Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia (Review)

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[Intervention Review]

Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

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ABSTRACT

Background

Myopia is a condition in which the focusing power (refraction) of the eye is greater than that required for clear distance vision. There are two main types of surgical correction for moderate to high myopia; excimer laser and phakic intraocular lenses (IOLs). Excimer laser refractive surgery for myopia works by removing corneal stroma to lessen the refractive power of the cornea and to bring the image of a viewed object into focus onto the retina rather than in front of it. Phakic IOLs for the treatment of myopia work by diverging light rays so that the image of a viewed object is brought into focus onto the retina rather than in front of the retina. They can be placed either in the anterior chamber of the eye in front of the iris or in the posterior chamber of the eye between the iris and the natural lens.

Objectives

To compare excimer laser refractive surgery and phakic IOLs for the correction of moderate to high myopia by evaluating postoperative uncorrected visual acuity, refractive outcome, potential loss of best spectacle corrected visual acuity (BSCVA) and the incidence of adverse outcomes.

Search methods

We searched CENTRAL (which contains the Cochrane Eyes and Vision Group Trials Register) (2014, Issue 1), Ovid MEDLINE, Ovid MEDLINE In-Process and Other Non-Indexed Citations, Ovid MEDLINE Daily, Ovid OLDMEDLINE (January 1946 to February 2014), EMBASE (January 1980 to February 2014), the *meta*Register of Controlled Trials (*m*RCT) (www.controlled-trials.com), ClinicalTrials.gov (www.clinicaltrials.gov) and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/search/en). We did not use any date or language restrictions in the electronic searches for trials. We last searched the electronic databases on 11 February 2014.

Selection criteria

We included randomised controlled trials (RCTs) comparing excimer laser refractive surgery and phakic IOLs for the correction of myopia greater than 6.0 diopters (D) spherical equivalent.

Data collection and analysis

Two authors independently assessed trial quality and extracted data. We performed data analysis. We summarised data for outcomes using odds ratios. We used a fixed-effect model as only three trials were included in the review.

Main results

This review included three RCTs with a total of 228 eyes. The range of myopia of included patients was -6.0 D to -20.0 D of myopia with up to 4.0 D of myopic astigmatism. The percentage of eyes with uncorrected visual acuity (UCVA) of 20/20 or better at 12 months postoperative was not significantly different between the two groups. Phakic IOL surgery was safer than excimer laser surgical correction for moderate to high myopia as it results in significantly less loss of best spectacle corrected visual acuity (BSCVA) at 12 months postoperatively. However there is a low risk of developing early cataract with phakic IOLs. Phakic IOL surgery appears to result in better contrast sensitivity than excimer laser correction for moderate to high myopia. Phakic IOL surgery also scored more highly on patient satisfaction/preference questionnaires.

Authors' conclusions

The results of this review suggest that, at one year post surgery, phakic IOLs are safer than excimer laser surgical correction for moderate to high myopia in the range of -6.0 to -20.0 D and phakic IOLs are preferred by patients. While phakic IOLs might be accepted clinical practice for higher levels of myopia (greater than or equal to 7.0 D of myopic spherical equivalent with or without astigmatism), it may be worth considering phakic IOL treatment over excimer laser correction for more moderate levels of myopia (less than or equal to 7.0 D of myopic spherical equivalent with or without astigmatism). Further RCTs adequately powered for subgroup analysis are necessary to further elucidate the ideal range of myopia for phakic IOLs. This data should be considered alongside comparative data addressing long-term safety as it emerges.

PLAIN LANGUAGE SUMMARY

Excimer laser versus phakic intraocular lenses for the correction of moderate to high short-sightedness

Background

Myopia is a condition in which the focusing power (refraction) of the eye is greater than that required for clear vision of distant objects. Myopia is a common cause of visual disability throughout the world. The World Health Organization (WHO) has grouped myopia and uncorrected refractive error among the leading causes of blindness and vision impairment in the world. The overall power of the lens that would be needed to correct the myopia is expressed in diopters (D) of a sphere. Most people have some degree of astigmatism where the eye is better at focusing light in one meridian than it is at another. It is possible to combine the effect of any astigmatism with the overall focusing power of the eye as a spherical equivalent in diopters. There are two main types of surgical correction for moderate to high myopia; excimer laser and phakic intraocular lenses (IOLs). Excimer laser refractive surgery for myopia works by removing corneal stroma to lessen the refractive power of the cornea and to bring the image of a viewed object into focus onto the retina rather than in front of it. Phakic IOLs for the treatment of myopia work by diverging light rays so that the image of a viewed object is brought into focus onto the retina rather than in front of it. They can be placed either in the anterior chamber of the eye in front of the iris or in the posterior chamber of the eye between the iris and the natural lens.

Study characteristics

This review included three randomised controlled trials with a total of 228 eyes. The range of myopia of included patients was -6.0 D to -20.0 D with up to 4.0 D of myopic astigmatism.

Key results

The results of this review showed that the chance of the uncorrected visual acuity being 20/20 or better was not different between the two groups. Phakic IOL surgery was safer than excimer laser surgical correction for moderate to high myopia as it results in significantly less loss of best spectacle corrected visual acuity (BSCVA) at 12 months postoperatively. Phakic IOL surgery appears to result in better contrast sensitivity than excimer laser correction for moderate to high myopia. Phakic IOL surgery also scored more highly on patient satisfaction/preference questionnaires. Neither technique resulted in any complication that caused a loss of final BSCVA.

Quality of the evidence

Only studies that fulfilled the proper requirements were selected for inclusion in the analysis. The limitations of the studies that we included were the relatively short follow up period of one year as well as the fact that many of the interventions studied have now been superseded by more technologically advanced alternatives. In the present day the technology available for both excimer laser and phakic IOL surgical correction of high myopia is better than during the period of the included studies.

Conclusion

This review showed that phakic IOLs for the treatment of high myopia were safer and preferred by patients when compared with excimer laser. Studies looking at more up to date technology with longer follow to determine long term safety issues are needed.

BACKGROUND

Description of the condition

Myopia is also known as short-sightedness or near-sightedness. It is a condition in which the focusing power (refraction) of the eye is greater than that required for clear distance vision. The ocular determinants of refraction are the focusing power of the cornea and crystalline lens and the length of the eye (Fredrick 2002). In myopia, light from distant objects is focused in front of the retina instead of directly onto it. This occurs because the corneal curvature is too strong, the lens power is too strong, the eye is too long or a combination of these factors. As a result objects in the distance appear blurred. Near objects appear less blurred or may be seen clearly, depending on the degree of myopia. When the myopia is corrected (see 'Description of the intervention' below) the aim is normally to focus light directly onto the retina. When light is focused directly onto the retina the eye is described as being emmetropic.

Most cases of myopia present in children of school age and young adults. The presenting complaint is difficulty reading objects at a distance. Diagnosis is based on the results of refraction (spectacle testing). The overall power of the lens that would be needed to correct the myopia is expressed in diopters (D) of a sphere. Most people have some degree of astigmatism where the eye is better at focusing light at one angle than it is at another. It is possible to combine the effect of any astigmatism with the overall focusing power of the eye as a spherical equivalent in diopters.

Myopia is a common cause of visual disability throughout the world. The World Health Organization (WHO) has grouped myopia and uncorrected refractive error among the leading causes of blindness and vision impairment in the world (Fredrick 2002; Pararajasegaram 1999). The prevalence of myopia varies with age, country, ethnic group, level of education and occupation. The prevalence of myopia in Western populations is estimated to be approximately 25% (Kempen 2004; Sorsby 1960; Sperduto 1983). In some Asian populations myopia prevalence is as high as 70% to 90% (Chow 1990; Wong 2000). According to epidemiological evidence the prevalence of myopia is increasing, especially in Asian populations (Rajan 1995; Tay 1992).

There is substantial evidence that both genetic and environmental factors play a role in its aetiology (Fredrick 2002; Mutti 1996). People with myopia can be broadly classified into two groups:1) those with low to moderate myopia (less than or equal to 7.0 D of myopic spherical equivalent with or without astigmatism) and 2) those with high myopia (greater than or equal to 7.0 D of myopic spherical equivalent with or without astigmatism) (FDA 1997).

Description of the intervention

The most commonly used methods for correcting myopia are spectacle correction and contact lens wear. These conservative optical methods provide temporary correction of myopia. Surgical procedures have been developed in an attempt to permanently correct myopia. There are a variety of reasons why patients with myopia request refractive surgery as an alternative to contact lenses or spectacles. These reasons include:

- Contact lenses may be inconvenient, not tolerated or may be deemed unsafe.
- Spectacles may be associated with unacceptable aberrations, glare and/or reduction of visual field.
- Spectacles may be cosmetically unacceptable or inconvenient.

The goal of refractive surgery is to safely and predictably create a stable and desired refractive state without causing new optical problems. In order to correct myopia the refractive power of the eye must be decreased, either by increasing the anterior radius of curvature of the cornea (flattening the curvature of the anterior corneal surface) or by insertion of a synthetic intraocular lens (IOL) of appropriate power. There are several surgical techniques available for the treatment of myopia. These techniques are, broadly speaking, divided into two groups; those involving surgery on the cornea (corneal refractive surgery) and those involving surgery on the lens (lenticular refractive surgery). These techniques are outlined below.

Corneal refractive surgery

Corneal ablation by excimer laser

- Laser assisted stromal in-situ keratomileusis (LASIK).
- Epithelial laser assisted in-situ keratomileusis (Epi-LASIK).

- Photorefractive keratectomy (PRK).
- Laser assisted subepithelial keratomileusis (LASEK).

Corneal addition procedures

- Intracorneal ring segments (e.g. INTACS); most commonly used to treat keratoconus.
- Epikeratophakia (removal of epithelium and placement of a donor lenticule of Bowman's layer and anterior stroma).
- Keratophakia (intrastromal placement of a donor lenticule of corneal stroma after raising a microkeratome flap or by creating a stromal pocket by lamellar dissection).
- Intracorneal lens (placement of hydrogel lens inside the corneal stroma).
- Compression sutures (steepen the cornea to reduce astigmatism).

With the exception of intracorneal ring segments, the other corneal addition procedures are not currently in widespread use.

Corneal relaxation procedures

- Radial keratotomy (peripheral deep stromal radial incisions) has been generally abandoned in favour of laser surgery.
- Arcuate keratotomy (paired peripheral stromal incisions parallel to the limbus); most often used to treat astigmatism after corneal graft surgery.
- Limbal relaxing incisions (deep limbal incisions of varying arc) are used during cataract surgery to reduce pre-existing corneal astigmatism.

Corneal thermocoagulation

Thermokeratoplasty (heating the peripheral cornea to shrink collagen and steepen the central corneal curvature) can be used to treat hyperopia or presbyopia.

Lenticular refractive surgery

Refractive lens exchange

This is extraction of the natural lens and insertion of a posterior chamber IOL i.e. 'cataract surgery' in the absence of a visually significant cataract.

Phakic IOL

This is the insertion of an additional synthetic lens in front of the natural lens, placed either behind the iris in the ciliary sulcus or clipped to the iris in the anterior chamber.

Multifocal lens

These lenses have concentric ring segments that have two different focal lengths for distance and near vision.

Toric lens

These lenses have a cylindrical power to address astigmatism.

How the intervention might work

Excimer laser refractive surgery for myopia works by removing corneal stroma to lessen the refractive power of the cornea and to bring the image of a viewed object into focus onto the retina rather than in front of it.

Phakic IOLs for the treatment of myopia work by diverging light rays so that the image of a viewed object is brought into focus onto the retina rather than in front of the retina. They can be placed either in the anterior chamber of the eye in front of the iris or in the posterior chamber of the eye behind the iris and in front of the natural lens in the ciliary sulcus.

Why it is important to do this review

In recent years excimer laser refractive surgery has been the preferred refractive surgical procedure for most patients seeking spectacle independence (Chang 2006; Duffey 2004). Excimer laser refractive surgery has the benefit of rapid visual recovery, excellent visual outcomes and relatively painless postoperative recovery. For patients with moderate to high degrees of myopia, excimer laser refractive surgery may be less predictable and less safe. Iatrogenic keratectasia, optical aberrations, severe night glare, flap-related complications and significant loss of spectacle corrected visual acuity have been reported (el Danasoury 1998; Knorz 1998; Seiler 1998; Stulting 1999).

Phakic IOLs, approved by the US Food and Drug Administration (FDA) in September 2004, represent a new alternative surgical treatment for moderate to high myopia. Phakic IOLs have the benefit of being a reversible procedure. Their insertion requires intraocular surgery which carries the risk of endophthalmitis, surgically induced astigmatism, corneal endothelium loss, chronic uveitis, pupillary block glaucoma, pigment dispersion syndrome and cataracts. In addition, the lens power calculation and surgical implantation of phakic IOLs require special techniques and the long term outcomes of several types of phakic IOLs are unknown (Espandar 2008).

Which of these two methods for correction of moderate to high myopia is more accurate, more stable and more safe than the other has not been assessed to date by a systematic review. This review will evaluate data from randomised controlled trials (RCTs) in order to address this question.

OBJECTIVES

To compare excimer laser refractive surgery and phakic IOLs for the correction of moderate to high myopia by evaluating post-operative uncorrected visual acuity, refractive outcome, potential loss of best spectacle corrected visual acuity (BSCVA) and the incidence of adverse outcomes.

METHODS

Criteria for considering studies for this review

Types of studies

We included all RCTs that met the inclusion criteria.

Types of participants

We included trials in which the participants were males and females over 21 years of age and under 60 years of age undergoing excimer laser refractive surgery or phakic IOL insertion for myopia greater than 6.0 D of spherical equivalent. We excluded participants under 21 years of age due to the frequent change in refractive error still occurring in this age group. We excluded participants over 60 years of age on the basis that some degree of cataract is observed in the majority of these patients and corneal refractive procedures will not correct aberrations or reduced visual acuity caused by cataract. We also excluded participants with myopia that is lower than 6.0 D as there is currently little evidence to support the use of phakic IOLs in such patients. We excluded participants undergoing LASIK for correction of refractive errors other than primary myopia, for example post corneal graft, and participants with any other simultaneous ocular disease.

Types of interventions

We included studies in which excimer laser refractive surgery was compared with phakic IOL insertion for correction of moderate to high myopia.

Types of outcome measures

Primary outcomes

Percentage of eyes with uncorrected visual acuity (UCVA) of 20/20 or better at 12 months post-treatment.

Secondary outcomes

1. Percentage of eyes with UCVA of 20/20 or better at six months post-treatment.
2. Percentage of eyes within ±0.50 D of target refraction at six months post-treatment.
3. Percentage of eyes within ±0.50 D of target refraction at 12 months post-treatment.
4. Percentage of eyes within ±1.00 D of target refraction at six months post-treatment.
5. Percentage of eyes within ±1.00 D of target refraction at 12 months post-treatment.
6. Percentage of eyes that lost 2 or more lines of BSCVA at six months post-treatment.
7. Percentage of eyes that lost 2 or more lines of BSCVA at 12 months post-treatment.
8. Percentage of eyes that lost 1 or more lines of BSCVA at six month post-treatment.
9. Percentage of eyes that lost 1 or more lines of BSCVA at 12 months post-treatment.
10. Percentage of eyes with UCVA of 20/40 or better at six months post-treatment.
11. Percentage of eyes with UCVA of 20/40 or better at 12 months post-treatment.

The secondary outcome measures listed above have been modified slightly from those initially set out in the protocol. We have added the percentage of eyes within ±1.0 D of target refraction at six and 12 months post-treatment as this provides further important information on the accuracy of the procedure. We have also added the percentage of eyes that lost 1 or more lines of BSCVA at six and 12 months post-treatment in order to provide more information on potential safety measures for the two procedures. The 12 month time point for both of these additions is reported by all three RCTs and therefore allows us to adequately address the diversity of outcomes reported in the individual trials.

Adverse effects

We examined the incidence of severe complications, that is, those leading to significant permanent visual loss (loss of 2 or more lines from pre-treatment best corrected visual acuity) within 24 months of treatment, arising directly as a result of undergoing treatment. We examined the incidence of flap related complications (whether or not they resulted in significant visual loss) in patients undergoing LASIK. We examined the incidence of corneal endothelial cell loss, pupillary block glaucoma, pigment dispersion syndrome, uveitis, large visually significant iridectomies, need for IOL exchange and endophthalmitis in the phakic IOL group. We assessed minor complications such as dry eye symptoms, glare or haloes under quality of life measures using suitable patient satisfaction questionnaires, and we also assessed changes in contrast sensitivity. For paired eye studies it was not possible to look at such quality of life issues and we needed to restrict the quality of life analysis to

studies where the separate interventions were performed on separate individuals.

Search methods for identification of studies

Electronic searches

We searched CENTRAL (which contains the Cochrane Eyes and Vision Group Trials Register) (2014, Issue 1), Ovid MEDLINE, Ovid MEDLINE In-Process and Other Non-Indexed Citations, Ovid MEDLINE Daily, Ovid OLDMEDLINE (January 1946 to February 2014), EMBASE (January 1980 to February 2014), the *meta*Register of Controlled Trials (*m*RCT) (www.controlled-trials.com), ClinicalTrials.gov (www.clinicaltrials.gov) and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/search/en). We did not use any date or language restrictions in the electronic searches for trials. We last searched the electronic databases on 11 February 2014.

See: Appendices for details of search strategies for CENTRAL (Appendix 1), MEDLINE (Appendix 2), EMBASE (Appendix 3), LILACS (Appendix 4), *m*RCT (Appendix 5), ClinicalTrials.gov (Appendix 6) and the ICTRP (Appendix 7).

Searching other resources

We searched the reference lists of the studies included in the review for information about further trials. We contacted experts in the field for further information. We used the Science Citation Index to search for papers that cite any studies included in this review. We did not handsearch journals or conference proceedings specifically for this review.

Data collection and analysis

Selection of studies

Both authors independently assessed the titles and abstracts resulting from the searches and screened the full copies of all relevant studies against the inclusion criteria. We dealt with potential discrepancies and unclear studies by contacting the authors for clarification and additional information.

Data extraction and management

Both authors extracted data independently using a standard data collection form. We compared the results and resolved any disagreements by discussion. One author entered data into RevMan (RevMan 2012) and then both authors independently checked the data entered. We extracted the following details from the studies: methods, participants, interventions, outcomes and notes.

Assessment of risk of bias in included studies

Both review authors assessed studies that met the inclusion criteria for methodological quality. We considered the following domains of quality: random sequence generation (to determine whether the sequence allocation was adequately generated), allocation concealment, masking (blinding) of outcome assessors (to determine whether knowledge of the allocated intervention was adequately prevented during the study), incomplete outcome data, selective outcome reporting and other sources of bias. As the two treatments concerned are inherently different, masking of participants and providers was not possible and was not assessed. We graded each domain of trial quality as: low risk of bias, high risk of bias or unclear. We resolved any disagreements between the review authors by discussion. We contacted the trial authors for clarification on any domain assessed as unclear. We did not perform sensitivity analyses as there were too few RCTs included to make this worthwhile. Furthermore we included all trials in our analysis as none were graded as high risk of bias on 'allocation concealment and concealment approach'.

Measures of treatment effect

All outcome measures stated are dichotomous, with the exception of "postoperative patient satisfaction scores" which are ordinal. For dichotomous outcomes we calculated an odds ratio. Ordinal outcomes included a large enough number of categories to assume similar characteristics to continuous outcomes and therefore we calculated a standardized mean difference.

Unit of analysis issues

The preferred unit of analysis were outcomes for eyes rather than individuals, since some individuals might have had unilateral treatment or different treatments in each eye. Paired eye studies, where one eye had been randomised to one intervention and the second eye had by default gone on to receive the other intervention, were included as carry-over and period effects were not thought likely to be a problem. Similarly we included paired eye cluster studies where both eyes were randomised to the same intervention. We included the effect estimate for these paired studies in the meta-analysis using the generic inverse-variance method.

Dealing with missing data

Where we were unable to extract all the information we were interested in from published reports, both with regard to the details of the study and its numerical results, we requested the missing data from the original investigators.

Assessment of heterogeneity

We endeavoured to identify differences between the studies which were likely to introduce heterogeneity. As some degree of heterogeneity always exists due to the clinical and methodological diversity of the studies, we employed the results of the Chi^2 test as well as I^2 statistic to quantify inconsistencies across studies.

Assessment of reporting biases

In order to investigate whether our review was subject to reporting biases, we examined the relevant funnel plots for signs of asymmetry in RevMan (RevMan 2012).

Data synthesis

We performed the data analysis according to Chapter 9 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Deeks 2011) and summarised data for outcomes using odds ratios. We used a fixed-effect model for our analyses as only three trials were included.

Subgroup analysis and investigation of heterogeneity

As per our protocol, we did not perform subgroup analyses.

Sensitivity analysis

We did not perform a sensitivity analyses in order to evaluate how robust the results of the review were relative to decisions and assumptions made in the process of conducting the review. There were too few RCTs included to make this worthwhile. Furthermore we included all trials in our analysis as none were graded as high risk of bias on 'allocation concealment and concealment approach'.

RESULTS

Description of studies

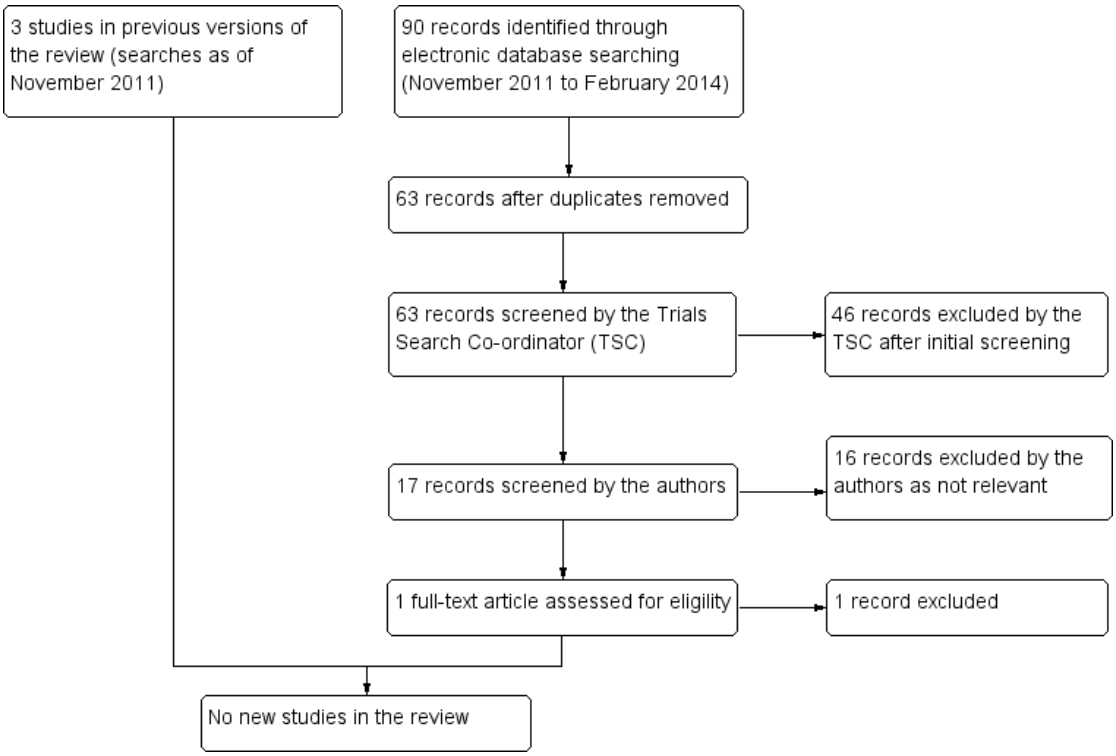
Results of the search

The electronic searches identified 221 reports of trials. Of these, seven were retrieved for further assessment of which three studies were included and four studies were excluded.

An update search was done in November 2011. After deduplication the search identified a total of 53 references. The Trials Search Co-ordinator scanned the search results and removed any references which were not relevant to the scope of the review. We reviewed the remaining three references but they did not meet the inclusion criteria for the review.

An update search run in February 2014 identified a further 90 references (Figure 1). The Trials Search Co-ordinator removed 27 duplicates and screened the remaining 63 references, of which 46 were not relevant to the scope of the review. We reviewed the remaining 17 reference and obtained one full-text report (Albarran-Diego 2012) for potential inclusion in the review. However, the trial did not meet the inclusion criteria and we excluded the study.

Figure 1. Results from searching for studies for inclusion in the review.



Included studies

The following is a summary of the characteristics of the three RCTs that met the review inclusion criteria (el Danasoury 2002; Malecaze 2002; Schallhorn 2007). Further details can be found in the 'Characteristics of included studies' table.

Types of participants

The three RCTs included a total of 228 eyes of 132 consecutive patients. The age range of all included patients was 21 to 52 years. All included patients had a stable refraction for at least 12 months prior to inclusion. The range of myopia of included patients was 6.0 D to 20.0 D with up to 4.0 D of myopic astigmatism. One study included patients with between 9.0 and 19.5 D of myopia and refractive astigmatism less than 3.0 D (el Danasoury 2002). One study included patients with bilateral myopia between 8.0 and 12.0 D with an astigmatism less than 1.5 D (Malecaze 2002). One study included patients with myopia between -6.0 to -20.0 D and astigmatism in the range of 1.0 to 4.0 D (Schallhorn 2007). Exclusion criteria included: previous refractive surgery, keratoconus or keratoconus suspected by videokeratography, active ocular disease, dry eyes, systemic disease likely to affect corneal wound healing (such as connective tissue disease) and inability to achieve the follow-up schedule given to the patients before surgery.

Types of interventions

Two of the studies compared LASIK with the Artisan phakic IOL (el Danasoury 2002; Malecaze 2002). The Artisan phakic IOL is an iris claw-fixated anterior chamber lens. One study compared PRK and mitomycin C (MMC) augmentation with the Visian Toric Implantable Collamer Lens (Schallhorn 2007). The Visian Toric Implantable Collamer Lens (STAAR Surgical) has a toric anterior surface and is designed to vault anteriorly to the crystalline lens in the ciliary sulcus. The excimer laser platforms and nomograms used varied between studies but not within individual studies. For LASIK procedures the microkeratomes used for flap creation varied between studies but not within studies. For all surgery the refractive aim was emmetropia.

Types of outcome measures

The primary and secondary outcomes, as well as adverse outcomes, are set out above. All three trials reported data for some of the primary and secondary outcome measures. No trial reported data for

every outcome measure. The studies involving the Artisan phakic IOL provided data on corneal endothelial cell counts. All studies provided data on patient satisfaction questionnaires.

Excluded studies

One trial was excluded because the minimum follow up was less than one year (Soliman 1999). A further two studies were excluded because the eyes were not randomised to treatments (Morara 1999; Sanders 2003). In Morara 1999 there was no specific mention of randomisation. We attempted contact with the various authors involved to confirm that there was no randomisation to treatments but no response was forthcoming. We, therefore, assumed that randomisation was not performed. We contacted the authors of Kamiya 2008 and they confirmed that the two groups were not randomised and therefore this study was not included.

In the latest update of this review (2014), we excluded one study (Albarran-Diego 2012) because there were several limitations with this study. Firstly the fact that two eyes of each participant were randomised to the same intervention is a source of bias. Secondly the fact that the upper limit cut off of myopia was only -9.0 in this study excludes the results from a meaningful analysis. The really relevant participants are those with more than -9.0 of myopia which were included in all of the original studies that were part of our meta-analysis. Finally the laser technology used (the VisX S2) is essentially out of date technology.
See the 'Characteristics of excluded studies' table for further details.

Risk of bias in included studies

See Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

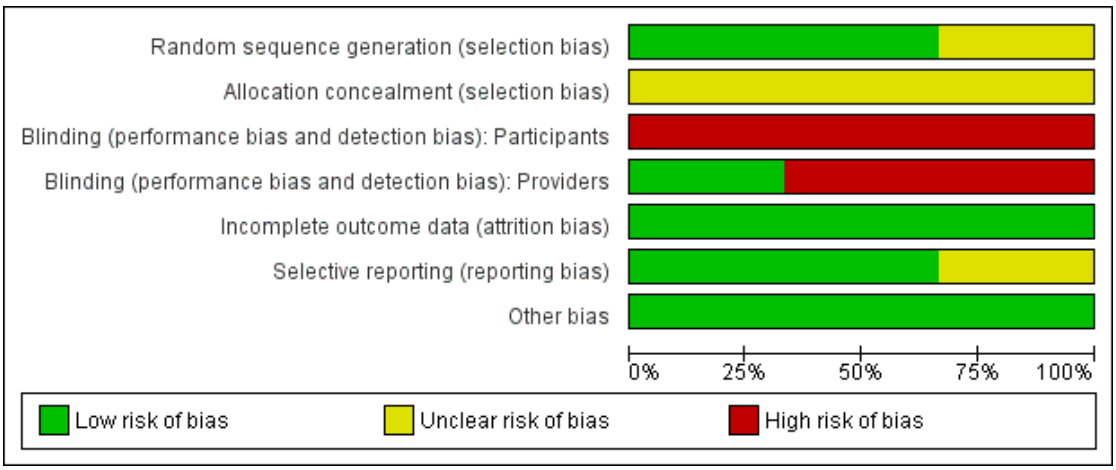
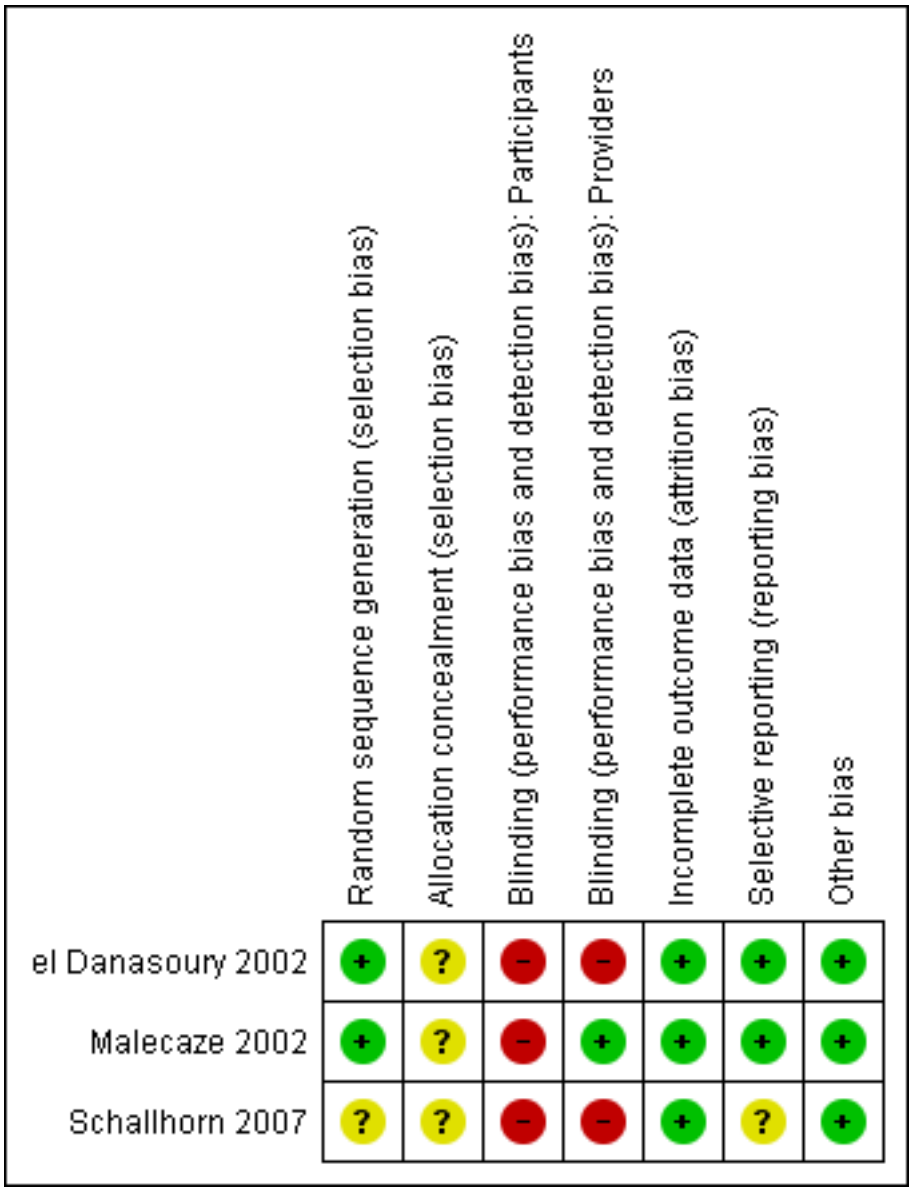


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



One of the studies randomised each eye involved to the individual treatments being compared (el Danasoury 2002) such that some participants had LASIK in one eye and phakic IOL in the other and some had bilateral phakic IOL or bilateral LASIK. Another study (Schallhorn 2007) did not specify whether eyes or participants were randomised to the individual treatments. The authors were contacted regarding this and kindly responded stating that where participants underwent bilateral treatment, both eyes were randomised to the same treatment. The third study (Malecaze 2002) used a paired eye comparison where one eye was randomised to an individual treatment and the other eye received the other treatment by default. We have no reason to believe that surgery on one eye could influence the outcome of the surgery on the other eye or vice versa and therefore we did not consider carry-over and period effects to be a problem.

Allocation

The method of sequence generation for one of the studies was not specified (Schallhorn 2007). A random number table was used for the other two studies (el Danasoury 2002, Malecaze 2002). All three studies were graded as unclear on allocation concealment.

Blinding

As the two treatments concerned are inherently different, masking of participants and providers was not possible and was therefore deemed to have not been done in all studies. One study, Malecaze 2002, masked the assessors and we therefore graded it as low risk of bias for this parameter. We graded the other two studies (el Danasoury 2002; Schallhorn 2007) as unclear on masking of assessors.

Incomplete outcome data

This was assessed as low risk of bias in all studies. Losses to follow up were reported and were equal in both groups of each study.

Selective reporting

All of the studies reported on all of the pre-specified primary and secondary outcomes. However, none of the studies provided information on whether the methods used in the statistical analysis were pre-specified or not and therefore we graded all studies as unclear for selective reporting.

Other potential sources of bias

We did not identify any other potential threats to validity for the included studies.

Effects of interventions

1. Visual acuity

a. Percentage of eyes with uncorrected visual acuity (UCVA) of 20/20 or better at 12 months post-treatment (primary outcome) (see Analysis 1.1)

Data were available for analysis for a total of 166 eyes in two trials (el Danasoury 2002; Schallhorn 2007). Analysis of the data showed no difference between the two groups (odds ratio (OR) 1.33, 95% confidence interval (CI) 0.08 to 22.55, P = 0.84).

b. Percentage of eyes with UCVA of 20/20 or better at six months post-treatment (secondary outcome) (see Analysis 1.2)

Data were available for analysis for a total of 157 eyes in two trials (el Danasoury 2002; Schallhorn 2007). Analysis of the data showed no difference between the two groups (OR 0.99, 95% CI 0.25 to 3.91, P = 0.99).

c. Percentage of eyes with UCVA of 20/40 or better at six months post-treatment (secondary outcome) (see Analysis 1.3)

Data were available for analysis for a total of 125 eyes in two trials (el Danasoury 2002; Malecaze 2002). Analysis of the data showed no difference between the two groups (OR 0.71, 95% CI 0.36 to 1.39, P = 0.32).

d. Percentage of eyes with UCVA of 20/40 or better at twelve months post-treatment (secondary outcome) (see Analysis 1.4)

Data were available for analysis for a total of 134 eyes in two trials (el Danasoury 2002; Malecaze 2002). Analysis of the data showed no difference between the two groups (OR 0.66, 95% CI 0.36 to 1.22, P = 0.18).

2. Refraction (accuracy)

a. Percentage of eyes within ±0.50 D of target refraction at six months post-treatment (secondary outcome) (see Analysis 1.5)

One study (Schallhorn 2007) reported data for this outcome. In this study there was significantly greater accuracy in the phakic IOL group (P = 0.02). We included subtotals only in the meta-analysis.

b. Percentage of eyes within ±0.50 D of target refraction at 12 months post-treatment (secondary outcome) (see Analysis 1.6)

Data were available for analysis for a total of 216 eyes in three trials (el Danasoury 2002; Malecaze 2002; Schallhorn 2007). Analysis of data showed no difference between the two groups (OR 0.72, 95% CI 0.40 to 1.29, P = 0.27).

c. Percentage of eyes within ±1.00 D of target refraction at six months post-treatment (secondary outcome) (see Analysis 1.7)

One study (Schallhorn 2007) reported data for this outcome. In this study there was significantly greater accuracy in the phakic

IOL group (P = 0.03). We included subtotals only in the meta-analysis.

d. Percentage of eyes within ±1.00 D of target refraction at 12 months post-treatment (secondary outcome) (see Analysis 1.8)

Data were available for analysis for a total of 216 eyes in three trials (el Danasoury 2002; Malecaze 2002; Schallhorn 2007). Analysis of data showed no difference between the two groups (OR 1.01, 95% CI 0.42 to 2.45, P = 0.98).

3. Safety measures

a. Percentage of eyes that lost 2 or more lines of BSCVA at six months post-treatment (secondary outcome)

Only one study (Schallhorn 2007) reported data for this outcome. In this study there were no patients in either group who lost 2 or more lines of BSCVA and it was therefore not possible to generate an odds ratio for this outcome.

b. Percentage of eyes that lost 2 or more lines of BSCVA at 12 months post-treatment (secondary outcome) (see Analysis 1.9)

Data were available for analysis for a total of 216 eyes in three trials (el Danasoury 2002; Malecaze 2002; Schallhorn 2007). Analysis of data showed that the phakic IOL group were less likely to lose 2 or more lines of BSCVA at 12 months post-treatment than the excimer laser group and this effect was statistically significant (OR 0.35, 95% CI 0.19 to 0.66, P = 0.001).

c. Percentage of eyes that lost 1 or more lines of BSCVA at six months post-treatment (secondary outcome) (see Analysis 1.10)

One study reported data for this outcome (Schallhorn 2007). In this study there was no difference between the two groups (P = 0.12). We included subtotals only in the meta-analysis.

d. Percentage of eyes that lost one or more lines of BSCVA at 12 months post-treatment (secondary outcome) (see Analysis 1.11)

Data were available for analysis for a total of 216 eyes in three trials (el Danasoury 2002; Malecaze 2002; Schallhorn 2007). Analysis of data showed that the phakic IOL group were less likely to lose 1 or more lines of BSCVA at 12 months post-treatment than the excimer laser group and this effect was statistically significant (OR 0.41, 95% CI 0.33 to 0.51, P = 0.00001).

Safety Index

Although Malecaze 2002 did not report data directly on loss of BSCVA at six months it does give a measure of safety as a safety index which is expressed as the ratio of the mean postoperative BSCVA over the mean preoperative BSCVA. In this study at three, six and 12 months postoperatively they show that the safety index was significantly higher in the phakic IOL treated eyes than in the excimer laser treated eyes at all periods (three, six and 12 months postoperative) except at one month.

4. Adverse effects

Due to inconsistency between studies it was not possible to combine data for adverse effects and hence a descriptive account of the findings is provided.

a. Incidence of flap/interface/decentered ablation/haze related complications in laser treated eyes

One study (el Danasoury 2002) reported a single case of diffuse lamellar keratitis which completely resolved with topical steroid treatment. There were no other cases reported of flap, interface complications or haze and there were no studies that reported decentered ablations. These results are summarised in Table 1.

b. Endothelial cell loss

Two studies examined endothelial cell loss (el Danasoury 2002; Malecaze 2002). Both of these studies found no significant difference between endothelial cell loss in the two groups. These results are summarised in Table 2.

c. Incidence of cataract in the phakic IOL group

One study (Schallhorn 2007) reported, at two years postoperatively, the presence of an anterior subcapsular cataract in one (2.3%) phakic IOL patient who was lost to follow up until two years postoperatively. The patient's BCVA had reduced to 20/50 $^{-1}$. The patient underwent successful removal of the phakic IOL and cataract with implantation of a posterior chamber pseudophakic IOL. One month after surgery the BSCVA was 20/20. In the same study there was one further patient who was noted to have a visually insignificant anterior lens opacity throughout the follow-up period. The other two studies, which used anterior chamber phakic IOLs, did not report any cases of lens opacification or cataract.

d. Incidence of glaucoma/uveitis in the phakic IOL group

One study (Malecaze 2002) measured intraocular pressure (IOP) preoperatively and at one, three, six and 12 months postoperatively. There was no significant change in IOP in the phakic IOL group. In the LASIK group there was a significant reduction in apparent IOP (P < 0.001). The same study measured flare and did not find any significant difference between preoperative and postoperative patients in both groups. One other study (el Danasoury 2002) reported two (4.4%) cases of transient ocular hypertension that responded to topical therapy and resolved upon discontinuation of the topical steroid. There were no cases of glaucoma or uveitis reported in any study.

e. Need for IOL exchange in the phakic IOL group

Two studies (el Danasoury 2002; Schallhorn 2007) reported the need for IOL exchange in the phakic IOL group. The rate of incidence ranged from 2.2% to 2.3%. In both studies a BSCVA of 20/20 was restored following IOL exchange. These results are summarised in Table 3.

f. Changes in contrast sensitivity

All three studies reported contrast sensitivity outcomes. In Malecaze 2002 there is an apparent slight benefit to Artisan over LASIK but this is not statistically significant. Similarly, in el Danasoury 2002 there is an apparent advantage to Artisan IOL over LASIK but the trialists do not report whether this is statistically significant or not. Schallhorn 2007 shows the phakic IOL group to be significantly better than the excimer laser treated group for both scotopic and mesopic contrast sensitivity at most time

points postoperatively. These results are summarised in Table 4.

g. Subjective evaluation and quality of vision

All three studies report subjective evaluation and quality of vision outcomes. Of the patients who received Artisan in one eye and LASIK in the other, Artisan was the preferred procedure. Schallhorn 2007 showed that the phakic IOL group scored significantly higher for a number of satisfaction parameters. All three studies show that glare and halos are more of a problem with excimer laser than with phakic IOLs. The results are summarised in Table 5.

DISCUSSION

Summary of main results

- The percentage of eyes with UCVA of 20/20 or better at 12 months postoperatively was not significantly different between the two groups.
- Phakic IOL surgery is safer than excimer laser surgical correction for moderate to high myopia. It results in significantly less final loss of BSCVA.
- There is a low risk of developing early cataract with phakic IOLs.
- Phakic IOL surgery appears to result in better contrast sensitivity than excimer laser correction for moderate to high myopia. Phakic IOL surgery also scores more highly on patient satisfaction/preference questionnaires.

Overall completeness and applicability of evidence

Three RCTs met the review inclusion criteria (el Danasoury 2002; Malecaze 2002; Schallhorn 2007). All three trials reported data for some of the primary and secondary outcome measures. No trial reported data for every outcome measure and hence not all of the trials could be included in each of the outcome analyses. The studies involving the Artisan phakic IOL provided data on corneal endothelial cell counts. All studies provided data on patient satisfaction questionnaires. Incomplete outcome data were adequately addressed in all studies. Losses to follow-up were reported and were equal in both groups of each study. All of the studies reported on all of the pre-specified primary and secondary outcomes.

It should be noted that all systematic reviews are subject to the potential problem of multiplicity due to problems such as selective reporting of results or analyses by individual trials. For instance, when the results of a study are presented, it is not always possible to know how many tests or analyses were done. It is likely that in some studies interesting findings were selected for presentation or publication in relation to statistical significance, and other 'uninteresting' findings omitted, leading to misleading results and spurious conclusions (Deeks 2011).

There is some heterogeneity of the results between the studies for some of the outcomes. There are a variety of potential explanations as to why this might be. All three studies included patients with slightly different degrees of myopia and myopic astigmatism. None of the studies break down the treatment effect into subgroups with different levels of baseline refractive error and therefore it is not possible to take these potential differences into account when combining the studies into the analysis. Furthermore the excimer laser procedures are able to address myopic astigmatic error with a toric ablation profile but the Artisan lens used in el Danasoury 2002 and Malecaze 2002 could not address myopic astigmatism. It is possible that in these studies the potential benefit from phakic IOLs has been underestimated given that toric phakic IOLs are now readily available. The toric IOL used in Schallhorn 2007 was able to address myopic astigmatism and therefore may represent a more fair comparison of the two techniques. Another potential reason for heterogeneity is the issue of enhancement LASIK procedures that were administered in el Danasoury 2002, four to six months after the primary procedure, to patients in either group who had a residual refractive error of more than 1.0 D at the three month examination. It is possible that this could again result in an underestimation of the difference between the two groups. Another potential source of heterogeneity between the studies is due to Schallhorn 2007 being more contemporaneous than the other two studies, and it is possible that the excimer laser treatment nomograms as well as the IOL calculation formulae were more advanced in this study.

Studies looking at risk factors for progression to ectasia after excimer laser refractive surgery (Randleman 2008) recommend not performing LASIK on myopia greater then 14 D. However excimer laser surface ablation such as PRK may be safer on higher levels of myopia but this has not been properly established in clinical trials. All of the studies include a relatively high range of myopia and myopic astigmatism. None of the studies attempted to perform a subgroup analysis on smaller ranges of myopia in order to specifically determine exactly what population of moderate to highly myopic patients would most benefit from phakic IOLs.

Quality of the evidence

A major issue with this review is trial quality according to established modern criteria. In the presence of such concern, emphasis on the evidence of effectiveness must be cautious, as it is possible that systematic bias in the studies has led to overestimation of effect. The methodological quality of the trials that were included is in some cases unclear. For example, there is uncertainty about the allocation concealment in all three studies.

Potential biases in the review process

The mixture of study designs (unilateral versus bilateral treatment) posed a problem with data synthesis. In order to include data from all study types it was assumed that the response of any eye to one treatment was in no way related to or predictable from the response of the fellow eye. Paired eye studies, where one eye had been randomised to one intervention and the second eye had by default gone on to receive the other intervention, were therefore included. Similarly we included paired eye cluster studies where both eyes were randomised to the same intervention. We included the effect estimate for these paired studies in the meta-analysis using the generic inverse variance method. If we had analyzed the paired and unpaired data separately, there would have only been one trial with paired data, one trial with unpaired data and one trial with some paired and some unpaired data. Given that all trials did not report on all the outcomes and at all time points it would not otherwise have been possible to combine the studies into an analysis in a meaningful way.

The secondary outcome measures listed above were modified slightly from those initially set out in the protocol by the addition of new outcomes. Care must be taken in not placing too much weight on these additional secondary outcomes so as not to result in selective outcome reporting. Furthermore the review process is subject to the potential problem of multiplicity because of multiple outcomes in the review. The primary outcome for this study was the percentage of eyes with UCVA of 20/20 or better at 12 months post-treatment. The review revealed no significant difference in this outcome. This review shows that phakic IOLs are more accurate and safe than excimer laser. However the accuracy conclusion relates to only a single trial outcome (Schallhorn 2007). The safety outcomes are representative of lines of BSCVA lost. Adverse events were examined separately. One potential limitation of meta-analysis of RCTs is insufficient evidence to comment on serious rare adverse events. The reason for this which is certainly applicable in the trials analyzed in this review is the relatively short follow up and small numbers in each trial. It is important to acknowledge that accuracy and safety were secondary outcomes and some of the secondary outcomes were added post protocol submission.

Agreements and disagreements with other studies or reviews

The largest study that has been conducted comparing phakic IOL and LASIK (Sanders 2003) was excluded as the participants were not randomised to individual treatments. This study compared the results of 559 eyes that underwent LASIK and 210 eyes that underwent posterior chamber phakic IOL insertion (also known as the implantable contact lens, STAAR Surgical, Monrovia, CA). These series were concurrently operated on with 8.0 D to 10.0 D of preoperative myopia and were examined at one day, one week, one month, six months and one year postoperatively. Results from this study showed that every index of BSCVA, UCVA and predictability of refraction studied favoured the phakic IOL over LASIK. This study did not include subjective evaluation and quality of vision questionnaires. During the one year course of the study there was one phakic IOL-related secondary surgery; a lens repositioning at two weeks postoperatively. There were no reported clinically significant lens opacities. 4.3% of the phakic IOL group required an additional LASIK procedure. 23% of the LASIK treated eyes required an enhancement with further LASIK treatment. Diffuse lamellar keratitis occurred in 3% of eyes, and 2.1% of eyes required a flap lift to smooth out flap related striae. The results of this review also seem to favour phakic IOL over excimer laser surgical correction for moderate to high myopia (the range in this review was -6.0 to -20.0 D) particularly for the following parameters of accuracy and safety; refraction ± 0.50 D at six months and ± 1.00 D at six months, the percentage of eyes that lost 1 or more lines of BSCVA at 12 months post-treatment and the percentage of eyes that lost 2 or more lines of BSCVA at 12 months post-treatment. The subjective evaluation as well as quality of vision questionnaires in the individual studies favour phakic IOL over excimer laser surgical correction for moderate to high myopia.

AUTHORS' CONCLUSIONS

Implications for practice

The results of this review suggest that phakic IOLs are more accurate and safe than excimer laser surgical correction for moderate to high myopia in the range of -6.0 to -20.0 D. While this is accepted clinical practice for higher levels of myopia (greater than or equal to 7.0 D of myopic spherical equivalent with or without astigmatism), it may be worth considering phakic IOL treatment over excimer laser correction for more moderate levels of myopia (less than or equal to 7.0 D of myopic spherical equivalent with or without astigmatism). It is possible that the reason that phakic IOL surgery is not in more common use for moderate myopia may reflect the greater level of surgical complexity and skill required to perform it safely.

Patients undergoing posterior chamber phakic IOLs should be counselled about the risk of cataract and the potential need for further surgical intervention. Furthermore there may be more long term risks unique to patients with phakic IOLs, such as continued endothelial cell loss and cataract formation, that are not apparent in only one year of follow-up.

The poor quality of the presented evidence means that any interpretation must be cautious.

Implications for research

Further trials comparing phakic IOLs (ideally toric phakic IOLs)

and excimer laser surgical correction exclusively for moderate myopia may be warranted. The same primary and secondary outcome measures together with specified time points as those used in this review would be appropriate. It would also be helpful to have more long term outcome data to carefully monitor late adverse events. Furthermore any future trials should utilise a more standardized vision related quality of life scoring system so that subjective results can be included in a meta-analysis. In order to facilitate comparison between future trials in refractive surgery a standardized framework of outcome measures and follow-up intervals should be developed and used. Future trials should follow CONSORT guidelines to ensure that reporting of RCTs is complete. A separate search strategy specifically looking at reports of serious rare adverse effects may be more helpful than meta-analysis for providing this information.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

el Danasoury 2002

Methods	Single centre, single surgeon prospective randomised trial
Participants	Setting: Magrabi Eye and Ear Centre, Abu Dhabi, United Arab Emirates Numbers randomised: 90 eyes of 61 consecutive patients Age: range 21 to 47 years (mean, 33.7+/- 7.1 years) Gender: 37 (60.7%) were female Inclusion criteria: Age of at least 21 years, documented stable refraction for 1 year, spherical equivalent refraction between 9.0 and 19.5 D of myopia, refractive astigmatism less than 3.0 D, spectacle-corrected visual acuity of 20/40 or better, corneal thickness permitting the surgeon to leave at least 250 µm deep to the ablation, pupil size less than 6 mm in dim illumination for eyes with myopia of 15.50 D or less, and 5 mm for eyes with myopia greater than 15.50 D, and realistic expectations concerning the outcome Exclusion criteria: Previous refractive surgery, keratoconus or keratoconus suspected by videokeratography, active ocular disease, dry eyes, systemic disease likely to affect corneal wound healing (e.g. connective tissue disease) and inability to achieve the follow-up schedule given to the patients before surgery
Interventions	Emetropia was the refractive aim in all eyes Artisan phakic intraocular lens implantation: Lens power was calculated based on the refraction at the corneal plane according to a customised clinical nomogram based on the manufacturer's instructions and the authors previous experience with Artisan lens implantation LASIK: Nidek EC-5000 excimer laser with mean ablation zone diameter 5.6 +/- 0.3 mm (range, 5.0 to 6.0 mm); and transition zone 1 mm. A personal customised clinical nomogram was used for all LASIK procedures. A Carriazo-Barraquer microkeratome with a manually advanced turbine motor head was used to create a 160 µm flap for all LASIK procedures
Outcomes	All patients were examined, at 1 day, 1 week, and 1, 3, 6 and 12 months postoperatively. Slit lamp microscopy, manifest refraction, uncorrected and spectacle corrected visual acuity were performed at all visits from one month onwards. Contrast sensitivity, videokeratography, and specular microscopy were done at the 1, 6 and 12 month examinations One year after surgery, a patient satisfaction questionnaire was given to the 18 patients (29.5%) who had Artisan lens in one eye and LASIK in the other eye
Notes	LASIK enhancement procedures were performed in both groups 4 to 6 months after the primary procedure if there was a residual refractive error of more than 1.0 D at the 3 month examination. One Artisan eye (2.3%) and seven LASIK eyes (16.3%) had enhancement procedures

Risk of bias

Bias	Authors' judgement	Support for judgement

el Danasoury 2002 (*Continued*)

Random sequence generation (selection bias)	Low risk	A random number table was used to generate the sequence
Allocation concealment (selection bias)	Unclear risk	Not specified
Blinding (performance bias and detection bias) Participants	High risk	Not mentioned but presumably not done as both procedures are inherently different and participants would know which procedure they were undergoing
Blinding (performance bias and detection bias) Providers	High risk	Not mentioned but presumably not done as both procedures are inherently different and assessors would know which procedure had been performed
Incomplete outcome data (attrition bias) All outcomes	Low risk	Losses to follow-up were reported although no explanation was given as to why participants were lost to follow-up
Selective reporting (reporting bias)	Low risk	There was no evidence of selective outcome reporting
Other bias	Low risk	No other sources of bias were detected

Malecaze 2002

Methods	Two surgeon, two centre prospective, single masked randomised trial with paired eye control
Participants	Numbers randomised: 25 consecutive patients (50 eyes) Age: range 31 to 52 years (mean 38.4 +/- 7.6 years) Gender: 17 (68%) were female Inclusion criteria: Stable myopia for 2 years and unsatisfactory correction by glasses or contact lenses. They had bilateral myopia between -8.0 and -12.0 with an astigmatism < 1.5 D. The anterior chamber depth was ≥ 3.0 mm, the endothelial cell count was ≥ 2000 cells/mm^2, the corneal thickness was ≥ 530 µm and the mean keratometry was 42.0 to 45.0 D Exclusion criteria: Patients under the age of 30 years, corneal disease including keratoconus suspect with videokeratography, glaucoma, uveitis or a history of retinal detachment
Interventions	Emmetropia was the target refraction in all eyes LASIK procedure: Keracor Technolas 217 C (Bausch & Lomb Surgical, Claremont, CA) was used. The software used was version 2.67, subgroup 036, with an ablation zone diameter of 5 mm and a peripheral treatment zone from 6 to 8.5 mm. The Hansotome (Bausch & Lomb Surgical, Claremont, CA) microkeratome was used to create a 160 µm flap Artisan procedure: The Artisan phakic intraocular lens, a convex-concave, iris claw-

	fixated lens with a 6 mm optical zone diameter (Artisan lens; Ophtec B.V., Groningen, Netherlands) was used. Patient refractive error, anterior chamber depth and keratometric values (Van der Heijde formula) were used to calculate the dioptric power of the lens
Outcomes	The primary outcome measure was the postoperative spherical equivalent refraction at 1 year. The secondary outcome measure was safety measured by the percentage of eyes losing 2 or more Snellen lines of spectacle corrected visual acuity and the safety index Patients were examined postoperatively at 1 day, 1, 3 , 6 and 12 months after surgery. After day 1 postoperative all examinations included uncorrected and spectacle-corrected visual acuity, refraction, slit-lamp microscopy, applanation tonometry and corneal topography. At 3 months and 1 year postoperative an endothelial evaluation using a specular microscope was performed as well as contrast sensitivity. At 1 year postoperative a subjective evaluation and quality of vision score was calculated
Notes	The evaluators did not participate in the surgical process. Both evaluators worked independently from any objective testing, such as slit-lamp examination and corneal topography, which could have unmasked the surgical procedure. For this purpose independent evaluators performed objective tests

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	A random number table was used to generate the sequence
Allocation concealment (selection bias)	Unclear risk	Not specified
Blinding (performance bias and detection bias) Participants	High risk	Not mentioned but presumably not done as both procedures are inherently different and participants would know which procedure they were undergoing on each eye
Blinding (performance bias and detection bias) Providers	Low risk	The evaluators did not participate in the surgical process. Both evaluators worked independently from any objective testing, such as slit-lamp examination and corneal topography, which could have unmasked the surgical procedure
Incomplete outcome data (attrition bias) All outcomes	Low risk	Losses to follow-up were reported although no explanation was given as to why participants were lost to follow-up
Selective reporting (reporting bias)	Low risk	There was no evidence of selective outcome reporting
Other bias	Low risk	No other sources of bias were detected

Schallhorn 2007

Methods	Single centre, uncertain number of surgeons, prospective randomised trial
Participants	Number randomised: 88 eyes of 46 patients Age: PRK group 32.6 +/- 7 years, Toric Implantable Collamer Lens (TICL) group 30.8 +/- 6 years Gender: PRK group 37% female, TICL group 44% female Inclusion criteria: Phakic patients with moderate to high myopia (-6.0 to -20.0 D sphere) measured at the spectacle plane and astigmatism in the range of 1.0 to 4.0 D cylinder with a best spectacle-corrected visual acuity of 20/40 or better in the eye to be treated. Patients had to be between the ages of 21 and 45 years and have a stable refraction for the last 12 months as documented by previous clinical records Exclusion criteria: Patients with a history of previous intraocular surgery, diabetes, glaucoma, ocular hypertension, amblyopia and any other serious ophthalmic or non-ophthalmic conditions that may have precluded study completion
Interventions	PRK: This was performed using a conventional PRK technique partnered with the use of mitomycin C (MMC). The VISX Star S3 (VISX Inc, Santa Clara, Calif) excimer laser was used with specifications of a 6.5 mm optical zone (major axis) with an 8.0 mm treatment zone TICL: The Visian TICL (STAAR Surgical) was implanted in all 43 eyes in the series. The TICL is designed to be placed behind the iris and to vault anteriorly to the crystalline lens. All TICL patients received iridotomies using an Nd:YAG laser 2 weeks prior to surgery. The TICL was inserted through a horizontal temporal 3 mm corneal incision then injected into the eye and dialled into position
Outcomes	Visual measurements were collected to include uncorrected and best spectacle corrected vision and contrast sensitivity. Study follow up was 1 day, 1 week, and 1, 3, 6 and 12 months postoperatively. Additionally a psychometric subjective quality of vision and satisfaction after surgery questionnaire was given at the preoperative, 3 to 6 month and 12 month time points
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not specified
Allocation concealment (selection bias)	Unclear risk	Not specified
Blinding (performance bias and detection bias) Participants	High risk	Not mentioned but presumably not done as both procedures are inherently different and participants would know which procedure they were undergoing

Schallhorn 2007 (*Continued*)

Blinding (performance bias and detection bias) Providers	High risk	Not mentioned but presumably not done as both procedures are inherently different and assessors would know which procedure had been performed
Incomplete outcome data (attrition bias) All outcomes	Low risk	Losses to follow-up were reported although no explanation was given as to why participants were lost to follow-up
Selective reporting (reporting bias)	Unclear risk	There was no clear evidence of selective outcome reporting, however it should be noted that the one patient in the phakic IOL group who developed a cataract attended his one month postoperative visit and was then lost to follow up until 2 years after the surgery
Other bias	Low risk	No other sources of bias were detected

D: diopter
LASIK: laser assisted stromal in-situ keratomileusis
IOL: intraocular lens
PRK: photorefractive keratectomy

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Albarran-Diego 2012	Randomised controlled trial but several limitations including source of bias and out of date technology used
Kamiya 2008	The two groups were not randomised to treatment
Morara 1999	No randomisation to treatments
Sanders 2003	No randomisation to treatments
Soliman 1999	Minimum follow up less than one year

DATA AND ANALYSES

Comparison 1. Excimer laser versus phakic IOL

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Uncorrected visual acuity of 20/20 or better at 12 months post-treatment	2	166	Odds Ratio (Fixed, 95% CI)	1.33 [0.08, 22.55]
2 UCVA of 20/20 or better at 6 months post-treatment	2	157	Odds Ratio (Fixed, 95% CI)	0.99 [0.25, 3.91]
3 UCVA of 20/40 or better at 6 months post-treatment	2	125	Odds Ratio (Fixed, 95% CI)	0.71 [0.36, 1.39]
4 UCVA of 20/40 or better at 12 months post-treatment	2	134	Odds Ratio (Fixed, 95% CI)	0.66 [0.36, 1.22]
5 Percentage of eyes within ±0.50 D of target refraction at six months post-treatment	1		Odds Ratio (Fixed, 95% CI)	Subtotals only
6 Percentage of eyes within ±0.50 D of target refraction at 12 months post-treatment	3	216	Odds Ratio (Fixed, 95% CI)	0.72 [0.40, 1.29]
7 Percentage of eyes within ±1.00 D of target refraction at six months post-treatment	1		Odds Ratio (Fixed, 95% CI)	Subtotals only
8 Percentage of eyes within ±1.00 D of target refraction at 12 months post-treatment	3	216	Odds Ratio (Fixed, 95% CI)	1.01 [0.42, 2.45]
9 Percentage of eyes that lost 2 or more lines of BSCVA at 12 months post-treatment	3	216	Odds Ratio (Fixed, 95% CI)	0.35 [0.19, 0.66]
10 Percentage of eyes that lost 1 or more lines of BSCVA at 6 months post-treatment	1		Odds Ratio (Fixed, 95% CI)	Subtotals only
11 Percentage of eyes that lost 1 or more lines of BSCVA at 12 months post-treatment	3	216	Odds Ratio (Fixed, 95% CI)	0.41 [0.33, 0.51]

Analysis 1.1. Comparison 1 Excimer laser versus phakic IOL, Outcome 1 Uncorrected visual acuity of 20/20 or better at 12 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 1 Uncorrected visual acuity of 20/20 or better at 12 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	41	0.281 (1.449)		99.3 %	1.32 [0.08, 22.67]
Schallhorn 2007	38	44	0.915 (17.38)		0.7 %	2.50 [0.00, 1.55E15]
Total (95% CI)	**81**	**85**			**100.0 %**	**1.33 [0.08, 22.55]**

Heterogeneity: Chi² = 0.00, df = 1 (P = 0.97); I² =0.0%

Test for overall effect: Z = 0.20 (P = 0.84)

Test for subgroup differences: Not applicable

Analysis 1.2. Comparison 1 Excimer laser versus phakic IOL, Outcome 2 UCVA of 20/20 or better at 6 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

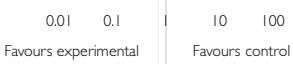
Outcome: 2 UCVA of 20/20 or better at 6 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	42	-0.0132 (0.702)		99.8 %	0.99 [0.25, 3.91]
Schallhorn 2007	33	39	0.845 (15.15)		0.2 %	2.33 [0.00, 1.83E13]
Total (95% CI)	**76**	**81**			**100.0 %**	**0.99 [0.25, 3.91]**

Heterogeneity: Chi² = 0.00, df = 1 (P = 0.95); I² =0.0%

Test for overall effect: Z = 0.02 (P = 0.99)

Test for subgroup differences: Not applicable



Analysis 1.3. Comparison 1 Excimer laser versus phakic IOL, Outcome 3 UCVA of 20/40 or better at 6 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 3 UCVA of 20/40 or better at 6 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	42	0.146 (0.949)		13.2 %	1.16 [0.18, 7.43]
Malecaze 2002	20	20	-0.42 (0.37)		86.8 %	0.66 [0.32, 1.36]
Total (95% CI)	**63**	**62**			**100.0 %**	**0.71 [0.36, 1.39]**

Heterogeneity: Chi² = 0.31, df = 1 (P = 0.58); I² =0.0%

Test for overall effect: Z = 1.00 (P = 0.32)

Test for subgroup differences: Not applicable

Analysis 1.4. Comparison 1 Excimer laser versus phakic IOL, Outcome 4 UCVA of 20/40 or better at 12 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 4 UCVA of 20/40 or better at 12 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	41	0.731 (3.76)		0.7 %	2.08 [0.00, 3296.00]
Malecaze 2002	25	25	-0.42 (0.311)		99.3 %	0.66 [0.36, 1.21]
Total (95% CI)	**68**	**66**			**100.0 %**	**0.66 [0.36, 1.22]**

Heterogeneity: Chi² = 0.09, df = 1 (P = 0.76); I² =0.0%

Test for overall effect: Z = 1.33 (P = 0.18)

Test for subgroup differences: Not applicable

Analysis 1.5. Comparison 1 Excimer laser versus phakic IOL, Outcome 5 Percentage of eyes within ±0.50 D of target refraction at six months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 5 Percentage of eyes within 0.50 D of target refraction at six months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
Schallhorn 2007	33	39	0.5198 (1.929)			1.68 [0.04, 73.74]
Subtotal (95% CI)	**0**	**0**				**0.0 [0.0, 0.0]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P < 0.00001)

Analysis 1.6. Comparison 1 Excimer laser versus phakic IOL, Outcome 6 Percentage of eyes within ±0.50 D of target refraction at 12 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

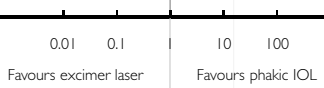
Outcome: 6 Percentage of eyes within 0.50 D of target refraction at 12 months post-treatment

Study or subgroup	Phakic IOL N	Excimer N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	41	0.241 (0.918)		10.4 %	1.27 [0.21, 7.69]
Malecaze 2002	25	25	-0.398 (0.314)		89.3 %	0.67 [0.36, 1.24]
Schallhorn 2007	38	44	0.389 (5.43)		0.3 %	1.48 [0.00, 61796.65]
Total (95% CI)	**106**	**110**			**100.0 %**	**0.72 [0.40, 1.29]**

Heterogeneity: Chi^2 = 0.45, df = 2 (P = 0.80); I^2 =0.0%

Test for overall effect: Z = 1.11 (P = 0.27)

Test for subgroup differences: Not applicable



Analysis 1.7. Comparison 1 Excimer laser versus phakic IOL, Outcome 7 Percentage of eyes within ±1.00 D of target refraction at six months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 7 Percentage of eyes within 1.00 D of target refraction at six months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
Schallhorn 2007	33	39	1.533 (152.81)			4.63 [0.00, 5.47E130]
Subtotal (95% CI)	**0**	**0**				**0.0 [0.0, 0.0]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P < 0.00001)

Analysis 1.8. Comparison 1 Excimer laser versus phakic IOL, Outcome 8 Percentage of eyes within ±1.00 D of target refraction at 12 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

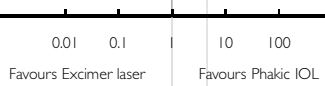
Outcome: 8 Percentage of eyes within 1.00 D of target refraction at 12 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	41	0.121 (0.676)		44.6 %	1.13 [0.30, 4.25]
Malecaze 2002	25	25	-0.076 (0.607)		55.4 %	0.93 [0.28, 3.05]
Schallhorn 2007	38	44	1.314 (93.36)		0.0 %	3.72 [0.00, 1.09E80]
Total (95% CI)	**106**	**110**			**100.0 %**	**1.01 [0.42, 2.45]**

Heterogeneity: Chi^2 = 0.05, df = 2 (P = 0.98); I^2 =0.0%

Test for overall effect: Z = 0.03 (P = 0.98)

Test for subgroup differences: Not applicable



Analysis 1.9. Comparison 1 Excimer laser versus phakic IOL, Outcome 9 Percentage of eyes that lost 2 or more lines of BSCVA at 12 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 9 Percentage of eyes that lost 2 or more lines of BSCVA at 12 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	41	-1.0969 (0.365)		76.4 %	0.33 [0.16, 0.68]
Malecaze 2002	25	25	-0.886 (0.656)		23.6 %	0.41 [0.11, 1.49]
Schallhorn 2007	38	44	0 (0)			Not estimable
Total (95% CI)	**106**	**110**			**100.0 %**	**0.35 [0.19, 0.66]**

Heterogeneity: Chi^2 = 0.08, df = 1 (P = 0.78); I^2 =0.0%

Test for overall effect: Z = 3.28 (P = 0.0010)

Test for subgroup differences: Not applicable

Analysis 1.10. Comparison 1 Excimer laser versus phakic IOL, Outcome 10 Percentage of eyes that lost 1 or more lines of BSCVA at 6 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 10 Percentage of eyes that lost 1 or more lines of BSCVA at 6 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
Schallhorn 2007	38	39	-1 (0.5)			0.37 [0.14, 0.98]
Subtotal (95% CI)	**0**	**0**				**0.0 [0.0, 0.0]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P < 0.00001)

Test for subgroup differences: Not applicable

Analysis 1.11. Comparison 1 Excimer laser versus phakic IOL, Outcome 11 Percentage of eyes that lost 1 or more lines of BSCVA at 12 months post-treatment.

Review: Excimer laser refractive surgery versus phakic intraocular lenses for the correction of moderate to high myopia

Comparison: 1 Excimer laser versus phakic IOL

Outcome: 11 Percentage of eyes that lost 1 or more lines of BSCVA at 12 months post-treatment

Study or subgroup	Phakic IOL N	Excimer laser N	log [Odds Ratio] (SE)	Odds Ratio IV,Fixed,95% CI	Weight	Odds Ratio IV,Fixed,95% CI
el Danasoury 2002	43	41	-0.959 (0.122)		84.4 %	0.38 [0.30, 0.49]
Malecaze 2002	25	25	-0.538 (0.304)		13.6 %	0.58 [0.32, 1.06]
Schallhorn 2007	38	44	-0.824 (0.783)		2.0 %	0.44 [0.09, 2.04]
Total (95% CI)	**106**	**110**			**100.0 %**	**0.41 [0.33, 0.51]**

Heterogeneity: Chi^2 = 1.66, df = 2 (P = 0.44); I^2 =0.0%

Test for overall effect: Z = 8.02 (P < 0.00001)

Test for subgroup differences: Not applicable

ADDITIONAL TABLES

Table 1. Flap/interface/decentered ablation related complications in excimer laser treated eyes

Study	Complication rate	Flap/interface complication	Management	Outcome
el Danasoury 2002	1 interface complication in 45 LASIK treatments. No other flap/decentered ablation complications	Diffuse lamellar keratitis 3 days after uneventful LASIK	Topical steroid therapy	Inflammation completely resolved within one week
Malecaze 2002	0 flap/interface/decentered ablation complications in 25 LASIK treatments	N/A	N/A	N/A
Schallhorn 2007	Flap/interface complications N/A as all treatments PRK. No decentered ablations or haze reported in 45 laser treatments	N/A	N/A	N/A

LASIK: laser assisted stromal in-situ keratomileusis

PRK: photorefractive keratectomy

Table 2. Endothelial cell loss

Study	Follow-up	Findings
el Danasoury 2002	One year	The mean endothelial cell loss 0.7% ± 1.1% (range -3.1% to 1.7 %) at 1 year in the Artisan group and mean 0.3% ± 0.9% (range -1.9% to 1.8%) at 1 year in the LASIK group. There was no statistically significant difference between endothelial cell loss in the 2 groups
Malecaze 2002	One year	The differences between mean endothelial cell loss in LASIK treated eyes and Artisan-treated eyes was not statistically different at either 3 months (P = 0.73) or 1 year (P = 0.60) postoperatively
Schallhorn 2007	Endothelial cell loss was not reported.	N/A

LASIK: laser assisted stromal in-situ keratomileusis

Table 3. Need for IOL exchange in the phakic IOL group

Study	IOL exchange rate	Indication for IOL exchange	Management	Outcome
el Danasoury 2002	1 eye (2.2%)	Severe night glare in a patient with a preoperative pupil at dim illumination of 5mm who received a 5 mm Artisan lens	Lens was removed and exchanged for a 6 mm Artisan lens	Night glare completely resolved. UCVA was 20/40 correcting to 20/20
Malecaze 2002	0 cases reported of IOL exchange	N/A	N/A	N/A
Schallhorn 2007	1 eye (2.3%)	Anterior subcapsular cataract resulting in BCVA $20/50^{-1}$	Phakic IOL and cataract were removed and replaced with pseudophakic IOL	BSCVA of 20/20

BCVA: best corrected visual acuity
BSCVA: best spectacle corrected visual acuity
IOL: intraocular lens
UCVA: uncorrected visual acuity

Table 4. Changes in contrast sensitivity

Study	Method	Findings
el Danasoury 2002	Measured using the Vision Contrast Test System (VCTS-6000, Vistech consultants, Inc. Dayton, OH) performed under normal room lighting	One year after surgery the contrast sensitivity curve of each eye was compared to its baseline curve. Two Artisan eyes (4.7%) and six LASIK eyes (14.6%) lost 2 or more lines, three Artisan eyes (7.0%) and nine LASIK eyes (22.0%) lost 1 line, four Artisan eyes (9.3%) and no LASIK eyes gained 2 or more lines, and seven Artisan eyes (16.3%) and five LASIK eyes (12.2%) gained 1 line. The contrast sensitivity did not change in 27 Artisan eyes (62.8%) and 21 LASIK eyes (51.2%). There was no comment on whether this difference was statistically significant or not
Malecaze 2002	Not described	Pre-operative contrast sensitivity measurements to one year postoperative measurements were slightly reduced in the LASIK group and slightly improved in the phakic IOL group. However this difference was not statistically significant at all 4 spatial frequencies (P = 0.66, 0.70, 0.06 and 0.29 for 3, 6, 12 and 18 cycles per degree cyc/deg respectively)
Schallhorn 2007	Photopic contrast sensitivity was conducted with a back-illuminated chart (5% ETDRS Chart, 9x14, Model 2186; Precision Vision, LaSalle, ILL) with room lights off. Mesopic testing was conducted with a 25% ETDRS chart (Precision Vision) behind two neutral density filters and room lights off	5% photopic level: The mean BSCVA (logMAR) was significantly better in the phakic IOL group than the PRK laser group at all time points postoperatively (P = 0.002 at one week and P = <0.001 at all other time points). Loss of 2 or more lines of BSCVA was significantly higher in the PRK group at all time points except six months. Improvement in BSCVA by 2 or more lines and 1 or more lines was significantly better in the phakic IOL group from 1 to 12 months postoperatively 25% mesopic level: The mean BSCVA (logMAR) was significantly better in the phakic IOL group than the PRK laser group at all time points postoperatively (P = 0.048 at one week and P = <0.001 at all other time points). Improvement in BSCVA (2 or more lines) was significantly better in the phakic IOL group at all time points from 1 to 12 months. Losses of 1 or more lines of BSCVA was significantly higher in the PRK group at all time points after one week. Improvement of one or more lines of BSCVA was better in the phakic IOL series at 1, 3 and 12 months

BSCVA: best spectacle corrected visual acuity
ETDRS: Early treatment diabetic retinopathy study
IOL: intraocular lens
LASIK: laser assisted stromal in-situ keratomileusis
PRK: photorefractive keratectomy

Table 5. Subjective evaluation and quality of vision

Study	Methods	FIndings
el Danasoury 2002	Patient satisfaction and preference questionnaire at 12 months postoperatively. This was only given to the 18 patients that had Artisan in one eye and LASIK in the other eye	There was no significant difference in the satisfaction levels between the two groups. 11 patients (61.1%) experienced more night glare or halos with their LASIK eye, 3 patients (16.7%) had more night glare with their Artisan eye, 1 patient (5.6%) reported equal glare in both eyes and 3 patients (16.7%) said that they had no glare with either eye (P = 0.001) Patient preference for Artisan was significantly higher (P = 0.0001) mainly because of better reported quality of vision
Malecaze 2002	Patient satisfaction questionnaire at 12 months postoperatively	There was a slightly significantly increased frequency of halos following LASIK (P = 0.05) and non-significantly increased frequency of halos following Artisan (P = 0.19). Both groups showed a significantly increased frequency of glare (P = 0.02 for LASIK and P = 0.01 for Artisan) but there was no statistically significant difference between the two groups (P = 0.30 for halos and P = 0.20 for glare). The satisfaction levels were not statistically different (P = 0.40) between the two groups. Concerning preference for one of the two techniques: 16% of patients preferred LASIK, 44% preferred Artisan and 40% had no preference
Schallhorn 2007	Psychometric questionnaire was given preoperatively and 3, 6 and 12 months postoperatively. The questionnaire assessed subjective quality of vision (glare, halos, night vision, need for artificial tears) and satisfaction after the surgery	The PRK group showed significantly more need for artificial tears (P = 0.002) and more visual fluctuation (0.001) at the 3 and 6 month postoperative time periods. The PRK group had more glare symptoms at night (P = 0.033) and more trouble with oncoming car headlights at night (P = 0.014). All other questions at 3 and 6 months showed no difference between the two groups. The 12-month questionnaire showed similar subjective visual results between the two groups with the exception of greater use of artificial tears in the PRK group (P = 0.008) and greater glare when watching television or computer monitors (P = 0.043)

LASIK: laser assisted stromal in-situ keratomileusis
PRK: photorefractive keratectomy

APPENDICES

Appendix 1. CENTRAL search strategy

#1 MeSH descriptor Myopia
#2 myop*
#3 sight* AND (short or near*)
#4 (#1 OR #2 OR #3)
#5 MeSH descriptor Corneal Surgery, Laser
#6 keratectom*
#7 keratomileusis
#8 LAS?K
#9 PRK
#10 laser* near/3 refractive near/3 surg*
#11 laser* near/3 epithel* near/3 surg*
#12 excimer near/3 laser*
#13 (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12)
#14 MeSH descriptor Lenses, Intraocular
#15 MeSH descriptor Lens Implantation, Intraocular
#16 lens* or IOL*
#17 (#14 OR #15 OR #16)
#18 (#4 AND #13 AND #17)

Appendix 2. MEDLINE (OvidSP) search strategy

1. randomized controlled trial.pt.
2. (randomized or randomised).ab,ti.
3. placebo.ab,ti.
4. dt.fs.
5. randomly.ab,ti.
6. trial.ab,ti.
7. groups.ab,ti.
8. or/1-7
9. exp animals/
10. exp humans/
11. 9 not (9 and 10)
12. 8 not 11
13. exp myopia/
14. myop$.tw.
15. ((short or near) adj3 sight$).tw.
16. or/13-15
17. exp corneal surgery, laser/
18. keratectom$.tw.
19. keratomileusis.tw.
20. LAS?K.tw.
21. PRK.tw.
22. (laser$ adj3 refractive adj3 surg$).tw.
23. (laser$ adj3 epithel$ adj3 surg$).tw.
24. (excimer adj3 laser$).tw.
25. or/17-24
26. exp lenses intraocular/
27. lens implantation intraocular/
28. (lens$ or IOL$).tw.

29. or/26-28
30. 16 and 25 and 29
31. 12 and 30

The search filter for trials at the beginning of the MEDLINE strategy is from the published paper by Glanville et al (Glanville 2006).

Appendix 3. EMBASE (OvidSP) search strategy

1. exp randomized controlled trial/
2. exp randomization/
3. exp double blind procedure/
4. exp single blind procedure/
5. random$.tw.
6. or/1-5
7. (animal or animal experiment).sh.
8. human.sh.
9. 7 and 8
10. 7 not 9
11. 6 not 10
12. exp clinical trial/
13. (clin$ adj3 trial$).tw.
14. ((singl$ or doubl$ or trebl$ or tripl$) adj3 (blind$ or mask$)).tw.
15. exp placebo/
16. placebo$.tw.
17. random$.tw.
18. exp experimental design/
19. exp crossover procedure/
20. exp control group/
21. exp latin square design/
22. or/12-21
23. 22 not 10
24. 23 not 11
25. exp comparative study/
26. exp evaluation/
27. exp prospective study/
28. (control$ or prospectiv$ or volunteer$).tw.
29. or/25-28
30. 29 not 10
31. 30 not (11 or 23)
32. 11 or 24 or 31
33. exp myopia/
34. exp high myopia/
35. myop$.tw.
36. ((short or near) adj3 sight$).tw.
37. or/33-36
38. exp keratectomy/
39. exp photorefractive keratectomy/
40. exp keratomileusis/
41. exp laser epithelial keratomileusis/
42. keratectom$.tw.
43. keratomileusis.tw.
44. LAS?K.tw.
45. PRK.tw.

46. (laser$ adj3 refractive adj3 surg$).tw.
47. (laser$ adj3 epithel$ adj3 surg$).tw.
48. (excimer adj3 laser$).tw.
49. or/38-48
50. exp lens implant/
51. exp lens implantation/
52. (lens$ or IOL$).tw.
53. or/50-52
54. 37 and 49 and 53
55. 32 and 54

Appendix 4. LILACS search strategy

myop$ or short sight$ or near sight$ and kerat$ or laser$ or LASIK or LASEK or PRK or photorefract$ and lens$ or IOL$

Appendix 5. *meta*Register of Controlled Trials search strategy

myopia and IOL and refractive surgery

Appendix 6. ClinicalTrials.gov search strategy

Myopia AND IOL AND Refractive Surgery

Appendix 7. ICTRP search strategy

Myopia AND LASIK OR LASEK OR PRK AND Phakic OR Lens OR IOL

WHAT'S NEW

Last assessed as up-to-date: 11 February 2014.

Date	Event	Description
17 June 2014	New citation required but conclusions have not changed	Issue 6, 2014: One RCT excluded, plain language summary updated
17 June 2014	New search has been performed	Issue 6, 2014: Searches updated

HISTORY

Protocol first published: Issue 2, 2009

Review first published: Issue 5, 2010

Date	Event	Description
29 November 2011	New citation required but conclusions have not changed	Issue 1 2012: Electronic searches were updated but no new studies were identified for inclusion in this update
29 November 2011	New search has been performed	Issue 1 2012: Risk of bias assessment has been changed to reflect updated Cochrane methodology

CONTRIBUTIONS OF AUTHORS

AB conceived the review question and co-ordinated the review, designed other search strategies, undertook manual searches, organised retrieval of full-text copies, provided additional data about papers and entered data in to RevMan.

BA provided general advice on review.

AB and BA screened search results, screened retrieved papers against inclusion criteria, appraised quality of papers, extracted data from papers, wrote to authors for additional information, obtained and screened data on unpublished studies, performed analysis of data, provided methodological, clinical, policy and consumer perspective, wrote drafts of the review and responded to peer review comments and comments from the editorial base.

Update of review Issue 1, 2011 and Issue 6, 2014

AB and Cochrane Eyes and Vision Group (CEVG) Trials Search Co-ordinator (TSC) screened search results.

AB, CEVG Managing Editor and TSC updated the review (minor edits).

DECLARATIONS OF INTEREST

None

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We have added the percentage of eyes within ±1.00 D of target refraction at six and at 12 months post-treatment as this provides further important information on the accuracy of the procedure. We have also added the percentage of eyes that lost 1 or more lines of BSCVA at six and at 12 months post-treatment in order to provide more information on potential safety measures for the two procedures. The 12 month time point for both of these additions is reported by all three RCTs and therefore allows us to adequately address the diversity of outcomes reported in the individual trials.

INDEX TERMS

Medical Subject Headings (MeSH)

*Phakic Intraocular Lenses [adverse effects]; Astigmatism [surgery]; Cataract [etiology]; Lasers, Excimer [adverse effects; *therapeutic use]; Myopia [*surgery]; Randomized Controlled Trials as Topic; Visual Acuity

MeSH check words

Humans