* 2001 **221** 18-23.
9. Schor P, Beer SM, da Silva O, Takahashi R, Campos M. A clinical follow-up of PRK and LASIK in eyes with preoperative abnormal corneal topographies. *Br J Ophthalmol* 2003 **87** 682-685.
10. Chiang RK, Park AJ, Rapuano CJ, Cohen EJ. Bilateral keratoconus after LASIK in a keratoconus patient. *Eye Contact Lens* 2003 **29** 90-92.
11. Machat JJ. *Excimer Laser Refractive Surgery – Practice and Principles.* New Jersey: Slack Incorporated, 1996.
12. Dastgheib KA, Clinch TE, Manche EE, Hersh P, Ramsey J. Sloughing of corneal epithelium and wound healing complications associated with Laser in situ Keratomileusis in patients with epithelial basement membrane dystrophy. *Am J Ophthalmol* 2000 **130** 297-303.
13. Dastjerdi MH, Sugar A. Corneal decompensation after laser in situ keratomileusis in Fuchs' endothelial dystrophy. *Cornea* 2003 **22** 379-381.
14. Fogla R, Rao SK, Padmanabhan P. Keratectasia in 2 cases with pellucid marginal corneal degeneration after laser in situ keratomileusis. *J Cataract Refract Surg* 2003 **29** 788-791.
15. Shah S,Ilango B. Refractive surgery in practice: Part 3 – Laser in situ keratomileusis (LASIK). *Optician* 2001 **221** 16-20.
16. Yu EYW, Jackson B. Recent advances in refractive surgery. *Can Med Assoc J* 1999 **160** 1329-1337.
17. Murray M. Should you have your eyes lasered? *Fortune* 1999 September 27th 95-99.
18. Chisholm C. Refractive surgery in practice: Part 5 – Postoperative follow-up of the patient. Optician 2001 **221** 16-21.
19. Slade SG, Baker RN, Brockman DK. *The Complete Book of Laser Eye Surgery.* Illinois. Sourcebooks, Inc, 2000.
20. Myint J. A day in the life of a Lasik optometrist. *Optician* 2001 **221** 24-26.
21. Filatov V, Vidaurri-Leal JS, Talamo JH. Selected complication of radial keratotomy, photorefractive keratectomy, and laser in situ keratomileusis. *International Ophthalmology Clinics Year* 1997 **37** 123-148.
22. Stulting RD, Carr JD, Thompson KP, Waring III GO, Wile WM, Walker JG. Complications of Laser In Situ Keratomileusis for the correction of myopia. *Ophthalmology* 1999 **106** 13-20.
23. Davidorf JM, Zaldivar R, Oscherow S. Results and complications of laser in situ keratomileusis by experienced surgeons. *J Refract Surg* 1998 **14** 114-122.
24. Rama P, ChamonW, Genisi C, Azar DT. Excimer Laser Intrastromal Keratomileusis. In: Azar DT. *Refractive Surgery.* Appleton and Lange: Connecticut, 1997.
25. Molebny V, Semenov A, Kornilovsky I. Eye movements compensation in excimer laser keratectomy. *Progress in Biomedical Optics – Proceedings Of Laser Applications In Ophthalmology* 1993 **2079** 113-119.
26. McDonnell PJ. Complications of Excimer Laser Refractive Surgery. In: Wu HK, Thompson VM, Steinert RF, Hersh PS, Slade SG. *Refractive Surgery.* Thieme: New York, 1999.
27. Chisholm C. Refractive surgery and optometric co-management. *Optician* 2001 **221** 15.
28. Sridhar MS, Rapuano CJ, Cohen EJ. Accidental self-removal of a flap – a rare complication of Laser in situ Keratomileusis surgery. *Am J Ophthalmol* 2001 **132** 780-782.
29. Chandra NS, Torres MF, Winthrop KL, Bruckner DA, Heidemann DG, Calvet HM, Yakrus M, Mondino BJ, Holland GN. Cluster of Mycobacterium chelonae keratitis cases following laser in-situ keratomileusis. *Am J Ophthalmol* 2001 **132** 298-299.
30. Daines BS, Vroman DT, Sandoval HP, Steed LL, Solomon KD. Rapid diagnosis and treatment of mycobacterial keratitis after laser in situ keratomileusis. *J Cataract Refract Surg* 2003 **29** 1014-1018.
31. Freitas D, Alvarenga L, Sampaio J, Mannis M, Sato E, Sousa L, Vierira L, Yu MC, Martins MC, Hofling-Lima A, Belfort R Jr. An outbreak of Mycobacterium chelonae infection after LASIK. *Ophthalmology* 2003 **110** 276-285.
32. Rocha G, Schultz GS. Corneal wound healing in Laser *in situ* Keratomileusis. *International Ophthalmology Clinics Year* 1996 **36** 9-20.
33. Wang MY, Maloney RK. Epithelial ingrowth after Laser *in situ* Keratomileusis. *Am J Ophthalmol* 2000 **129** 746-751.
34. Yang B, Wang Z, Chen J. The management of epithelial ingrowth after laser *in situ* keratomileusis. *Chin Med Sci J* 2001 **16** 241-243.
35. Kaufman SC. Post-LASIK interface keratitis, Sands of the Sahara Syndrome, and microkeratome blades (letter to the editor). *J Cataract Refract Surg* 1999 **25** 603-604.
36. Sandoval HP, Crosson CE, Holzer MP, Vroman

DT, Solomon KD. Residual cleaner after normal cleaning of laser in situ keratomileusis instruments. *J Cataract Refract Surg* 2003 **29** 1727-1732.
37. Tabb RL.Surgical and non-surgical techniques to correct refractive errors. *Optom Today* 2001 **41** 34-38.
38. Wang Z, Chen J, Yang B. Posterior corneal surface topographic changes after Laser in situ Keratomileusis are related to residual corneal bed thickness. *Ophthalmology* 1999 **106** 406-410.
39. Damiano RE. Late onset regression after myopic keratomileusis – Letter to the Editor. *J Refract Surg* 1999 **15** 160.
40. Chisholm C. Refractive surgery in practice: Part 6 – Postoperative follow-up of the patient. *Optician* 2001 **222** 20-25.
41. Giledi O, Daya SM. Unexpected flap thickness in laser in situ keratomileusis. *J Cataract Refract Surg* 2003 **29** 1825-1826.
42. Randleman JB,Russell B, Ward MA, Thompson KP, Stulting RD. Risk factors and prognosis for corneal ectasia after LASIK. *Ophthalmology* 2003 **110** 267-275.
43. 43.Jory WJ. Refractive surgery today. *Optom Today* 1996 **36** 33-35.
44. Luna JD, Reviglio VE, Juarez CP. Bilateral macular hemorrhage after laser in situ keratomileusis. *Graefes Arch Clin Exp Ophthalmol* 1999 **237** 611-613.
45. Chan CK and Lawrence FC. Macular hole after Laser in situ keratomileusis and photorefractive keratectomy. *Am J Ophthalmol* 2001 **131** 666-667.
46. Rashad KM. Laser in situ keratomileusis for myopia anisometropia in children. *J Refract Surg* 1999 **15** 429-435.
47. Condon PI, Mulhern M, Fulcher T, Foley-Nolan A, O'Keefe M. Laser intrastromal keratomileusis for high myopia and myopic astigmatism. *Br J Ophthalmol* 1997 **81** 199-206.
48. Pallikaris IG, Siganos DS. Laser in situ keratomileusis to treat myopia: early experience. *J Cataract Refract Surg* 1997 **23** 39-49.
49. Lohmann CP, Gυell JL. Regression after LASIK for the treatment of myopia: the role of the corneal epithelium. *Semin Ophthalmol* 1998 **13** 79-82.
50. Ghormley NR. Refractive surgery? You be the judge! *Int Contact Lens Clin* 1999 **6** 81-83.
51. Moreno-Barriouso E, Lloves JM, Marcos S, Navarro R, Llorente L, Barbero S. Ocular aberrations before and after myopic corneal refractive surgery: LASIK induced changes measured with laser ray tracing. *Invest Ophthalmol Vis Sci* 2001 **42** 1396-1403.
52. Mrochen M, Semchishen V. From scattering to wavefronts-what's in between? *J Refract Surg* 2003 **19** S597- S601.
53. Karpecki PM. Dry eye in LASIK: clues to the cause. *Review of Optometry Online* 2001
54. Lenton LM, Albeitz JM. Effect of carmellose-based artificial tears on the ocular surface in eyes after laser in situ keratomileusis. *J Refract Surg* 1999 **15** S227-S231.
55. Aras C, Ozdamar A, Bahcecioglu H, Karacorlu M, Sener B, Ozkan S. Decreased tear secretion after laser in situ keratomileusis for high myopia. *J Refract Surg* 2000 **16** 362-364.
56. Toda I, Asano-Kato N, Komai-Hori Y, Tsubota K. Dry eye after laser in situ keratomileusis. *Am J Ophthalmol* 2001 **132** 1-7.
57. Tseng S, Tsubota K. Important concept for treating ocular surface and tear disorders. *Am J Ophthalmol* 1997 **124** 825-835.
58. Donnenfeld ED, Solomon K, Perry HD, Doshi SJ, Ehrenhaus M, Solomon R, Biser S. The effect of hinge position on corneal sensation and dry eye after LASIK. *Ophthalmology* 2003 **110** 1023-1029.
59. Vajpayee RB, Balasubramanya R, Rani A, Sharma N, Titiyal JS, Pandey RM. Visual performance after interface haemorrhage during laser in situ keratomileusis. *Br J Ophthalmol* 2003 **87** 717-719.
60. Vesaluoma M, Pérez-Santonja J, Petroll WM, Linna T, Alió J, Tervo T. Corneal stromal changes induced by myopic LASIK. *Invest Ophthalmol Vis Sci* 2000 **41** 369-375.
61. Masters BR, Thaer AA. Real-time confocal microscopy of corneal innervation in the in vivo human cornea. *Progress in Biomedical Optics - Ophthalmic Technologies* IV 1994 **2126** 136-140.
62. Bergmanson J, Sheldon T. Current status of photorefractive keratectomy. *Optician* 1994 **208** 20-24.
63. Conway R. PRK counselling in optometric practice. *Optician* 1994 **208** 32-34.