Epikeratophakia: Current Clinical Practice

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EPIKERATOPHAKIA was devised by Werblin in 1979 and subsequently developed by Kaufman and his coworkers at Louisiana State University, New Orleans.[1] The procedure was used initially for the refractive correction of paediatric and adult aphakia, and later applied to the correction of myopia and phakic hypermetropia. In addition, epikeratoplasty grafts using tissue lathed without refractive power have been used for the treatment of keratoconus and for tectonic patch grafting.

Unlike Barraquer's keratorefractive procedures of keratophakia and keratomileusis, the technique of epikeratophakia is very easy. No microkeratome lamellar keratectomy is necessary. The patient's corneal epithelium is simply stripped off and a superficial annular groove formed with trephine and scissors. A prelathed lenticule is placed on top of the patient's cornea, tucked into the groove, and stabilised with interrupted sutures.

The availability of commercially lathed lenticules for epikeratophakia has brought this procedure within the reach of any ophthalmologist. When the donor corneal tissue has been cut to the required shape on the cryolathe, it can be lyophilised (freeze dried) and placed in a vacuum-sealed vial. In this state, it will remain in a stable condition at room temperature for a prolonged period of time. This enables cryolathing to be performed at a specialist centre and the lathed lenticules can later be dispatched by post to surgeons anywhere in the world. During the past few years, a multicentre evaluation of epikeratophakia using commercially prepared lenticules has been conducted by Allergan Medical Optics (AMO; Irvine, CA).

INDICATIONS

Keratoconus

Patients with keratoconus and contact lens intolerance are generally treated by penetrating keratoplasty. The decision for surgical intervention is usually fairly easily reached in the absence of alternative therapeutic modalities. Epikeratoplasty using a plano-powered on-lay graft can be used instead of penetrating keratoplasty in many cases.

Lyophilised tissue is devoid of living cells and, when grafted, becomes populated by the patient's own keratocytes and covered by the patient's own epithelium. Therefore, it does not carry the same risk of rejection and subsequent graft failure that is associated with penetrating keratoplasty. Recurrence of keratoconus in the grafted tissue has not been reported, but remains a possibility in the absence of long-term follow-up with this technique. The procedure has the advantage over penetrating keratoplasty in that it is entirely extraocular and so avoids the problems of wound leakage with flat anterior chamber and damage to the iris or lens. This makes it particularly suitable in poor-risk cases such as Down's syndrome with keratoconus. If the keratoconus has advanced to the stage of causing axial scarring, epikeratophakia is less suitable because visual recovery will be limited. Preoperative visual acuity should be 6/12 or better with a pinhole if good visual rehabilitation is required.

Paediatric Aphakia

Many surgeons are reluctant to perform intraocular lens implantation in children, and contact lens compliance is frequently a problem. In this situation, epikeratophakia is an excellent alternative and the vitality of the infantile tissues ensures rapid recovery after the surgery (Fig 1).

Because of the rapid growth of the infant's eye during the first few years of life, there tends to be a shift toward myopia following surgery.[2] For this reason, congenital cataracts are probably best treated by extraction and contact lens wear, with epikeratophakia as a secondary procedure if contact lens noncompliance develops. Children with aphakia following perforating eye injury often have associated astigmatism from corneal laceration. The application of an epikeratophakia lenticule can mask this underlying astigma-

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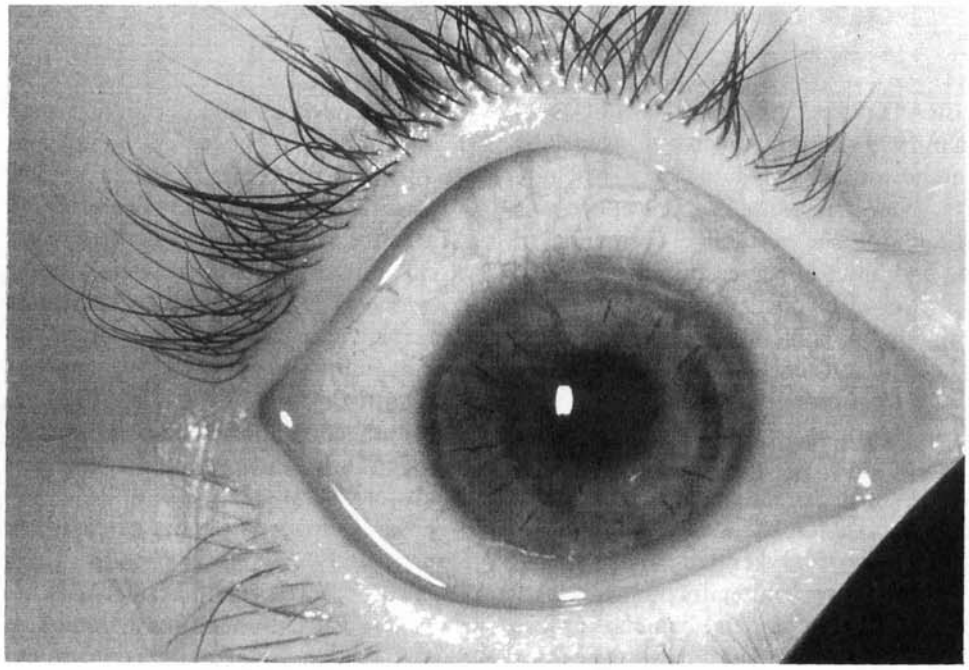

Fig 1. Paediatric aphakic epikeratophakia at 2 weeks postoperatively just before suture removal.

tism as well as correct the ametropia. The visual outcome of paediatric epikeratophakia is dependent on compliance with intensive occlusion therapy for the associated amblyopia. Ability to comply with patching is a prerequisite to make surgical intervention worthwhile.

Adult Aphakia

Epikeratophakia is unlikely to supercede intraocular lens implantation because the surgical procedure is more lengthy, the accuracy of correction less predictable, and the visual recovery time more prolonged. However, there are a number of situations in which it would seem to be the preferable mode of surgical correction of adult aphakia.

As an extraocular procedure, epikeratophakia has been shown to have no significant effect on corneal endothelial cell count.[3] This makes it a good alternative to secondary intraocular lens implantation, especially when the endothelial cell count is low. Other factors, such as vitreous in the anterior chamber, disorganised anterior segment anatomy, and previous cystoid macular oedema, militate against lens implantation. A history of previous uveitis is a good indication for epikeratophakia, but active uveitis should be controlled before undertaking surgery because topical steroids are contraindicated in the early postoperative phase.

Myopia

Surgical correction of myopia is a contentious issue as the myope's nontolerance of glasses and contact lenses is generally more relative than absolute. Surgical correction of low myopia (up to -5 dioptres) is most easily and predictably achieved with radial keratotomy.[4] Between -5 and -10 dioptres of myopia, the risks, complications, and side effects of radial keratotomy increase, making it progressively less efficacious.

Up to -37 dioptres of myopia has been corrected using epikeratophakia, but the reported results show significant degrees of under- and over-correction.[5] This is particularly relevant because the main aim in myopic refractive surgery is to obtain good uncorrected visual acuity. A small degree of inaccuracy in the correction of a high myopic error can still leave the patient with a poor uncorrected visual acuity, and patients may not necessarily consider themselves better off wearing a small rather than a large correction.

Tectonic Epikeratoplasty

Prelathed plano powered lamellar tissue of standard thickness (0.3 mm) may be used for patch grafting following excision of pterygia, limbal dermoids, etc. This can be more convenient than using fresh donor tissue, but is unlikely to be widely used in the United Kingdom, with the current cost of commercially prepared tissue from AMO being approximately $1,000.

CONTRAINDICATIONS

Since failure of an epikeratophakia graft is usually related to poor epithelialisation, with subsequent melting, opacification, or infection, the main contraindications are conditions that give a poor-graft environment. These constitute dry-eye syndrome, chronic blepharitis, and lagophthalmos. These are particularly important in the elderly, in whom slowing wound healing can make these factors more apparent.

PREOPERATIVE MEASUREMENTS

The surgeon will need to have assessed the keratometry and refractive error to be in a position to advise surgery. It may be preferable for the surgeon personally to make these measurements and have them checked independently by another person on a separate occasion. This is helpful to clarify the source of error if the refractive surgical correction later proves to be inaccurate. An endothelial cell count in aphakes may help in deciding whether a secondary intraocular lens or epikeratophakia is indicated. Photokeratoscopy may be advantageous in the assessment of keratoconus, although slit-lamp assessment of corneal thickness is the most relevant factor in planning surgical strategy. Other investigations must be performed as necessary (eg, fluorescein angiography), particularly if a subnormal best-corrected visual acuity needs elucidation.

ORDERING THE LENTICULE

If the epikeratophakia lenticule is to be ordered from a commercial supplier, the refractive error and keratometry must be quoted. The astigmatic component of the prescription is halved and added to the spherical component, and this is then converted to power at the corneal plane. The keratometry readings are similarly averaged and the two figures quoted to the nearest half dioptre. It is usual to aim for emmetropia, but a degree of over-correction may be desirable in aphakes, as they may then have good, unaided near vision. For myopes, slight under-correction is preferable to rendering them hypermetropic.

THE SURGICAL PROCEDURE

The operative procedure of epikeratophakia is readily mastered, but careful attention to detail is essential. Lamellar refractive surgeons become particularly aware of particulate matter that becomes caught in the graft-host interface, because they are then perpetually confronted with it during the follow-up period. Whilst it is not always practical to adopt complete clean room techniques, the use of paper gowns and drapes can go a long way towards reducing the level of particulate contamination of the operating field. Additional measures such as the use of lint-free instrument wipes (Mentor; O. and O. Inc, Hingham, MA) and 0.2-μm filter for the irrigation fluid are also advocated.

Surgical Technique

Alcohol was initially recommended as an adjunct for stripping the patient's epithelium, but due to its toxicity, 4% cocaine is now preferred. However, a dulled curved surgical blade is probably all that is required for this purpose. Loose epithelial cells must be scrupulously removed with combined irrigation of the cornea and aspiration from the conjuctival fornices.

Whilst a normal guarded trephine can be used to make the partial thickness trephination, a hollow barrelled trephine aids accurate centration of the graft. The double-bladed Barron trephine (AMO) has been designed specifically for epikeratophakia and makes the trephination manoeuvre particularly simple. The blade is advanced on a screw thread that has an end stop to ensure the cut is made to a standard depth (0.3 mm). Whilst more expensive than the alternative single-bladed Hessburg-Barron vacuum trephine (Jedmed; St Louis), this latter instrument has no end stop. Although partial thickness trephination can be achieved by rotating the screw-threaded

barrel a fixed number of turns, the accuracy of this method is impaired by the difficulty of determining the zero point where the blade first starts to cut. The purpose of the trephine cut is to take the edge of the lenticule beneath Bowman's layer to allow migration of host keratocytes into the graft. Some current lenticule designs call for a wedge resection of the host's superficial stroma on the inner aspect of the trephine cut, and this is considerably easier with the double-bladed trephine. Once the groove is cut, a peripheral lamellar split is made. The Suarez spreader (Storz; St Louis) is ideal for this, but an angled Beaver blade No 6600 (Beaver Inc; Waltham, MA) will suffice. Placement of the initial sutures in the graft is facilitated by double-ended Lieberman tissue-holding forceps (Jedmed), a technique that is also to be favoured in penetrating keratoplasty. Familiarity with a monofilament suture that allows easy knot burial is important; eg, 10/0 Dermalon (Davis & Geck; Wayne, NJ). Suture tightness adjustment can usually be satisfactorily achieved through visual inspection of the graft contour for stress lines, but operative keratometry can be useful in keratoconus or when there is significant preexisting astigmatism. The overall degree of suture tightness is also important because general overtightness will result in spherical under correction.

POSTOPERATIVE PHASE

Bandage Contact Lenses

It is important that the graft is kept protected until reepithelialisation is complete. This may be achieved by padding or tarsorrhaphy, but bandage contact lens wear is preferable. It is advisable to have a range of size and shape of contact lenses available, because the fit can change rapidly as the graft re-epithelialises and deturgesces. A lens fitting satisfactorily at the end of surgery can soon become excessively mobile. Alternatively, the lens may become "sucked on" and immobile. Either situation will require the lens to be changed. Due to the abnormal contour of the grafted eye, the bandage lenses necessary have to be specially made. A useful range includes back curves of 6.5 mm to 9.5 mm, with diameters from 9 mm to 11 mm, and some bicurve lenses in Ledasoft 80% (D. Thomas Contact Lenses, Northampton, England).

Epithelialisation

If a small limbal rim of epithelium has been left on the host cornea before the graft application, reepithelialisation will usually be complete by the fourth postoperative day. Failure of graft epithelialisation is a complication that may necessitate graft removal. The bandage lens may be left in place for a further day or two following closure of the epithelial defect to allow the epithelium to stabilise. Once the contact lens is removed, any very loose sutures will immediately be liable to cause problems. The loose sutures collect mucus, which can lead to secondary epithelial breakdown in the surrounding area and go on to produce local stromal melting. This can happen at any stage before the planned date of suture removal, and so necessitates close follow-up of patients during the first month or two. The patient's ability to comply with this must obviously be borne in mind before the surgery is performed. Suture removal can be performed on the slit lamp, but the best quality suture-tying forceps must be available if this is to be done atraumatically and without the risk of wound dehiscence.

Astigmatism

The epikeratophakia lenticule has a tendency to correct host corneal astigmatism of two or three dioptres. Greater degrees of preexisting or induced astigmatism may be modified by selective suture removal during the early postoperative phase. Postoperative photokeratoscopy can be useful in defining which sutures to remove. In practice, however, the corrective effect possible in this way is often limited. Further modification of astigmatism must be left until complete healing and stabilisation of the lenticule has occurred. The problem can then be tackled by controlled sectorial wound dehiscence, additional sutures with wedge resection, etc. The use of toric lenticules to correct astigmatism is under evaluation.

Epitheliopathy

Although graft cover may be established fairly quickly, it can take some weeks for the epithelium to stabilise. A number of factors are involved: patient age, tear film quality, graft anaesthesia and steepness, graft-host junction

irregularity, suture tension, anterior segment inflammation, and topical therapy. When all the sutures are removed and the corneal contour becomes more regular, the epithelial quality and visual acuity improve. Graft hypoaesthesia is relatively persistent with significantly diminished sensitivity even after 1 year,[6] and this may be reflected by some trophic disturbances in the epithelium or even frank epithelial breakdown. This necessitates urgent treatment with patching or bandage lens wear to prevent irregularity or scarring on the graft optic zone.

Interface Opacity

Careful inspection of the dry cornea at the time of surgery is necessary to avoid leaving islands of epithelial cells beneath the graft. The epithelial stripping must be continued some distance beyond the trephine cut because the lenticule is 1.5 mm greater in diameter, and if it rests on intact epithelium the lenticule may dislodge cells into the interface zone. Cells may also be pulled down the suture track at the time of suture removal and proliferate in the natural cleavage zone of the interface. If present, epithelial islands generally do not enlarge significantly and may undergo spontaneous involution.[7] If an island does increase significantly, or comes to lie on the visual axis, it may be removed surgically by lifting the graft edge and scraping it out.

Infection

Graft infection is one of the major risks of epikeratophakia surgery. Not only may infection cause graft failure, but the host cornea may also become infected. The periods of special risk are during the initial epithelialisation and following any episode of suture removal. The severe consequences of graft infection can be avoided only by the closest follow-up so that any infection is caught early. Treatment of this complication proceeds along standard lines with Gram stain, microbiological culture and sensitivity, and intensive topical antibiotic therapy. Signs of progression should lead to early graft removal to reduce the infective load and the risk of permanent damage to the patient's cornea. The overall incidence of graft removal from infection in reported series is low, with the highest rate of removal in the paediatric group approximately five %.[8]

Inaccurate Dioptric Correction

The commonest complication of refractive surgery is probably failure to correct accurately the refractive error. However, small degrees of inaccuracy are tolerable in the majority of situations. In infantile aphakia, a perfect correction to emmetropia may be short-lived due to refractive change in the growing eye. Whilst emmetropia is a reasonable goal to aim for, the aphakic eye is devoid of accommodative power, and spectacle correction for near will be necessary. If glasses are to be worn, a bifocal lens can equally be used and any residual ametropia corrected simultaneously. The majority of cases suitable for epikeratophakia are unilateral aphakes (trauma, complicated cataract extraction), and the prime aim of surgery in this situation is to reduce anisometropia to tolerable proportions, any residual ametropia being corrected with lenses.

In keratoconus, the aim is to eliminate the irregular astigmatism and allow the patient to resume contact lens or spectacle wear. It is not possible to attempt to render the patient emmetropic, as accurate assessment of the refractive state of the eye is usually not possible preoperatively. It has been found[9] that there is a general trend toward a decrease in preexisting myopia with this technique.

Whilst clinical epikeratophakia for aphakia commenced in 1980, myopia correction has been attempted only recently. Initial findings[5] showed very wide-ranging refractive and visual results, and even with subsequent modification of lenticule design and application, the refractive results still showed a considerable variability. In light of this, the recommendation of epikeratophakia for myopia is difficult to make, since unlike other groups of patients seeking epikeratophakia, myopes generally already have good preoperative visual acuity corrected with glasses.

CONCLUSION

The ease of epikeratophakia surgery and its wide-ranging indications will ensure it an increasing role in ophthalmic surgical practice. For the first time, a powerful technique for correction of both myopia and hypermetropia is available to any ophthalmic surgeon. With appropriate training, good results can be obtained with this procedure by surgeons without a background in the keratorefractive field.

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