# NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

## INTERVENTIONAL PROCEDURES PROGRAMME

## Interventional procedure overview of laser correction of refractive error following non-refractive ophthalmic surgery

**Laser surgery to correct refractive errors caused by eye surgery**

Refractive errors include common conditions such as myopia (short sightedness) and hyperopia (long sightedness) that impede the accuracy of vision without spectacles or contact lenses.

Laser surgery aims to establish visual accuracy by changing the shape of the cornea (the clear outer layer at the front of the eye), so that light rays are more precisely directed onto the retina.

## Introduction

The National Institute for Health and Clinical Excellence (NICE) has prepared this overview to help members of the Interventional Procedures Advisory Committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

## Date prepared

This overview was prepared in August 2010.

## Procedure name

- Laser correction of refractive error following non-refractive ophthalmic surgery

## Specialty societies

- Royal College of Ophthalmologists
- United Kingdom & Ireland Society of Cataract & Refractive Surgeons

# Description

## *Indications and current treatment*

Refractive errors (myopia, hyperopia or astigmatism) can result from non-refractive ophthalmic surgery such as cataract surgery or corneal transplantation.

Refractive errors are usually managed by wearing spectacles or contact lenses. In patients for whom spectacles and contact lenses do not adequately correct the refractive error, other options include corneal relieving incisions, intraocular surgery such as cataract extraction with standard or toric intraocular lenses and laser corrective procedures.

## *What the procedure involves*

There are 3 types of laser correction considered in this overview:

1. Photorefractive keratectomy (PRK), which involves the removal of the corneal epithelium by surgical dissection followed by excimer laser ablation of a calculated amount of the stromal bed of the cornea.

2. Laser epithelial keratomileusis (LASEK), a modification of PRK, where dilute alcohol is used to loosen the corneal epithelium before it is lifted from the treatment zone as a hinged sheet, and then replaced at the end of the procedure.

3. Laser in situ keratomileusis (LASIK), in which a flap is created with a microkeratome, lifted before laser ablation and then repositioned.

All procedures are performed under local anaesthesia and patients may be given pre- or post-operative antibiotics as prophylaxis against infection. If required, the procedure can be performed on both eyes during the same surgical session.

## Outcome measures to assess efficacy

### Refractive error measurement

Mean spherical equivalent refraction: if the optical power of the eye is too large or too small to focus light correctly onto the retina then spherical refractive errors can occur. Blurred vision is often a consequence of refractive error. The average (mean) spherical equivalent refraction is provided in the majority of studies in table 2. People with no refractive error (emmetropia) have a reading of 0.00 diopters (D). A negative reading indicates myopia (either the cornea has too much curvature or the eyeball is too long) and a positive reading indicates hyperopia (either the cornea does not have enough curvature or the eyeball is too short).

**Visual acuity**

Visual acuity indicates the acuteness or clearness of vision, and is a measure of the spatial resolution of the visual processing system. A Snellen chart with rows of letters decreasing in size is used to measure visual acuity. A person with good visual acuity is able to read all lines on the Snellen chart. This is described as 20/20 or 6/6 vision indicating that the subject is 20 feet or 6 meters from the chart (numerator) and that the distance at which the lines that make up the letters is separated by a visual angle of 1 arc minute is 20 feet or 6 meters (denominator).

Best spectacle-corrected visual acuity is the reading taken when the subject is wearing spectacles or contact lenses and uncorrected visual acuity is taken when they are not using any visual aid.

# Literature review

## *Rapid review of literature*

The medical literature was searched to identify studies and reviews relevant to photorefractive laser correction for postoperative refractive errors. Searches were conducted of the following databases, covering the period from their commencement to 2 August 2010: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches (see appendix C for details of search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The following selection criteria (table 1) were applied to the abstracts identified by the literature search. Where selection criteria could not be determined from the abstracts the full paper was retrieved.

**Table 1 Inclusion criteria for identification of relevant studies**

| Characteristic | Criteria |
|---|---|
| Publication type | Clinical studies were included. Emphasis was placed on identifying good quality studies.<br>Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or a laboratory or animal study.<br>Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature. |
| Patient | Patients with residual refractive errors following non-refractive ocular surgery |
| Intervention/test | Photorefractive laser surgery (PRK, LASEK and LASIK) |
| Outcome | Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy. |
| Language | Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base. |

## *List of studies included in the overview*

This overview is based on 376 eyes from 6 case series[1,2,3,4,5,6]. A further 8 eyes from 8 case reports[7,8,9,10,11,12,13,14] are included to report additional safety outcomes not included in the other papers in the main extraction table (table 2).

Other studies that were considered to be relevant to the procedure but were not included in table 2 have been listed in appendix A.

## Table 2 Summary of key efficacy and safety findings on photorefractive laser correction for postoperative refractive errors

Abbreviations used: BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intraocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; PRK, photorefractive keratectomy; RK, radial keratotomy; UCVA, uncorrected distance visual acuity

| Study details | Key efficacy findings | Key safety findings | Comments |
|---|---|---|---|
| Güell J L (1999)[1]<br><br>**Case series**<br><br>Spain<br><br>Recruitment period: 1994–1996<br><br>Study population: patients with residual myopia and astigmatism following previous surgical techniques.<br><br>n = **62 (87 eyes) – 32 with prior refractive surgery (22 RK, 10 PRK) and 55 with non-refractive surgery, including cataract surgery (26), corneal transplantation (20),implantation of intra-ocular lens in phakic eye (5) and trauma (4)**<br><br>Age: 33.2 years (mean)<br>Sex: not reported<br><br>Patient selection criteria: all included patients had stable refraction in the last 6 months. Any remaining sutures from previous procedures were removed at least 8 weeks before LASIK.<br><br>Technique: LASIK under topical anaesthesia.<br><br>Follow-up: **12 months**<br><br>Conflict of interest/source of funding: not reported | Number of patients analysed: **62 (87 eyes)**<br><br>See table below<br><br>• Refractive accuracy at 12 months: 5.7%±6.1%.<br>• At 12 months: 56.3% (49/87) eyes were plano to -0.50 D, 75.9% (66/87) eyes were plano to -1.00 D and 98.9%(86/87) were plano to -2.25 D.<br>• 1 patient overcorrected (+0.50 D) at 12 months<br>• 70.1% (61/87) did not present any residual refractive astigmatism postoperatively.<br><br><u>Reoperation:</u><br>21.8% (19/87) required reoperation with LASIK due to under-correction. | 1 patient required reoperation for under-correction and they subsequently presented with recurrent corneal erosion symptoms for 3 months after the procedure. Application of topical hyperosmotic agents controlled this. | **Follow-up issues**:<br>• Completeness of follow-up is not reported.<br><br>**Study design issues**:<br>• Unclear if single centre / single surgeon study.<br>• Unclear if follow-up assessments were made by an independent clinician.<br><br>**Study population issues**:<br>• A substantial proportion of patients had prior surgery unrelated to refractive error corrections: Phacoemulsification with IOL implantation: 29.9% (26/87), PK: 23.0% (20/87), RK: 25.3% (22/87), PRK: 11.5% (10/87), penetrating ocular trauma: 4.6% (4/87) and IOL implantation in phakic eyes 5.7% (5/87).<br>• Preoperative cylindrical error: 0.75 D to 6.00 D |

| | Preoperative | 12 months |
|---|---|---|
| Mean spherical equivalent subjective refraction (myopia) | -5.25±2.1 D<br><br>(range: -0.5 to -9.75 D | -0.70±0.65 D |
| Spectacle corrected visual acuity of 1.0 or better | 24.1% (21/87) | 26.4% (23/87) |
| Spectacle corrected visual acuity of 0.5 or better | 89.7% (78/87) | 95.4% (83/87) |
| Uncorrected visual acuity of 1.0 or better | 2.3% (2/87) | 1.1% (1/87) |
| Uncorrected visual acuity of 0.5 or better | 4.6% (4/87) | 70.1% (61/87) |

Abbreviations used BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intraocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; PRK, photorefractive keratectomy; RK, radial keratotomy; UCVA, uncorrected distance visual acuity

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Muftuoglu O (2009)[2]<br><br>Case series<br><br>USA<br><br>Recruitment period: 2005–2008<br><br>Study population: patients with residual refractive error after AcrySof ReSTOR multifocal IOL implantation.<br><br>n = 59 (85 eyes) – all with prior multifocal IOL implantation<br><br>Age: 61 years (mean)<br>Sex: 49.2% (29/59) male<br><br>Patient selection criteria: patients had to meet 1 of 3 inclusion criteria: 1) manifest spherical equivalent of ±0.75 D or greater, 2) UCVA of 20/25 or worse, 3) patient dissatisfaction with the initial visual result of IOL implantation. Patients also had to have a stable refraction for at least 3 months prior to LASIK. Patients could not wear contact lenses for 2 weeks before LASIK. Exclusions: sight-threatening complications after cataract surgery, macular disease, cystoids macular oedema, epiretinal membrane ectasia or keratoconus, residual stromal bed thickness <300 micrometres, active ocular or systemic disease; and pregnant or nursing.<br><br>Technique: LASIK with femtosecond laser flap creation using Visx S4 excimer laser under topical anaesthesia.<br><br>Follow-up: 6 months<br><br>Conflict of interest/source of funding: none</td>
<td>Number of patients analysed: 59 (85 eyes)<br><br>
<table>
<tr><td></td><td>Preoperative</td><td>6 months</td><td>p value</td></tr>
<tr><td>Spherical equivalent</td><td>-0.34±0.90 D</td><td>-0.07±0.29 D</td><td>0.004</td></tr>
<tr><td>UCVA</td><td>0.34±0.24</td><td>0.05±0.08</td><td><0.001</td></tr>
</table>
<br>At 6 months:<br>• 91.8% had UCVA of 20/25 or better.<br>• 98.8% (84/85) of eyes were within ±1.00 D of emmetropia and 97.6% (83/85) of eyes were within ±1.00 D cylinder.
<table>
<tr><td></td><td>Myopic eyes (n = 36)</td><td>Mixed astigmatic eyes (n = 35)</td><td>Hyperopic eyes (n = 14)</td><td>p value*]</td></tr>
<tr><td>Preoperative spherical equivalent</td><td>-0.94±0.53</td><td>-3.0±0.68</td><td>1.04±0.42</td><td><0.001</td></tr>
<tr><td>6 month spherical equivalent</td><td>-0.04±0.31</td><td>-0.16±0.30</td><td>-0.02±0.21</td><td>0.014</td></tr>
<tr><td>Preoperative UCVA</td><td>0.40±0.28</td><td>0.30±0.20</td><td>0.27±0.15</td><td>0.124</td></tr>
<tr><td>6 month UCVA</td><td>0.04±0.09</td><td>0.06±0.08</td><td>0.05±0.08</td><td>0.408</td></tr>
</table>
* unclear which comparison each p value relates to<br><br><u>Retreatment:</u><br>5.9% (5/85) of eyes had 1 additional retreatment with LASIK due to residual myopia or compound myopic astigmatism in 3 eyes and mixed astigmatism in 2 eyes. 3 eyes had retreatment between 3 to 6 months and 2 eyes had retreatment between 6 to 12 months. All eyes had a spherical equivalent within ±0.50 D 6 months after retreatment.</td>
<td>Mild microstriae without a change in BSCVA: 1 eye<br><br>Epithelial nests / ingrowth that remained stable until end of follow-up: 2 eyes<br><br>Moderate or marked dry eye developed between 3 to 6 months: 4 eyes (all received frequent lubricants, 3 had cyclosporine)<br><br>Mild to moderate halos reported after surgery: 2 patients<br><br>Loss of 1 Snellen line: 2 eyes</td>
<td>Follow-up issues:<br>• Follow-up complete for all patients.<br><br>Study design issues:<br>• Single centre retrospective study.<br>• Unclear if follow-up assessments were made by an independent clinician.<br><br>Study population issues:<br>• The studied patients had multifocal IOL implantation in the context of either cataract surgery or for ‘refractive lens exchange’; the latter understood to denote ‘phakic eye’ IOL implantation. Proportions of either group are not quantified.<br>• Mean interval between previous procedure and LASIK: 7.8 months.<br>• Reason for LASIK: 42.4% (36/85) for myopia or compound myopia and astigmatism, 41.2% (35/85) for mixed astigmatism and 16.5% (14/85) for residual hyperopia or compound hyperopia and astigmatism.</td>
</tr>
</table>

Abbreviations used: BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intra-ocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; PRK, photorefractive keratectomy; RK, radial keratotomy; UCVA, uncorrected distance visual acuity

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Hardten D R (2004)[3]<br><br>Case series<br><br>USA<br><br>Recruitment period: 1996–2000<br><br>Study population: patients with significant refractive errors following PK.<br><br>n = 48 (57 eyes) – all with prior corneal transplantation<br><br>Age: 59.6 years<br>Sex: 66.7% (38/57) male eyes<br><br>Patient selection criteria: all patients were intolerant of spectacles and contact lenses and aged at least 18 years. All eyes had all sutures removed at least 45 days before LASIK.<br><br>Technique: LASIK (using VISX STAR Excimer laser system) under topical anaesthesia performed at a minimum of 13 months after PK. Patients received antibiotic and steroid drops after the procedure.<br>15 eyes also had astigmatic keratotomy at the same time.<br><br>Follow-up:21.4 months (mean)<br><br>Conflict of interest/source of funding: authors are consultants for the manufacturer.</td>
<td>Number of patients analysed: 48 (57 eyes)<br><br>
<table>
<tr><th></th><th>Preoperative (n=57)</th><th>1-year follow-up (n=52)</th><th>2-year follow-up (n=28)</th></tr>
<tr><td>Mean spherical equivalent</td><td>-3.94±3.23 D</td><td>NA</td><td>-0.61±1.81 D (reported in abstract)</td></tr>
<tr><td>Mean astigmatism</td><td>4.57 D</td><td>1.76 D</td><td>1.58 D</td></tr>
<tr><td>Best spectacle-corrected visual acuity 20/40 or better</td><td>73.7% (42/57)</td><td>75.0% (39/52)</td><td>85.7%(24/28)<br><br>(reported in abstract)</td></tr>
<tr><td>Uncorrected visual acuity 20/40 or better</td><td>0</td><td>38.5% (20/52)</td><td>42.9% (12/28)<br><br>(reported in abstract)</td></tr>
</table>
<br>Reoperation:<br>8.8% (5/57) required further LASIK for residual refractive errors. One of these eyes developed epithelial ingrowth that did not require removal.</td>
<td>• Intraoperative microperforation: 1.8% (1/57) requiring suture<br>• Sterile interface inflammation: 5.3% (3/57) between 1 week to 1 month<br>• Epithelial ingrowth requiring removal: 7.0% (4/57) between 1 week to 12 months<br>• Epithelial ingrowth not requiring removal: 8.8% (5/57) between 1 month to 3 months<br>• Mild flap striae: 7.0% (4/57) between 1 day to 1 week<br>• Interface fluid pocket: 3.5% (2/57) at 1 month and 3 months<br>• Herpes simplex keratitis recurrence: 1.8% (1/57) at 6 months which resolved after treatment with no loss of BCVA<br>• Repeat graft for persistent irregular astigmatism: 3.5% (2/57) between 1 and 3 years<br>• Repeat graft for oedema: 5.3% (3/57) between 8 months to 3 years.<br>• Flap dislocation: 8.8% (5/57) between 1 day and 1 week (2 required sutures, 1 flap was removed and 1 flap was successfully repositioned without sutures).<br>• Loss of 2 Snellen lines of BCVA at 1 year: 13.5% (7/52)<br>• Loss of 2 or more Snellen lines of BCVA at 1 year: 15.4% (8/52)<br>• Persistent dry eye at last follow-up: 3 eyes</td>
<td>Follow-up issues:<br>• 8.8% (5/57) of eyes lost to follow-up at 1 year, 50.9% (29/57) at 2 years and 78.9% (45/57) at 3 years<br><br>Study design issues:<br>• Retrospective study.<br>• Unclear if follow-up assessments were made by an independent clinician.<br>• Significant irregular astigmatism defined as steep and flat meridians not 90 degrees apart.<br><br>Study population issues:<br>• Baseline: Significant irregular astigmatism: 71.9% (41/57); Regular astigmatism 28.1% (16/57)<br>• 12 of the eyes that had the combination procedure had irregular astigmatism and 3 had high astigmatism.<br>• 5 eyes with glaucoma – none had a preoperative IOP of >25 mmHG or increase of >10 mmHg after the procedure.<br><br>Other issues<br>Discrepancies in the paper:<br>• Mean preoperative spherical equivalent reported as -4.19±3.38 D in the abstract.<br>• Mean preoperative astigmatism reported as 4.67 D in abstract.</td>
</tr>
</table>

Abbreviations used: BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intra-ocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; UCVA, uncorrected distance visual acuity

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Barraquer CC (2004)[4]<br><br>Case series<br><br>Colombia<br><br>Recruitment period: 1995–1997<br><br>Study population: patients with refractive errors after PK<br><br>n = 38 (46 eyes) – all with prior corneal transplantation<br><br>Age: 35 years (mean)<br>Sex: not reported<br><br>Patient selection criteria: patients with complete 5 year follow-up<br><br>Technique: LASIK (using VISX 20/20 laser) under topical anaesthesia.<br><br>Follow-up: 5 years<br><br>Conflict of interest/source of funding: not reported</td>
<td>Number of patients analysed: 38 (46 eyes)<br><br><u>Myopic eyes (n = 40)</u>
<table>
<tr><th></th><th>Preoperative (n = 40)</th><th>1-year follow-up (n = 40)</th><th>5-year follow-up (n = 40)</th></tr>
<tr><td>Mean spherical refraction</td><td>-5.16 D</td><td>-0.21 D</td><td>-0.44 D</td></tr>
<tr><td>Mean cylindrical refraction</td><td>-3.66 D</td><td>-1.72 D</td><td>-1.69 D</td></tr>
<tr><td>Mean BSCVA</td><td>20/39</td><td>20/29</td><td>20/27</td></tr>
<tr><td>Mean UCVA</td><td>20/477</td><td>20/95</td><td>20/110</td></tr>
<tr><td>Mean defocus equivalent</td><td>9.75 D</td><td>2.45 D</td><td>2.57 D</td></tr>
</table>
<u>Hyperopic eyes (n = 3) [calculated by IP analyst]</u>
<table>
<tr><th></th><th>Preoperative (n = 40)</th><th>1-year follow-up (n = 40)</th><th>5-year follow-up (n = 40)</th></tr>
<tr><td>Mean spherical refraction</td><td>5.75 D</td><td>0.50 D</td><td>1.67 D</td></tr>
<tr><td>Mean cylindrical refraction</td><td>-2.00 D</td><td>-0.67 D</td><td>-1.17 D</td></tr>
</table>
<u>Mixed astigmatism (n = 3) [calculated by IP analyst]</u>
<table>
<tr><th></th><th>Preoperative (n = 40)</th><th>1-year follow-up (n = 40)</th><th>5-year follow-up (n = 40)</th></tr>
<tr><td>Mean spherical refraction</td><td>0.50 D</td><td>0.00 D</td><td>0.17 D</td></tr>
<tr><td>Mean cylindrical refraction</td><td>-5.50 D</td><td>-1.67 D</td><td>-2.42 D</td></tr>
</table>
Overall at 5-year follow-up:<br>• 63% (29/46) had a refractive error within 1.00 D of emmetropia<br>• 33% had uncorrected visual acuity of 20/40 or better<br>• 59% eyes gained more than 1 line of best spectacle-corrected visual acuity at 5 years.<br><br>Enhancements:<br>15.2% (7/46) required reoperation (3 eyes after 3 months, 2 after 6 months and 2 eyes after 1 year following LASIK)</td>
<td>Endothelial rejection: 1 eye (treated successfully)</td>
<td>Follow-up issues:<br>• Follow-up complete to 5 years for all included patients. A further 19 patients were excluded from the study because of incomplete follow-up.<br><br>Study design issues:<br>• Unclear if single centre / single surgeon study.<br>• Unclear if follow-up assessments were made by an independent clinician.<br><br>Study population issues:<br>• Mean interval between PK and LASIK: 7 years<br>• Condition leading to graft procedure: keratoconus: 65.2% (30/46), leukoma: 8.7% (4/46) and previous refractive surgery: 26.1% (12/46)<br>• Type of previous refractive surgery before PK: myopic epikeratophakia: 3 eyes, homoplastic keratoplasty: 4 eyes and radial or astigmatic procedures: 5 eyes.<br>• 2 eyes had refractive surgery after PK but 6 months before LASIK (1 wedge resection and 1 opposing arcuate relaxing incision)</td>
</tr>
</table>

Abbreviations used: BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intra-ocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; UCVA, uncorrected distance visual acuity

**Study details**

La Tegola MG (2007)[5]

**Case series**

Italy

Recruitment period: not reported

Study population: patients with regular and irregular astigmatism following PK

n = **41 (44 eyes) – all with prior corneal transplantation**

Age: 40.9 years (mean)
Sex: 48.8% (20/41) male

Patient selection criteria: patients intolerant to contact lenses or spectacles.

Technique: customised PRK using software ablation programme (Corneal Interactive Programmed Topographic Ablation). All eyes received mitomycin C after treatment. Epithelial debridement with alcohol performed before PRK in 16 eyes and transepithelial PRK performed in 28 eyes.

Follow-up: **25.4 months (mean)**

Conflict of interest/source of funding: none

**Key efficacy findings**

Number of patients analysed: **41 (44 eyes)**

Regular astigmatism eyes (n = 18)

| | Preoperative (n = 18) | At last follow-up (n = 18) |
|---|---|---|
| UCVA 20/40 or better | 0 | 72.2% (13/18) |
| UCVA 20/20 | 0 | 22.2% (4/18) |
| % within 1.00 D of emmetropia | NA | 77.7% (14/18) |

Irregular astigmatism eyes (n = 26)

| | Preoperative (n = 26) | At last follow-up (n = 26) |
|---|---|---|
| UCVA 20/40 or better | 0 | 69.2% (18/26) |
| UCVA 20/20 | 0 | 30.8% (8/26) |
| % within 1.00 D of emmetropia | NA | 69.2% (18/26) |

Refractive Error

Regular astigmatism eyes (n = 18)

| | Preoperative (n = 18) | 12 months (n = 12) | 36 months (n = 8) |
|---|---|---|---|
| Spherical equivalent refraction | -4.76±2.40 | -0.02±1.00 | -0.66±1.40 |

Irregular astigmatism eyes (n=26)

| | Preoperative (n = 26) | 12 months (n = 17) | 36 months (n=4) |
|---|---|---|---|
| Spherical equivalent refraction | -5.52±3.60 | 0.03±1.40 | -0.47±1.60 |

**Key safety findings**

Grade 2 haze: 3 eyes (1 eye in the regular astigmatism group at 8 months and 2 eyes in the irregular astigmatism group at 8 months and 10 months respectively). All eyes required retreatment.

No eyes in either group lost Snellen lines of BSCVA.

**Comments**

**Follow-up issues**:
- Standard deviation of follow-up period: ±13 months. 34.1% (15/44) lost to follow-up at 12 months and 72.7% (32/44) at 36 months

**Study design issues**:
- Prospective single centre study.
- Unclear if follow-up assessments were made by an independent clinician.

**Study population issues**:
- Minimum interval of 2 years between PK and LASIK.
- Condition leading to graft procedure: keratoconus: 86.4% (38/44), corneal scar: 4.5% (2/44) and Fuch's dystrophy: 9.1% (4/44)
- 1 eye in the irregular astigmatism group had a previous arcuate keratotomy prior to PRK.

Abbreviations used: BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intra-ocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; PRK, photorefractive keratectomy; RK, radial keratotomy; UCVA, uncorrected distance visual acuity

| Study details | Key efficacy findings | Key safety findings | Comments |
|---|---|---|---|
| Pershin K B (2000)[6]<br><br>**Case series**<br><br>Russia<br><br>Recruitment period: not reported<br><br>Study population: patients with artiphakia after phakic posterior chamber intraocular lens implantation and after corneal transplant.<br><br>n = **57 eyes– with prior cataract surgery (22), corneal transplantation (15) and IOL implantation following clean lens extraction (20)**<br><br>Age: 24–73 years<br>Sex: not reported<br><br>Patient selection criteria: see above<br><br>Technique: LASIK (using Nidek EC-5000 Excimer laser system) performed at a minimum of 6 months after IOL implantation and a minimum of 18 months after corneal transplantation.<br><br>Follow-up: **9 months (mean)**<br><br>Conflict of interest/source of funding: not reported | Number of patients analysed: **57 eyes**<br><br>Preoperative (n = 57) / Follow-up<br>Mean deviation from emmetropia (sharp focus): 3.50 D (range: -6.00 to +4.00) / 0.5 D (range: -1.50 to +0.75 D)<br>Mean astigmatism: 2.75 D (range: 0 to 5.00 D) / -0.75 D (range: 0 to 1.50 D)<br>Mean uncorrected visual acuity: 0.2 (range: 0.05 to 0.4) / 0.7 (range: 0.4 to 1.0)<br><br>Reoperation: 11.6% (actual figures not provided)<br><br>[Only patients with prior cataract surgery and corneal transplantation are relevant, however, results were presented for all patients.] | Free cap: 3.5% (2/57)<br><br>Epithelial ingrowth: 7.0% (4/57)<br><br>Induced astigmatism: 3.5% (2/57)<br><br>Night vision problems: 24.6% (14/57)<br><br>Macular haemorrhages 7 days after LASIK: 1.8% (1/57) | **Follow-up issues**:<br>• Completeness of follow-up is unclear.<br><br>**Study design issues**:<br>• Unclear if retrospective study.<br>• Unclear if follow-up assessments were made by an independent clinician.<br><br>**Study population issues**:<br>• Type of refractive error: hyperopia and hyperopic astigmatism: 17.5% (10/57), myopic and myopic astigmatism: 82.5% (47/57)<br>• Previous procedure: IOL implantation after prior cataract surgery: 38.6% (22/57), clean lens extraction and IOL implantation: 31% (20/57), and corneal transplantation: 26.3% (15/57). Results are presented for all patients. |

Abbreviations used: BSCVA, best spectacle-corrected near visual acuity; D, diopters; IOL, intra-ocular lens; IOP, intraocular pressure; LASIK, laser in situ keratomileusis; NA, not available; PK, penetrating keratoplasty; PRK, photorefractive keratectomy; RK, radial keratotomy; UCVA, uncorrected distance visual acuity

| Study details | Key safety findings (this table describes serious safety outcomes that have not occurred in the previous 9 studies in table 2) |
|---|---|
| Scupola A (2003)[7] Hasan S A (2007)[8]<br>Sharma N (2006)[9]<br>Reinhard T (2004)[10]<br>Danjoux J P (1998)[11]<br>Fulton J C (1996)[12]<br>Epstein R J (1994)[13]<br>Dawson D G (2003)[14] | **Scupola 2003**<br>Case report of a 30 year old patient who developed **severe loss of vision and metamorphopsia due to a retrofoveal choroidal neovascularisation** in one eye 6 months after LASIK following bilateral PK for keratoconus 2 years previously. Patient was treated with photodynamic therapy with verteporin 2 days later and after 3 months. At one year, BCVA was stable at 20/200.<br>**Hasan 2007**<br>Case report of a 71 year old patient who developed **cystoid macular oedema** in one eye after PRK to treat a residual hyperopic error following cataract surgery. PRK was performed 3 months after cataract surgery. 5 days after PRK the patient reported worsening vision and pain. A small corneal infiltrate was scraped, cultured and treated with vancomycin and ceftazidime. 2 weeks later the patient reported decreasing vision (best corrected visual acuity: 20/60) and fundus examination showed macular thickening. Optical coherence tomography showed macular oedema and submacular fluid with macular thickness 613 micrometres. Macular oedema resolved following treatment with prednisolone acetate, nepafenac and triamcinolone. At 3 months the patients had macular thickness 176 micrometres and uncorrected visual acuity of 20/20.<br>**Sharma 2006**<br>Case report of a 48 year old patient who developed **corneal lamellar flap retraction** after LASIK to treat high astigmatism following corneal graft 1 year earlier for healed keratitis. Preoperative uncorrected visual acuity was 3/60. The flap was retracted 1 day after the procedure. At 1 week the area was totally epithelialised and there was epithelial ingrowth in the interface (uncorrected visual acuity 6/60). Patient was treated with fluorometholone and lubricants. At 1 and 3 months there was no increase in ingrowth and the flap was well apposed.<br>**Reinhard 2004**<br>Case report of a 56 year old patient who developed **recurrent interface infiltration and hypopyon** after LASIK to treat high astigmatism following PK for Fuch's endothelial dystrophy. *Pseudomonas eruginosa* was the causative pathogen. LASIK was performed twice 2 years after PK. Each occurrence was successfully treated with topical and systemic antibiotics. After the third occurrence another PK was performed and the graft remained clear for 4.5 years.<br>**Danjoux 1998**<br>Case report of a 26 year old patient who developed **corneal scarring and irregular astigmatism** after PRK to treat increased regular and irregular astigmatism following PK for keratoconus. Before PRK, the patient's uncorrected visual acuity was 6/12. Patient presented 2 years after PRK with deteriorating visual acuity. Examination with slit lap showed a new corneal scar which was excised and sent for histopathological examination 2 months later. Uncorrected visual acuity improved from 1/60 to 6/12 following excision.<br>**Fulton 1996**<br>Case report of a 77 year old patient who developed a severe **bacterial ulcer** 3 days after PRK to treat regular astigmatism following PK for pseudophakic bullous ketatopathy. Patient was admitted to hospital and treated with intensive topical and systemic antibiotic therapy. The ulcer responded to treatment but the penetrating keratoplasty failed and the patient required a repeat graft 3 weeks later. The patient had a clear graft at 2 year follow-up.<br>**Epstein 1994**<br>Case report of a patient with **corneal graft rejection** after PRK to treat astigmatism and myopia following PK for keratoconus. Endothelial rejection occurred 5 days after PRK and was treated successfully for 1 week with prednisolone (topical and intravenous).<br>**Dawson 2003**<br>Case report of a 68 year old patient who developed a **pocket of fluid in the lamellar interface** after LASIK and astigmatic keratotomy to treat myopia and astigmatism following PK 3 years earlier. The corneal transplant was required because of trauma. The pocket of fluid developed 3 months after the procedure and the patient's best corrected and uncorrected visual acuity deteriorated to counting fingers. This was successfully treated by repeat PK. |

## *Efficacy*

### Deviation from emmetropia (sharp focus)

A case series of 62 patients (87 eyes) treated with laser in situ keratomileusis (LASIK) after previous surgical techniques reported that mean spherical equivalent refraction (MSER) improved from -5.25 D preoperatively (indicating myopia) to -0.70 D at 1-year follow-up[1].

A case series of 59 patients (85 eyes) treated with LASIK after multifocal intraocular lens (IOL) implantation reported that MSER improved from -0.34 D preoperatively to -0.07 D at 6-month follow-up ($p = 0.004$)[2].

A case series of 48 patients (57 eyes) treated with LASIK after penetrating keratoplasty (PK) reported that MSER improved from -3.94 D preoperatively (indicating myopia) to -0.61 D at 2-year follow-up[3].

A case series of 57 eyes treated with LASIK after intraocular lens implantation and corneal transplant reported the mean deviation from emmetropia improved from 3.50 D preoperatively to 0.5 D at mean follow-up of 9 months[6].

A case series of 38 patients (46 eyes) treated with LASIK after PK reported an improvement in mean spherical refraction from -5.16 D preoperatively to -0.44 D at 5 years in myopic eyes (n = 40), an improvement from 5.75 D preoperatively to 1.67 D at 5 years in hyperopic eyes (n = 3) and an improvement in mean cylindrical refraction from -5.50 D preoperatively to -2.42 D at 5 years in eyes with mixed astigmatism (n = 3). Overall, at 5 year follow-up, 63% (29/46) had a refractive error within 1.00 D of emmetropia[4].

A case series of 41 patients (44 eyes) treated with photorefractive keratectomy (PRK) after PK reported an improvement in MSER from -4.76 D preoperatively to -0.66 D at 36 months in eyes with irregular astigmatism (n = 18) and an improvement in MSER from -5.52 D preoperatively to -0.47 D at 36 months in eyes with irregular astigmatism (n = 26). At mean follow-up of 25.4 months 78% (14/18) of eyes with regular astigmatism and 69% (18/26) of eyes with irregular astigmatism had a refractive error within 1.00 D of emmetropia[5].

### Visual acuity

The case series of 62 patients (87 eyes) treated with LASIK after previous surgical techniques reported that the proportion of patients with uncorrected visual acuity of 0.5 or better increased from 5% preoperatively to 70% at 1-year follow-up[1].

The case series of 59 patients (85 eyes) treated with LASIK after multifocal IOL implantation reported uncorrected distance visual acuity of 20/25 or better in 92% of eyes at 6-month follow-up[2].

The case series of 48 patients (57 eyes) treated with LASIK after PK reported that the proportion of patients with uncorrected visual acuity of 20/40 or better increased from 0% preoperatively to 43% (12/28) at 2-year follow-up[3].

The case series of 57 eyes treated with LASIK after IOL implantation and corneal transplant reported that mean uncorrected visual acuity improved from 0.2 preoperatively to 0.7 at mean follow-up of 9 months[6].

The case series of 38 patients (46 eyes) treated with LASIK after PK reported an improvement in mean uncorrected visual acuity from 20/477 preoperatively to 20/110 at 5 years, and an improvement in mean best spectacle-corrected visual acuity from 20/39 preoperatively to 20/27 at 5 years in myopic eyes (n = 40). Overall, 33% (absolute values not given) had uncorrected visual acuity of 20/40 or better at 5 years[4].

The case series of 41 patients (44 eyes) treated with PRK after PK reported an improvement in the proportion of eyes with UCVA of 20/40 or better from 0% preoperatively in both groups to 72% (13/18) and 69% (18/26) in the regular astigmatism and irregular astigmatism groups respectively[5].

**Reoperation**

The case series of 62 patients (87 eyes) treated with LASIK after previous surgical techniques reported 22% (19/87) of eyes required reoperation with LASIK due to under-correction of myopia during the 12-month follow-up period[1].

The case series of 59 patients (85 eyes) treated with LASIK after multifocal IOL implantation reported that 6% (5/85) of eyes required reoperation with LASIK (due to residual myopia or compound myopic astigmatism in 3 eyes and mixed astigmatism in 2 eyes) during the 6-month follow-up period. All 5 eyes had a spherical equivalent refraction of ±0.50 D, 6 months after reoperation[2].

The case series of 48 patients (57 eyes) treated with LASIK after PK reported 9% (5/57) of eyes required reoperation with LASIK due to residual refractive errors during the 2-year follow-up period[3].

The case series of 57 eyes treated with LASIK after IOL implantation and corneal transplant reported 12% of eyes (absolute values not given) required reoperation at mean follow-up of 9 months[6].

The case series of 38 patients (46 eyes) treated with LASIK after PK reported 15% (7/46) required reoperation within 5 years follow-up[4].

## *Safety*

### Loss of 2 or more Snellen lines of visual acuity

The case series of 48 patients (57 eyes) treated with LASIK after PK reported 15% (8/52) of eyes lost 2 or more Snellen lines of best corrected visual acuity at 1 year[3].

### Haze

The case series of 41 patients (44 eyes) treated with PRK after PK reported 3 eyes with grade 2 haze (1 eye in the regular astigmatism group at 8 months and 2 eyes in the irregular astigmatism group at 8 months and 10 months respectively). All eyes required retreatment[5].

### Dry eye

The case series of 59 patients (85 eyes) treated with LASIK after multifocal IOL implantation reported 4 eyes with moderate or marked dry eye which developed between 3–6 months follow-up. All eyes were treated with frequent lubricant and 3 of the eyes were also treated with cyclosporine[2].

The case series of 48 patients (57 eyes) treated with LASIK after PK reported persistent dry eye in 3 eyes at mean follow-up of 21.4 months[3].

### Other serious adverse events

The case series of 48 patients (57 eyes) treated with LASIK after PK reported 1 eye with herpes simplex keratitis at 6 months which resolved after treatment, 4 eyes with epithelial ingrowth requiring removal between 1 week and 12 months, 2 eyes that required repeat graft for persistent astigmatism between 1 and 3 years, 3 eyes needing repeat graft for oedema between 8 months to 3 years, and 5 eyes with flap dislocation between 1 day and 1 week (details were provided for 4 of these 5 eyes: 2 required sutures, 1 flap was removed and 1 was repositioned without sutures)[3].

The case series of 57 eyes treated with LASIK after IOL implantation and corneal transplant reported 1 eye with macular haemorrhages 7 days after LASIK, 4 eyes with epithelial ingrowth, 2 eyes with induced astigmatism, 2 eyes with free cap and 25% (14/57) of eyes with night vision problems at mean follow-up of 9 months[6].

The case series of 38 patients (46 eyes) treated with LASIK after PK reported endothelial rejection which was successfully treated in one eye[4].

Individual case reports highlighted eyes with severe loss of vision and metamorphopsia due to a retrofoveal choroidal neovascularisation 6 months after LASIK treated with photodynamic therapy[7], cystoid macular oedema

(successfully treated with medication) after PRK[8], corneal lamellar flap retraction (successfully treated with medication) after LASIK[9], recurrent interface filtration and hypopyon (requiring medication and a repeat corneal graft) after LASIK[10], corneal scarring and irregular astigmatism after PRK[11], bacterial ulcer (leading to a repeat corneal graft) after PRK[12], corneal graft rejection (successfully treated with medication) after PRK[13] and a pocket of fluid in the lamellar interface (requiring repeat PK) after LASIK[14].

## *Validity and generalisability of the studies*

- Only case series and case report evidence was available.
- Some of the published evidence is more than 10 years old, and techniques and equipment may have changed during this time.
- Two different procedures (LASIK and PRK) are reported in Table 2 to treat refractive errors following a variety of different ocular procedures. It may therefore be difficult to generalise the findings.
- No LASEK studies are presented in table 2 due to the small number of patients in these publications.
- There are no longer term (>5 years) data reported in Table 2.

## *Existing assessments of this procedure*

There were no published assessments from other organisations identified at the time of the literature search.

## *Related NICE guidance*

Below is a list of NICE guidance related to this procedure. Appendix B gives details of the recommendations made in each piece of guidance listed.

**Interventional procedures**

- Phototherapeutic laser keratectomy for corneal surface irregularities. NICE interventional procedures guidance 358 (2010). Available from www.nice.org.uk/guidance/IPG358
- Intraocular lens insertion for correction of refractive error, with preservation of the natural lens. NICE interventional procedures guidance 289 (2009). Available from www.nice.org.uk/guidance/IPG289
- Corneal implants for the correction of refractive error. NICE interventional procedures guidance 225 (2007). Available from www.nice.org.uk/guidance/IPG225

- Photorefractive (laser) surgery for the correction of refractive error. NICE interventional procedures guidance 164 (2006). Available from www.nice.org.uk/guidance/IPG164

## Specialist Advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College. The advice received is their individual opinion and does not represent the view of the society.

Mr David Spalton (United Kingdom & Ireland Society of Cataract and Refractive Surgeons), Mr JP Danjoux and Mr Jeremy Prydal (Royal College of Ophthalmologists).

- One of the specialist advisers performs this procedure regularly. The other 2 advisers have never performed the procedure, but take part in patient selection or referral. All specialist advisers consider this to be an established procedure.
- Comparators are glasses or contact lenses, intra-ocular implant exchange, secondary lens implants and astigmatic keratotomy.
- Reported and anecdotal adverse events: dry eye, buttonhole flap (0.2%), 1% risk of small degree of loss of vision. Less than 1 in 1000 risk of serious side effects causing profound loss of vision.
- Theoretical adverse events: ectasia, corneal recurrent epithelial erosion syndrome, epithelial defects, bleeding from flap edge, interface haemorrhage, interface debris, flap striae, diffuse lamellar keratitis, corneal scarring, glare, small risk of infection and pain after treatment.
- Efficacy outcomes: uncorrected visual acuity, reduced refractive error, maintained best-corrected spectacle vision and improved quality of life.
- Training and facilities: surgeons should have training and experience in laser refractive surgery and preferably sub-speciality training in corneal surgery. Laser facilities with appropriate diagnostic equipment (e.g. corneal topography, pachymetry, optical coherence tomography and optometry support) are required. One specialist adviser states that the equipment is only available in the private sector and that most trusts will not fund it. Another adviser reports that only a few eye departments have the appropriate facilities.

- One specialist adviser states that the use of this procedure should be reserved for patients with significant ametropia or anisometropia who are contact lens or spectacle intolerant and have problems with poor vision or imbalance between eyes following surgery.

## Patient Commentators' opinions

NICE's Patient and Public Involvement Programme sent 6 questionnaires to 1 trust for distribution to patients who had the procedure (or their carers). NICE received 0 completed questionnaires.

## Issues for consideration by IPAC

None

## References


1. Guell JL, Gris O, de MA et al. (1999) LASIK for the correction of residual refractive errors from previous surgical procedures. Ophthalmic Surg Lasers 30:341-349.

2. Muftuoglu O, Prasher P, Chu C et al. (2009) Laser in situ keratomileusis for residual refractive errors after apodized diffractive multifocal intraocular lens implantation. Journal of Cataract and Refractive Surgery 35:1063-1071.

3. Hardten DR, Chittcharus A, Lindstrom RL (2004) Long term analysis of LASIK for the correction of refractive errors after penetrating keratoplasty. Cornea 23:479-489.

4. Barraquer CC, Rodriguez-Barraquer T (2004) Five-Year Results of Laser in-Situ Keratomileusis (LASIK) after Penetrating Keratoplasty. Cornea 23:243-248.

5. La Tegola MG, Alessio G, Sborgia C (2007) Topographic customized photorefractive keratectomy for regular and irregular astigmatism after penetrating keratoplasty using the LIGI CIPTA/LaserSight platform. Journal of Refractive Surgery 23:681-693.

6. Pershin KB, Pashinova NF (2000) Fine tuning excimer laser correction after intraocular lens implantation and corneal transplantation. Journal of Refractive Surgery 16:S257-S260.

7. Scupola A, Mosca L, Balestrazzi A et al. (2003) Choroidal neovascularization after laser-assisted in situ keratomileusis following penetrating keratoplasty. Graefes Archive for Clinical & Experimental Ophthalmology 241:682-684.

8. Hasan SA, Stewart MW (2007) Cystoid macular edema following photorefractive keratectomy complicated by presumptive infectious keratitis. Journal of Cataract & Refractive Surgery 33:348-349.

9. Sharma N, Sinha R, Vajpayee RB (2006) Corneal lamellar flap retraction after LASIK following penetrating keratoplasty [1]. Cornea 25:496-

10. Reinhard T, Knorz M, Sundmacher R (2004) Recurrent interface infiltration with hypopyon after astigmatic laser in situ keratomileusis on a penetrating corneal graft. Journal of Cataract & Refractive Surgery 30:257-258.

11. Danjoux JP, Fraenkel G, Wai D et al (1998) Corneal scarring and irregular astigmatism following refractive surgery in a corneal transplant. Australian & New Zealand Journal of Ophthalmology 26:47-49.

12. Fulton JC, Cohen EJ, Rapuano CJ (1996) Bacterial ulcer 3 days after excimer laser phototherapeutic keratectomy. Archives of Ophthalmology 114:626-627.

13. Epstein RJ, Robin JB (1994) Corneal graft rejection episode after excimer laser phototherapeutic keratectomy. Archives of Ophthalmology 112:157-

14. Dawson DG, Hardten DR, Albert DM (2003) Pocket of fluid in the lamellar interface after penetrating keratoplasty and laser in situ keratomileusis. Archives of Ophthalmology 121:894-896.

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# Appendix A: Additional papers on laser correction of refractive error following non-refractive ophthalmic surgery

The following table outlines the studies that are considered potentially relevant to the overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies.

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Alio JL, Javaloy J, Osman AA et al. (2004) Laser in situ keratomileusis to correct post-keratoplasty astigmatism; 1-step versus 2-step procedure. Journal of Cataract & Refractive Surgery 30:2303-2310. | NRCT<br><br>n = 22 (11 one step LASIK vs 11 two stop LASIK)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 6 months | Two step LASIK group had a significantly greater vector analysis of refractive cylinder (p=0.24) in comparison to the one step LASIK group.<br><br>No major intraoperative complications or graft rejection. | Comparison is not relevant. |
| Yoshida K, Tazawa Y, and Demong TT. (1999) Refractive results of post penetrating keratoplasty photorefractive keratectomy. Ophthalmic Surgery & Lasers 30:354-359. | Case series<br><br>n = 42 eyes<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 6 months | Mean spherical equivalent improved from -8.29 ±4.01 D preoperatively to -2.96±3.26 in 33 eyes at 6 months.<br>2 eyes required treatment or haze after 6 months. | Larger studies in table 2 |
| Arne JL, Lesueur LC, and Hulin HH. (2003) Photorefractive keratectomy or laser in situ keratomileusis for residual refractive error after phakic intraocular lens implantation. Journal of Cataract & Refractive Surgery 29:1167-1173. | Case series<br><br>n = 28 (32 eyes)<br><br>Previous procedure: phakic intraocular lens implantation<br><br>Follow-up = not reported | Uncorrected visual acuity improved in all eyes but a loss of 1 line of corrected vision occurred in 22.2% eyes treated with PRK and 13.6% yes treated with LASIK.<br>20% patients reported halos postoperatively. | Larger studies in table 2 |
| Artola A, Ayala MJ, Claramonte P et al. (1999) Photorefractive keratectomy for residual myopia after cataract surgery. Journal of Cataract & Refractive Surgery 25:1456-1460. | Case series<br><br>n = 30 (30 eyes)<br><br>Previous procedure: cataract surgery<br><br>Follow-up =1 year | Proportion of eyes with uncorrected visual acuity of 20/40 or better improved from 0% preoperatively to 53.3% (16/30) at 1 year.<br>Refraction improved from -5.00±2.5 D to -0.25±0.5.0 D (p<0.001) at 1 year. | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Lima Gd, Moreira H, and Wahab SA. (1-1-2001) Laser in situ keratomileusis to correct myopia, hypermetropia and astigmatism after penetrating keratoplasty for keratoconus: a series of 27 cases. Canadian Journal of Ophthalmology 36:391-396. | Case series<br><br>n = 22 (27 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =9.52 months (mean) | After the procedure 78% of myopic eyes and all of the hypermetropic eyes had uncorrected visual acuity of 20/40 or better. | Larger studies in table 2 |
| Webber SK, Lawless MA, Sutton GL et al. (1999) LASIK for post penetrating keratoplasty astigmatism and myopia. British Journal of Ophthalmology 83:1013-1018. | Case series<br><br>n = 24 (26 eyes<br><br>Previous procedure: corneal transplantation<br><br>Follow-up = 6+ months | Mean spherical equivalent at 6 months : -1.91 D<br>Mean astigmatism at 6 months: 2.92 | Larger studies in table 2 |
| Buzard K, Febbraro JL, and Fundingsland BR. (2004) Laser in situ keratomileusis for the correction of residual ametropia after penetrating keratoplasty. Journal of Cataract & Refractive Surgery 30:1006-1013. | Case series<br><br>n = 20 (26 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = minimum of 6 months | Mean spherical equivalent improved from -4.94 D preoperatively to -0.35 D at last follow-up. Mean astigmatism improved from 2.71 to 1.06. | Larger studies in table 2 |
| Kim P, Briganti EM, Sutton GL et al. (2005) Laser in situ keratomileusis for refractive error after cataract surgery. Journal of Cataract and Refractive Surgery 31:979-986. | Case series<br><br>n = 23 eyes<br><br>Previous procedure: cataract surgery<br><br>Follow-up = 8.4 months (mean) | Myopic eyes spherical equivalent refraction changed from -3.08±0.84 D preoperatively to 2.54±1.03 D at follow-up. Hyperopic eyes spherical equivalent refraction changed from +1.82±1.03 D preoperatively to 1.73±0.62 D at follow-up. (p=0.033). | Larger studies in table 2 |
| Donnenfeld ED, Kornstein HS, Amin A et al. (1999) Laser in situ keratomileusis for correction of myopia and astigmatism after penetrating keratoplasty. Ophthalmology 106:1966-1974. | Case series<br><br>n = 22 (23 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 12 months | The mean spherical equivalent improved from -7.58±4.42 D preoperatively to -1.57±1.20 D at 12 months. | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Ayala MJ, Perez-Santonja JJ, Artola A et al. (2001) Laser in situ keratomileusis to correct residual myopia after cataract surgery. Journal of Refractive Surgery 17:12-16. | Case series<br><br>n = 22 (22 eyes)<br><br>Previous procedure: cataract surgery<br><br>Follow-up =12 months | Uncorrected visual acuity of 0.5 or better:<br>Preoperatively: 4.5% (1/22)<br>12 months: 45.4% (10/22)<br>Mean refraction:<br>Preoperatively: -2.90±1.80 D<br>12 months: 0.40±0.60 D (p<0.01) | Larger studies in table 2 |
| Forseto AS, Francesconi CM, Nose RA et al. (1999) Laser in situ keratomileusis to correct refractive errors after keratoplasty. Journal of Cataract & Refractive Surgery 25:479-485. | Case series<br><br>n = 19 (22 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =10.09 months (mean) | Spherical equivalent refraction improved from -4.55±3.66 D preoperatively to -0.67±1.24 D at follow-up. | Larger studies in table 2 |
| Pereira T, Forseto AS, Alberti GN et al. (2007) Flap-induced refraction change in LASIK after penetrating keratoplasty. Journal of Refractive Surgery 23:279-283. | Case series<br><br>n = 19 (21 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =not reported | Spherical equivalent refraction improved from -4.26±3.41 D to -3.70±3.18 D (p=0.025) | Larger studies in table 2 |
| Norouzi H and Rahmati-Kamel M. (2003) Laser in situ keratomileusis for correction of induced astigmatism from cataract surgery. Journal of Refractive Surgery 19:416-424. | Case series<br><br>n = 20 (20 eyes)<br><br>Previous procedure: cataract surgery<br><br>Follow-up =6 months | Mean spherical refraction improved from -2.19±0.88 D preoperatively to -0.32±0.34 D at 6 months. Diffuse lamellar keratitis occurred in 3 eyes and treated successfully with eye drops | Larger studies in table 2 |
| Nordan LT, Binder PS, Kassar BS et al. (1995) Photorefractive keratectomy to treat myopia and astigmatism after radial keratotomy and penetrating keratoplasty. Journal of Cataract & Refractive Surgery 21:268-273. | Case series<br><br>n = 20 (20 eyes)<br><br>Previous procedure: radial keratotomy and penetrating keratoplasty<br><br>Follow-up = 2 years (min) | 5 eyes previously had penetrating keratoplasty. These 5 eyes had a mean preoperative refraction o f-7.4 D which improved to -3.35 at follow-up. One of the 5 eyes developed chronic glaucoma and maculopathy. | Larger studies in table 2 |
| Malecha MA and Holland EJ. (2002) Correction of myopia and astigmatism after penetrating keratoplasty with laser in situ keratomileusis. Cornea 21:564-569. | Case series<br><br>n = 17 (20 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =5 months (mean) | Uncorrected visual acuity became 20/40 or better in 73.7% of eyes after LASIK.<br>Diffuse lamellar keratitis: 3 eyes all treated with topical steroids. 1 of the eyes persisted resulting in stromal haze and decreased visual acuity. | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Rashad KM. (2000) Laser in situ keratomileusis for correction of high astigmatism after penetrating keratoplasty. Journal of Refractive Surgery 16:701-710. | Case series<br><br>n = 19 (19 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 3 months | 57.9 yes within ±1.00 D of refractive astigmatism at 1 year.<br>Mean % reduction of astigmatism: 87.9±3.7% | Larger studies in table 2 |
| Deschenes J, Jovkar S, Balazsi G et al. (1996) Photorefractive keratectomy for correction of astigmatism after penetrating keratoplasty. International Ophthalmology Clinics 36:113-118. | Case series<br><br>n = 19<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =not reported | Mean spherical refraction improved from -0.96 preoperatively to -0.55 after the procedure.<br>One patient developed regression with subepithelial fibrosis that required retreatment. | Larger studies in table 2 |
| Bahar I, Kaiserman I, Mashor RS et al. (2010) Femtosecond LASIK combined with astigmatic keratotomy for the correction of refractive errors after penetrating keratoplasty. Ophthalmic Surgery, Lasers & Imaging 41:242-249. | Case series<br><br>n = 16 (18 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 14.8 months (mean) | Best corrected vision of 20/40 or better:<br>Preoperatively: 83.3%<br>Follow-up: 94.4%<br>3 eyes lost 1 to line lines of best corrected visual acuity.<br><br>Deep lamellar keratitis: 3 eyes all treated with topical steroids. 1 eye persisted resulting in mild stromal haze and decreased BCVA/ | Larger studies in table 2 |
| Afshari NA, Schirra F, Rapoza PA et al. (2005) Laser in situ keratomileusis outcomes following radial keratotomy, astigmatic keratotomy, photorefractive keratectomy, and penetrating keratoplasty. Journal of Cataract & Refractive Surgery 31:2093-2100. | Case series<br><br>n = 18 eyes [also reports an additional 53 eyes with previous refractive surgery that are not relevant]<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 9.4 months (mean) [all eyes] | Mean manifest refractive spherical equivalent :<br>myopic eyes (n=13):<br>Preoperative: -5.86±2.74<br>Final follow-up :-1.23±1.50<br>Hyperopic eyes (n=5)<br>Preoperative: -0.60±3.24<br>Final follow-up: +0.48±0.94<br><br>% within ±1.00 D of emmetropia: 70%<br><br>UCVA of 20/30 or better at 12 months (from chart): 66.6% | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Kovoor TA, Mohamed E, Cavanagh HD et al. (2009) Outcomes of LASIK and PRK in previous penetrating corneal transplant recipients. Eye & Contact Lens: Science & Clinical Practice 35:242-245. | Case series<br><br>n = 16 (16 eyes)<br><br>Previous procedure: corneal transplant<br><br>Follow-up =not reported | PRK group:<br>Mean spherical equivalent:<br>Preoperative: -6.22±6.23<br>Postoperative:-3.61±4.23<br>(p=0.25)<br><br>LASIK group:<br>Mean spherical equivalent:<br>Preoperative: -3.05±3.29<br>Postoperative:-1.51±2.02<br>(p=0.24)<br><br>2 episodes of acute graft rejection. One resolved with topical and oral corticosteroids and the other required repeat corneal transplant. | Larger studies in table 2 |
| Rajan MS, O'Brart DP, Patel P et al. (2006) Topography-guided customized laser-assisted subepithelial keratectomy for the treatment of postkeratoplasty astigmatism. Journal of Cataract & Refractive Surgery 32:949-957. | Case series<br><br>n = 15 (16 eyes)<br><br>Previous procedure: keratoplasty<br><br>Follow-up =18 months | UK study<br><br>Spherical equivalent:<br>Preoperative: -3.5 ±3.97<br>18 months: -1.08±1.85<br><br>Corneal haze: 3 eyes: | Larger studies in table 2 |
| Bilgihan K, Ozdek SC, Akata F et al. (2000) Photorefractive keratectomy for post-penetrating keratoplasty myopia and astigmatism. Journal of Cataract & Refractive Surgery 26:1590-1595. | Case series<br><br>n = 16 (16 eyes)<br><br>Previous procedure: corneal transplant<br><br>Follow-up = 26 months (mean) | Spherical equivalent refraction:<br>Preoperative: -4.47±1.39<br>Follow-up: -3.39±1.84<br>(p=NS)<br>Grade 2 to 3 haze: 6 eyes (resolved spontaneously in 4 eyes and led to decrease in BSCVA in 2 eyes).<br>2 eyes had a graft rejection episode and successfully treated with topical steroids. | Larger studies in table 2 |
| Mularoni A, Laffi GL, Bassein L et al. (2006) Two-step LASIK with topography-guided ablation to correct astigmatism after penetrating keratoplasty. Journal of Refractive Surgery 22:67-74. | Case series<br><br>n = 15 (15 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 12 months (minimum) | Uncorrected visual acuity improved in all eyes.<br>Complications:<br>2 buttonhole flaps and 1 flap retraction | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Xie L, Gao H, and Shi W. (2007) Long-term outcomes of photorefractive keratectomy in eyes with previous epikeratophakia for keratoconus. Cornea 26:1200-1204. | Case series<br><br>n = 10 (14 eyes)<br><br>Previous procedure: epikeratophakia<br><br>Follow-up =3 years | UCVA of 20/40 or better: Preoperative: 7%<br>1 year: 57%<br><br>Haze: 2 eyes | Larger studies in table 2 |
| Kwitko S, Marinho DR, Rymer S et al. (2001) Laser in situ keratomileusis after penetrating keratoplasty. Journal of Cataract & Refractive Surgery 27:374-379. | Case series<br><br>n = 13 (14 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 1 year | Myopia decreased from -5.33±4.22 D preoperatively to 0.19±1.71 D at 12 months.<br>Retreatment required in 42.9% eyes due to cylindrical undercorrection.<br>Complications: Button hole flap: 1 eye Interface epithelial ingrowth at periphery: 2 eyes Pseudophakic retinal detachment at 2 years: 1 eye. | Larger studies in table 2 |
| Campos M, Hertzog L, Garbus J et al. (1992) Photorefractive keratectomy for severe postkeratoplasty astigmatism. American Journal of Ophthalmology 114:429-436. | Case series<br><br>n = 12<br><br>Previous procedure: keratoplasty<br><br>Follow-up =8 months (mean) | Mean spherical equivalent improved from -7.4±4.2 D preoperatively to -3.3±4.4 D postoperatively (p=0.003)<br>Complications: epithelial defect : 1 patient, healed by day 11<br>Recurrent herpes simplex keratitis at 4 weeks (1 patient, successfully treated initially with topical trifluridine but another recurrence at 10 months led to graft failure. | Larger studies in table 2 |
| Busin M, Zambianchi L, Garzione F et al. (2003) Two-stage laser in situ keratomileusis to correct refractive errors after penetrating keratoplasty. Journal of Refractive Surgery 19:301-308. | Case series<br><br>n = 11 (11 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 3 months | Spherical equivalent refraction was within ±1.00 D in 82% (9/11) eyes at follow-up | Larger studies in table 2 |
| Alessio G, Boscia F, La Tegola MG et al. (2001) Corneal interactive programmed topographic ablation customized photorefractive keratectomy for correction of postkeratoplasty astigmatism. | Case series<br><br>n = 10 (10 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 8.4 months (mean) | Postoperative UCVA 20/40 or better: 70% eyes<br>All eyes gained Snellen lines of BCVA. | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Ophthalmology 108:2029-2037. | | | |
| Bilgihan K, Ozdek SC, Gurelik G et al. (2000) Photorefractive keratectomy for visual rehabilitation of anisometropia induced by retinal detachment surgery. Journal of Refractive Surgery 16:75-78. | Case series<br><br>n = 10 (10 eyes)<br><br>Previous procedure: retinal detachment surgery<br><br>Follow-up = 12.9 months (mean) | Mean spherical equivalent refraction:<br>Preoperative: -5.20 D<br>Postoperative: -0.25 D | Larger studies in table 2 |
| Bansal AK. (1999) Photoastigmatic refractive keratectomy for correction of astigmatism after keratoplasty. Journal of Refractive Surgery 15: Suppl-5. | Case series<br><br>n = 10 (10 eyes)<br><br>Previous procedure: keratoplasty<br><br>Follow-up =6 months | Refractive cylinder decreased from 5.80 D preoperatively t o 3.20 D at 6 months<br><br>50% (5/10) had UCVA of 20/60 or better at 3 months<br><br>At 6 months, 50% (5/10) had a haze score ≥2. | Larger studies in table 2 |
| Dos Santos FA, Marques JC, and Nose W. (2010) Photorefractive keratectomy with mitomycin C after penetrating and lamellar keratoplasty. Cornea;29: 1103-8. | Case series<br><br>n =36<br><br>Follow-up = 16.27 months (mean) | The spherical equivalent decreased from -3.95 ± 4.11 to -1.07 ± 1.45 D postoperatively ($p < 0.001$).<br>At the last follow-up, 41.7% (n = 15) and 61.1% (n = 22) of the eyes were within ±0.50 and ±1.00 D of emmetropia, respectively. Nineteen eyes (52.8%) achieved an uncorrected visual acuity of 20/40 or better. The best-corrected visual acuity remained within 1 line of the preoperative values in 26 cases (72.2%), improved in 8 (22.2%), and decreased in 2 (5.6%).<br>Endothelial cell decompensation was observed in 1 eye (2.8%) 11 months postoperatively, and haze developed in 3 cases (8.3%). | Larger studies in table 2 |
| Koay PY, McGhee CN, Weed KH et al. (2000) Laser in situ keratomileusis for ametropia after penetrating keratoplasty. Journal of Refractive Surgery | Case series<br><br>n = 8 (8 eyes)<br><br>Previous procedure: penetrating keratoplasty | Mean spherical equivalent:<br>Preoperatively: -6.79 D<br>Follow-up: -0.64 D | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| 16:140-147. | Follow-up =8.6 months (mean) | | |
| Kollias AN, Schaumberger MM, Kreutzer TC et al. (2009) Two-step LASIK after penetrating keratoplasty. Clinical Ophthalmology 3:581-586. | Case series<br><br>n =8<br><br>Follow-up = 3 months | Median gain of UCVA: 7.38 ± 2.96 Snellen lines. Best spectacle-corrected visual acuity did not change significantly. Preoperative manifest refraction spherical equivalent decreased from -4.02 ± 4.77 D to -1.11 ± 2.45 D after laser ablation. | Larger studies in table 2. |
| Nassaralla BR and Nassaralla JJ. (2000) Laser in situ keratomileusis after penetrating keratoplasty. Journal of Refractive Surgery 16:431-437. | Case series<br><br>n = 8 (8 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 6+ months | Mean spherical equivalent refraction<br>Preoperatively: -4.50 D<br>Follow-up:-0.75 D | Larger studies in table 2 |
| Schraepen P, Vandorselaer T, Trau R et al. (2004) LASIK and arcuate incisions for the treatment of post-penetrating keratoplasty anisometropia and/or astigmatism. Bulletin de la Societe Belge d Ophtalmologie 19-25. | Case report<br><br>n = 5 (5 eyes) [ 3 other reported – not relevant]<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = not reported | Case 1: improvement in UCVA from 0.1 to 0.6<br>Case 2: visual acuity remained the same<br>Case 4: BSCVA improved to 0.7<br>Case 5: UCVA improved from 0.2 to 0.7<br>Case 6: BSCVA remained good postoperatively<br>Case 8: decrease in astigmatism from 5 D to 2.75 D. | Larger studies in table 2 |
| Davis EA, Hardten DR, and Lindstrom RL. (2000) Laser in situ keratomileusis after intracorneal rings. Report of 5 cases. Journal of Cataract & Refractive Surgery 26:1733-1741. | Case report<br><br>n = 5<br><br>Previous procedure: intracorneal implants<br><br>Follow-up =1 to 18 months | Case 1: UCVA 20/20 on day 1<br>Case 2: UCVA 20/20 at 3 months<br>Case 3: UCVA 20/20 at 3 months<br>Case 4: UCVA 20/30 at 1 month<br>Case 5: UCVA 20/20 at 1 year | Larger studies in table 2 |
| Spadea L, Mosca L, and Balestrazzi E. (2000) Effectiveness of LASIK to correct refractive error after penetrating keratoplasty. Ophthalmic Surg Lasers 31:111-120. | Case report<br><br>n = 4<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 12 months to 2 years | Case 1: UCVA 20/50 at 24 months<br>Case 2: UCVA 20/25 at 18 months<br>Case 3: UCVA 20/50 at 12 months<br>Case 4: UCVA 20/25 at 12 months | Larger studies in table 2 |
| Arenas E and Maglione A. (1997) Laser in situ | Case report | Case 1: retreated with LASIK after 1 year | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| keratomileusis for astigmatism and myopia after penetrating keratoplasty. Journal of Refractive Surgery 13:27-32. | n = 4<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =7 months (mean) | following progressive regression of astigmatism after first LASIK treatment. 3 weeks after second LASIK spherical equivalent refraction plano -2.00 D<br>Case 2: refraction +0.50 at 6 months. UCVA improved from count fingers preoperatively to 20/1000 after LASIK.<br>Case 3: spherical equivalent refraction -1.00 and UCVA 20/100 at 6 months.<br>Case 4: spherical equivalent refraction +0.5 and UCVA 20/100 at 6 months. | |
| Nagy ZZ. (2003) Laser in situ keratomileusis combined with topography-supported customized ablation after repeated penetrating keratoplasty. Journal of Cataract & Refractive Surgery 29:792-794. | Case report<br><br>n = 1 (2 eyes)<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 9 months | Right eye at follow-up:<br>Spherical refraction -4.5 D<br>Cylindrical refraction -1.5 D<br>BSCVA: 20/25<br><br>Left eye at follow-up:<br>Spherical refraction -3.0 D<br>BSCVA: 20/25 | Larger studies in table 2 |
| Barreto J, Jr., Netto MV, Reis A et al. (2009) Topography-guided (NIDEK customized aspheric treatment zone) photorefractive keratectomy with mitomycin C after penetrating keratoplasty for keratoconus: case report. Journal of Refractive Surgery 25: Suppl-5. | Case report<br><br>n = 1<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 6 months | Preoperatively:<br>BSCVA: 20/30<br>Manifest refraction: -2.0 D<br><br>Follow-up:<br>BSCV: 20/20<br>Manifest refraction: -0.5 D<br><br>Patient reported minor glare in mesopic conditions but satisfied with outcome. | Larger studies in table 2 |
| Cosar CB and Acar S. (2006) Topography-guided LASIK with the wavelight laser after penetrating keratoplasty. Journal of Refractive Surgery 22:716-719. | Case report<br><br>n = 1<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 3 months | Follow-up:<br>UCVA: 20/25 at 3 months<br>BSCVA: 20/20<br>Manifest refraction: +0.25 D | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| Chan CC and Rootman DS. (2004) Corneal lamellar flap retraction after LASIK following penetrating keratoplasty. Cornea 23:643-646. | Case report<br><br>n = 1<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 3 years | 3 days after LASIK the patient presented with blurred distance vision and slight photophobia due to corneal lamellar flap retraction. The flap was repositioned and sutured.<br><br>Manifest refraction:<br>Preoperatively: -5.50 D<br>5 months: -9.50 D<br>3 years: -9.00 D<br><br>UCVA:<br>Preoperatively: 20/60<br>5 months: 20/400<br>3 years: 20/40+2 | Larger studies in table 2 |
| Sforza PD and Saffra NA. (2003) Laser in situ keratomileusis as treatment for anisometropia after scleral buckling surgery. Journal of Cataract & Refractive Surgery 29:1042-1044. | Case report<br><br>n = 1<br><br>Previous procedure: sclera buckling surgery<br><br>Follow-up = 3 months | UCVA of 20/25 at 3 months. Patient able to drive without spectacles. | Larger studies in table 2 |
| Fraenkel G, Sutton G, Rogers C et al. (1998) Paradoxical response to photorefractive treatment for postkeratoplasty astigmatism. Journal of Cataract & Refractive Surgery 24:861-865. | Case report<br><br>n = 1<br><br>Previous procedure: corneal transplant<br><br>Follow-up = 12 months | Patient had PARK 3 years after corneal graft, followed by 2nd PARK 5 months later followed by refractive keratoplasty 8 months later. Each procedure was done to treat increasing refractive error.<br>Manifest refraction:<br>Preoperatively: -1.25<br>4months after 1st PARK procedure:+3.25<br>6months after 2nd PARK procedure:+4.00<br>13 months after Refractive keratoplasty:+0.00 | Larger studies in table 2 |
| Parisi A, Salchow DJ, Zirm ME et al. (1997) Laser in situ | Case report<br><br>n = 1 [reports 2 other | Case 3: manifest refraction of +1.00 and UCVA better than BCVA | Larger studies in table 2 |

| Article | Number of patients/follow-up | Direction of conclusions | Reasons for non-inclusion in table 2 |
|---|---|---|---|
| keratomileusis after automated lamellar keratoplasty and penetrating keratoplasty. J Cataract Refract.Surg 23:1114-1118. | patients who had previous refractive surgery – not relevant]<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up =11 months | before LASIK at 11 months. | |
| Zaldivar R, Davidorf J, and Oscherow S. (1997) LASIK for myopia and astigmatism after penetrating keratoplasty. Journal of Refractive Surgery 13:501-502. | Case report<br><br>n = 1<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 3 months | LASIK performed 25 years after PK. UCVA 20/60 and BSCV 20/40 at 3 months after LASIK | Larger studies in table 2 |
| Chan WK, Hunt KE, Glasgow BJ et al. (1996) Corneal scarring after photorefractive keratectomy in a penetrating keratoplasty. American Journal of Ophthalmology 121:570-571. | Case report<br><br>n = 1<br><br>Previous procedure: penetrating keratoplasty<br><br>Follow-up = 2 years and 5 months | 12 month follow up after PRK showed moderate superficial corneal haze and a second PRK was performed. At 24 months a 5mm circular dense subepithelial scar was noted. 3 months later a repeat penetrating keratoplasty was performed.<br>Cycloplegic refraction:<br>Preoperatively: -7.50<br>12 months: -7.50<br>53 months: -2.25<br>BSCVA:<br>Preoperatively: 20/60<br>12 months: 20/40<br>24 months: finger counting<br>53 months: 20/30 | Larger studies in table 2 |

# Appendix B: Related NICE guidance for laser correction of refractive error following non-refractive ophthalmic surgery

| Guidance | Recommendations |
|---|---|
| Interventional procedures | **Phototherapeutic laser keratectomy for corneal surface irregularities. NICE interventional procedures guidance 358 (2010).**<br>1.1 Current evidence on the safety and efficacy of phototherapeutic laser keratectomy for corneal surface irregularities is adequate to support the use of this procedure provided that normal arrangements are in place for clinical governance, consent and audit.<br><br>1.2 Patient selection and treatment should be carried out only by ophthalmologists who specialise in corneal surgery.<br><br>**Intraocular lens insertion for correction of refractive error, with preservation of the natural lens. NICE interventional procedures guidance 289 (2009).**<br>1.1 Current evidence on intraocular lens (IOL) insertion for correction of refractive error, with preservation of the natural lens is available for large numbers of patients. There is good evidence of short-term safety and efficacy. However, there is an increased risk of cataract, corneal damage or retinal detachment and there are no long-term data about this. Therefore, the procedure may be used with normal arrangements for clinical governance and audit, but with special arrangements for consent.<br>1.2 Clinicians wishing to undertake IOL insertion for correction of refractive error, with preservation of the natural lens should ensure that patients understand the risks of having an artificial lens implanted for visual impairment that might otherwise be corrected using spectacles or contact lenses. They should understand the possibility of cataract, corneal damage or retinal detachment, and the lack of evidence relating to long-term outcomes. Patients should be provided with clear information. In addition, the use of NICE's information for patients ('Understanding NICE guidance') is recommended (available from www.nice.org.uk/IPG289publicinfo).<br>1.3 Both clinicians and manufacturers are encouraged to collect long-term data on people who undergo IOL insertion, and to publish their findings. NICE may review the procedure |

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|---|---|
| | on publication of further evidence.<br><br>**Corneal implants for the correction of refractive error. NICE interventional procedures guidance 225 (2007).**<br>1.1 Current evidence on the efficacy of corneal implants for the correction of refractive error shows limited and unpredictable benefit. In addition, there are concerns about the safety of the procedure for patients with refractive error which can be corrected by other means, such as spectacles, contact lenses, or laser refractive surgery. Therefore, corneal implants should not be used for the treatment of refractive error in the absence of other ocular pathology such as keratoconus.<br><br>**Photorefractive (laser) surgery for the correction of refractive error. NICE interventional procedures guidance 164 (2006).**<br>1.1 Current evidence suggests that photorefractive (laser) surgery for the correction of refractive errors is safe and efficacious for use in appropriately selected patients.<br>1.2 Clinicians undertaking photorefractive (laser) surgery for the correction of refractive errors should ensure that patients understand the benefits and potential risks of the procedure. Risks include failure to achieve the expected improvement in unaided vision, development of new visual disturbances, corneal infection and flap complications. These risks should be weighed against those of wearing spectacles or contact lenses.<br>1.3 Clinicians should audit and review clinical outcomes of all patients who have photorefractive (laser) surgery for the correction of refractive errors. Further research will be useful and clinicians are encouraged to collect longer-term follow-up data.<br>1.4 Clinicians should have adequate training before performing these procedures. The Royal College of Ophthalmologists has produced standards for laser refractive surgery (www.rcophth.ac.uk/docs/ publications/RefractiveSurgeryStandardsDec2004.pdf ). |

# Appendix C: Literature search for laser correction of refractive error following non-refractive ophthalmic surgery

| Databases | Date searched | Version/files |
|---|---|---|
| Cochrane Database of Systematic Reviews – CDSR (Cochrane Library) | 2/8/2010 | July 2010 |
| Database of Abstracts of Reviews of Effects – DARE (CRD website) | 2/8/2010 | N/A |
| HTA database (CRD website) | 2/8/2010 | N/A |
| Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library) | 2/8/2010 | July 2010 |
| MEDLINE (Ovid) | 2/8/2010 | 1950 to July Week 3 2010 |
| MEDLINE In-Process (Ovid) | 2/8/2010 | 1950 to Present |
| EMBASE (Ovid) | 2/8/2010 | 1980 to 2010 Week 30 |
| CINAHL (NLH Search 2.0) | 2/8/2010 | N/A |
| BLIC (Dialog DataStar) | 2/8/2010 | N/A |
| Current Controlled Trials *meta*Register of Controlled Trials - *m*RCT | 4/08/2010 | Comparison of Cross-Cylinder Approach and Routine Method for Laser Correction of Astigmatism<br><br>Customized PRK With Mitomycin Versus Customized Lasik for Myopic Astigmatism<br><br>A Comparison of Pregabalin (LyricaÂ®) to Placebo in Pain Relief After Photorefractive Keratectomy (PRK) Surgery<br><br>A Comparison of Topical Nepafenac to Placebo in Corneal Epithelial Healing Times and Postoperative Pain Relief of Patients Status-Post Photorefractive Keratectomy: A Double-Masked Randomized Prospective Study<br><br>Oral Gabapentin Versus Placebo for Treatment of Postoperative Pain Following Photorefractive Keratectomy<br><br>Goblet Cell Response and Dry Eye Symptoms After PRK and LASIK |

| | | |
|---|---|---|
| | | Epithelial Healing and Visual Outcomes Using Omega-3 Therapy Before and After Photorefractive Keratectomy (PRK) Surgery#<br><br>Comparison of Photorefractive Keratectomy (PRK) and Sub-Bowman's Keratomileusis (SBK)<br><br>Comparison of Conventional and Custom Photorefractive Keratectomy (PRK)<br><br>Long-term Effects of Laser Refractive Surgery |
| Clinicaltrials.gov | 4/08/2010 | Multi Laser Platform Comparison Study for LASIK<br><br>Randomized, Prospective Comparison of the Outcome of Toric Implantable Contact Lens (TICL) and Q-LASIK for the Correction of Myopia With Astigmatism<br><br>The Role of Psychosocial and Other Quality of Life Parameters in Evaluating Functional Changes Prior to and Following Laser in-Situ Keratomileusis (LASIK)Changes Laser in-Situ Keratomileusis (LASIK)<br><br>Wavefront-guided Versus Wavefront-optimized LASIK for Nearsightedness<br><br>Epi-LASIK : A Confocal Microscopy Analysis of the Corneal Epithelium and Anterior Stroma.<br><br>Ten-year Follow-up of Laser in Situ Keratomileusis in Patients 8 to 15 Years Old<br><br>Study of the MEL 80 Excimer Laser Using LASIK in the Treatment of Mixed Astigmatism<br><br>Advanced Surface Ablation (ASA) vs Laser-Assisted In Situ Keratomileusis (LASIK)<br><br>Femtosecond Laser Assisted Keratoplasty |

Websites searched on 4/8/2010

- National Institute for Health and Clinical Excellence (NICE)
- Food and Drug Administration (FDA) - MAUDE database
- Australian Safety and Efficacy Register of New Interventional Procedures – surgical (ASERNIP-S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- Conference websites
- General internet search

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

| | |
|---|---|
| 1 | astigmatism/ or anisometropia/ |
| 2 | (astigmatism* or anisometropia*).tw. |
| 3 | 1 or 2 |
| 4 | Corneal Transplantation/ |
| 5 | Cataract Extraction/ |
| 6 | (corneal* adj3 (transplant* or graft*)).tw. |
| 7 | (cataract* adj3 (surgery or extract*)).tw. |
| 8 | or/4-7 |
| 9 | 3 and 8 |
| 10 | PRK.tw. |
| 11 | LASEK.tw. |
| 12 | LASIK.tw. |
| 13 | keratectomy, subepithelial, laser-assisted/ or keratomileusis, laser in situ/ or photorefractive keratectomy/ |
| 14 | keratectom*.tw. |
| 15 | keratomileusis*.tw. |
| 16 | or/10-15 |
| 17 | 9 and 16 |
| 18 | animals/ not humans/ |

| | |
|---|---|
| 19 | 17 not 18 |