A 51-year-old man who had previous penetrating corneal transplantation (penetrating keratoplasty [PKP]) for keratoconus in the right eye presented to his primary ophthalmologist 2 years later with a visually significant cataract. Because of high and relatively symmetric astigmatism, the patient had phacoemulsification with implantation of an Acrysof IQ toric intraocular lens (IOL) (SN60T7, Alcon Laboratories, Inc.) to correct post-PKP astigmatism.

After cataract surgery, the patient achieved an uncorrected distance visual acuity (UDVA) of 20/40 and a corrected distance visual acuity (CDVA) of 20/25 in the eye and he was very satisfied with his vision. Three months later, however, the patient presented with an episode of acute graft rejection. Despite treatment, the corneal graft failed.

After 4 months, the patient was referred with a visual acuity of counting fingers. The intraocular pressure (IOP) was 14 mm Hg, and slitlamp examination showed diffuse corneal graft edema and epithelial irregularity (Figure 1). Corneal topography showed some irregular astigmatism (Figure 2).

Given the high-power toric IOL in the capsular bag and corneal graft failure, what would be your approach to treat this patient?

Figure 1. Diffuse corneal graft edema, epithelial irregularity, and an in-the-bag IOL.

Figure 2. Corneal topography after graft rejection.
This case highlights the potential problems associated with the use of advanced IOLs (toric and multifocal) concomitant with or after full-thickness corneal transplantation. In general, I avoid these IOLs because the corneal transplant has a finite survival and if a repeat transplant is required (as in this case), you are left with a refractive dilemma. When possible, I prefer post-PKP corneal refractive surgery to deal with residual refractive errors. The exceptions could be a very elderly recipient, where the risk for rejection is lower and the expected graft survival may exceed the life expectancy of the patient, or (as in this case) patients with keratoconus, where overall graft survival is quite high. This case also highlights the risk that any surgical intervention or manipulation could induce a graft reaction/rejection. Although not mentioned, it is imperative to increase the steroid coverage during and after such procedures.

This 51-year-old patient requires repeat transplantation with an existing well-placed, in-the-bag, high-power toric IOL. Before the graft rejection, the UDVA and CDVA were good and the patient was pleased with his overall visual function. Corneal topography, although provided, is likely to be unreliable secondary to the poor corneal coverage and the presence of epithelial edema.

The approach, in the past, would have been repeat PKP. One could leave the toric IOL in place and risk that the post-PKP astigmatism and the toric IOL cylinder would be additive, leading to a very poor refractive result, or one could perform an IOL exchange with a standard multifocal IOL. Currently, especially in light of the reasonable refractive result before the graft rejection, the best option may be a post-PKP Descemet-stripping endothelial keratoplasty (DSEK). This has the benefit of being a closed-chamber procedure and is likely to maintain the previous anterior corneal contour. The currently used thin donors are less associated with a high hyperopic shift. Descemet-stripping endothelial keratoplasty after failed PKP is documented in the literature, although the techniques vary greatly. Some suggest stripping inside the graft–host junction, others at the junction, and some outside the graft–host margin. Others suggest that it is not necessary to strip Descemet membrane before donor insertion. My preference, as long as the PKP is at least 8.00 mm in diameter, is to strip just inside the graft–host junction and to place a donor button 0.25 mm smaller than the previous PKP.

Although not stated in the history, the PKP in this case appears somewhat small. With that said, it would also be important to ensure that the initial PKP was large enough to truly encompass the extent of the original ectatic change. This approach (post-PKP DSEK), if successful, offers the lowest surgical risk with the greatest chance of preserving the previous good refractive endpoint.

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Options for management of corneal endothelial failure after PKP include repeat PKP, endothelial keratoplasty, and keratoprosthesis implantation. The decision on the most appropriate treatment modality depends on several factors, including historical factors (eg, number of previous graft failures, spectacle-corrected or contact lens–corrected vision before graft failure), patient’s ability to successfully wear a contact lens before graft failure), anatomic factors (eg, significant corneal stromal opacification, presence of an intraocular IOL), and other factors that would complicate the performance of DSEK (eg, peripheral anterior synechiae, anteriorly positioned tube shunts, presence of an anterior chamber IOL, aphakia, partial or complete aniridia).

In this case, the most important piece of history provided is that the patient was “very satisfied” with his vision after cataract surgery. Because the decreased vision is secondary to endothelial dysfunction that resulted from endothelial rejection, restoration of endothelial function would likely make the patient very satisfied again with his vision. Therefore, DSEK is the procedure of choice in this case. The high corneal astigmatism would not be expected to change after DSEK; therefore, the power and orientation of the toric IOL would remain appropriate and an IOL exchange would not be required.

If visually significant corneal stromal opacification developed in the PKP or anatomic factors that would significantly complicate the DSEK were present, the appropriate procedure would be repeat PKP.

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Although I have never removed an IOL from the capsular bag though an open-sky approach, the expected positive pressure in this 51-year-old man after removal of the cornea would likely make opening the capsular bag and removing the toric IOL more difficult than in a closed anterior chamber. Therefore, it would be wise to remove the IOL after epithelial debridement but before removal of the failed graft, if the view were adequate. If not, I would advocate leaving the toric IOL in place until the completion of selective suture removal from the new graft, at which time the required IOL power (with toric correction, if needed) would be known. A disadvantage of waiting approximately 9 months after corneal transplantation until selective suture removal is completed is that the toric IOL might be more difficult to remove than it would have been 4 months after cataract surgery.

If the patient has a history of repeat graft failure secondary to rejection of the donor corneal endothelium or developed endothelial rejection and failure of the DSEK or repeat PKP procedure, I would consider a Boston type I keratoprosthesis. Because the high astigmatism induced by the toric IOL would not be neutralized by the spherical optic of the keratoprosthesis, I would remove the toric IOL at the time of surgery and place an aphakic keratoprosthesis.

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The key issue in this case is astigmatic management. The implantation of the high-power toric IOL makes the eye have an inherent 3.00 diopters (D) of cylinder at the corneal plane. There are 3 possible approaches to rehabilitate the patient's vision. The first is a traditional PKP. The combination of the astigmatism from the repeat corneal transplantation and from the toric IOL will lead to challenging postoperative astigmatic correction. The curvature of the corneal plane would have to be adjusted to offset the astigmatism induced by the toric IOL. This is achievable as long as the axis of the toric IOL is known.

The second option is to perform combined surgery comprising exchange for a monofocal IOL and PKP. The toric IOL is well placed in the bag, and the capsule is fibrotic. Intraocular lens exchange would carry the risk for capsule rupture and greatly increase the surgery time. Therefore, this approach would carry a higher risk for complications.

The third option is endothelial keratoplasty. The graft failure appeared to be caused by endothelial rejection, and there was minimal deep stromal vascularization. Clearing the corneal edema after successful endothelial keratoplasty is very likely.

The biggest advantage of DSEK in this case is minimally induced astigmatism after surgery. The average induced astigmatism is between −0.40 D and 0.60 D.1 That the patient achieved a CDVA of 20/25 after

The treatment of post-PKP corneal astigmatism has during cataract surgery. In this case, the surgeon could induce more tension on the corneal sutures, which correspond to the steep axis of the toric IOL (according to the marks on the IOL indicating the axis of astigmatism), or exchange the toric IOL for a monofocal IOL. Inducing more tension on corneal sutures is easy to perform during PKP. Even so, 2 issues must be addressed. First is that the refractive outcomes are highly unpredictable, and second is that the sutures may not be removed after PKP. Toric IOL removal and exchange for a monofocal IOL is a skill-demanding technique with an increased risk for intraoperative complications (especially after the long interval from the initial IOL implantation). In addition, this approach has prolonged visual recovery because the refractive surgery would be performed after suture removal and corneal astigmatism stabilization.

Thus, to retain the preoperative association of corneal astigmatism with the implanted toric IOL, DSAEK seems the procedure of choice. It would be beneficial to the patient in terms of fast, functional visual recovery with a single-step procedure, reducing the overall cost.

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Although I have never removed an IOL from the capsular bag though an open-sky approach, the expected positive pressure in this 51-year-old man after removal of the cornea would likely make opening the capsular bag and removing the toric IOL more difficult than in a closed anterior chamber. Therefore, it would be wise to remove the IOL after epithelial debridement but before removal of the failed graft, if the view were adequate. If not, I would advocate leaving the toric IOL in place until the completion of selective suture removal from the new graft, at which time the required IOL power (with toric correction, if needed) would be known. A disadvantage of waiting approximately 9 months after corneal transplantation until selective suture removal is completed is that the toric IOL might be more difficult to remove than it would have been 4 months after cataract surgery.

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**CONSULTATION SECTION**

The patient was referred for corneal graft failure after successful toric IOL implantation that provided satisfactory visual function. There are several treatment options in managing graft failure in this case; the main concern would be to not influence the overall refraction. The most effective treatment would be a single intraocular procedure in which the corneal endothelium of the failed corneal graft would be replaced (Descemet-stripping automated endothelial keratoplasty [DSEK]). This would restore corneal clarity and function and would not influence the topographic and refractive values (except a mild hyperopic shift due to the corneal DSEK lenticule). Thus, the final refraction and visual acuity would not be altered.

In the case of regrafting, the surgeon would have to consider that a high-power toric IOL was implanted during cataract surgery. In this case, the surgeon could induce more tension on the corneal sutures, which correspond to the steep axis of the toric IOL (according to the marks on the IOL indicating the axis of astigmatism), or exchange the toric IOL for a monofocal IOL. Inducing more tension on corneal sutures is easy to perform during PKP. Even so, 2 issues must be addressed. First is that the refractive outcomes are highly unpredictable, and second is that the sutures may not be removed after PKP. Toric IOL removal and exchange for a monofocal IOL is a skill-demanding technique with an increased risk for intraoperative complications (especially after the long interval from the initial IOL implantation). In addition, this approach has prolonged visual recovery because the refractive surgery would be performed after suture removal and corneal astigmatism stabilization.

Thus, to retain the preoperative association of corneal astigmatism with the implanted toric IOL, DSAEK seems the procedure of choice. It would be beneficial to the patient in terms of fast, functional visual recovery with a single-step procedure, reducing the overall cost.
In this case, several questions come to mind. First is whether continued medical treatment and a therapeutic contact lens (TCL) would resolve the visual problems or whether surgical treatment is needed. The corneal edema and irregular epithelium indicate corneal decompensation. Although medical treatment and TCL wear can alleviate the pain, they may have no effect on visual rehabilitation. I believe the patient should be treated surgically.

The second consideration is whether the patient should have PKP or DSAEK. Before the graft rejection, the patient had 20/40 UDVA and 20/25 CDVA and the refractive and visual outcomes of the PKP were acceptable. Thus, there is no need for repeat PKP and only the endothelium must be replaced. The likely result would be a clear cornea, corneal reepithelialization, and a regular corneal surface, which would help the patient regain good vision. I believe the best option would be DSAEK.

Next, how would DSAEK differ in this case? In a patient with previous PKP and posterior chamber IOL implantation, the anterior chamber is usually deep and stable. Thus, DSAEK in this case should be simpler than in primary cases. Although some surgeons may be against removing the endothelium and Descemet membrane in post-PKP cases, I have seen faster recovery and better vision when the membrane was stripped than in cases in which I skipped this step. For stripping, I approach Descemet membrane from approximately 0.5 mm inside the graft border to prevent wound dehiscence. In this case, I would start by scraping off the epithelium and then creating an incision 1.0 mm posterior to the limbus on the temporal side. Also, in post-PKP cases, I do not use inflow and perform ultrathin DSAEK with a 100 μm thick lenticule cut 0.5 mm larger in diameter than the previous graft. I perform the other steps as in standard DSAEK.

Another consideration is whether the topography pattern has a role in decision making for surgery. Considering the visual status before the edema, the corneal topography was likely regular; present maps reflect only the irregularity caused by decompensation and a diseased epithelium. Thus, the topography lacks significant clinical value compared with the visual acuity and refraction results.

As to whether the toric IOL should be removed or changed, as mentioned, the optical outcome with the graft was good. The graft-related astigmatism was minimized by implanting a toric IOL during cataract surgery, which can correct approximately 3.00 D of corneal astigmatism. Because DSAEK would be performed instead of PKP, the IOL should be left in place.

Regarding additional procedures, the pupil in Figure 1 appears dilated and irregular. If this is not pharmacologically induced, I would suggest that the patient have simultaneous pupilloplasty using the Siepser suture technique to prevent glare.

In short, I recommend ultrathin DSAEK and pupilloplasty and use of steroid eyedrops twice daily for life if IOP allows.

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The overall picture suggests that the visual loss is caused by graft edema secondary to endothelial failure. Although the regular astigmatism on topography is a concern, the patient achieved 20/25 CDVA after cataract surgery. Thus, the astigmatism is probably the result of epithelial irregularity secondary to edema. In-office epithelial debridement followed by topography of the deepithelialized cornea could differentiate epithelial irregularity from true corneal irregularity. Because the patient was satisfied after cataract surgery (before graft failure), he could have DSAEK. I make my main incision in the steep meridian and expect an approximate 1.00 D hyperopic shift postoperatively.

The other scenario is a corneal stromal scar or irregularity in addition to edema, which would preclude endothelial keratoplasty. Glycerin drops could help differentiate a corneal scar from corneal haze secondary to edema. If endothelial keratoplasty cannot be performed, we must consider a measure to correct the add-in astigmatism of the toric IOL. One option would be IOL exchange during PKP. The potential complications are capsule tear, zonulysis, and vitreous loss. There are several reports of IOL removal and in-the-bag implantation of a replacement IOL, even after 1 year.1,2

In the case of a corneal scar or severe corneal irregularity (less possible in this case), PKP could be performed. The cylindrical power of an implanted toric IOL at the corneal plane is 3.00 D. If the angle between the steep axis of postoperative corneal astigmatism and the lens were 90 ± 30 degrees, it would reduce the refractive astigmatism.3 Then, to correct the astigmatism, spectacle correction of the refractive astigmatism could be attempted. If this were not successful (ie, due to irregular astigmatism), a rigid gas-permeable (RGP) contact lens could be used to correct the corneal astigmatism and astigmatism glasses of approximately 3.00 diopters could be worn to correct the lenticular astigmatism. The RGP lens alone would not be an option because it would correct the corneal astigmatism and would manifest lenticular astigmatism.

If the patient did not accept or could not tolerate these measures, the other alternative would be surgery after all sutures are removed. There are 2 options to correct the relatively regular astigmatism. The first is refractive (corneal and lenticular) astigmatism correction on the cornea with LASIK or PRK and mitomycin-C. Because of the add-in effect of the toric IOL, these procedures would cause an astigmatic cornea postoperatively to compensate for the lenticular astigmatism. All astigmatic keratotomy nomograms are designed for corneal astigmatic correction; therefore, performing astigmatic keratotomy without considering the effect of the toric IOL would induce toric IOL astigmatism.

The second option is correction at the lenticular plane. Recently, toric IOLs designed for implantation as a piggyback in the ciliary sulcus were introduced. Theoretically, a toric phakic IOL could also be used. Jin et al.4 report piggyback toric IOL implantation to correct corneal and lenticular astigmatism in an eye with a misaligned toric IOL. Again, we should keep in mind that most toric IOL calculators were designed to correct corneal astigmatism. To correct corneal and lenticular astigmatism (refractive astigmatism) would require additional mathematical analysis.4,5

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Some surgical options to treat graft failure can yield good visual outcomes. Repeat PKP and endothelial keratoplasty, in particular DSAEK, are alternatives. A serious drawback of repeat PKP is the slow visual recovery resulting from large and unpredictable refractive changes; the implanted toric IOL should also be taken into consideration because refractive changes after PKP regraft are inevitable. The repeat PKP and IOL exchange can be performed at the same time or as a 2-stage procedure consisting of repeat PKP followed months later by IOL exchange. The first alternative avoids an additional surgery and allows rapid recovery of vision; however, it may result in large refractive errors because of the inability to predict the IOL power correctly. The risks of this procedure include posterior capsule rupture and vitreous prolapse during surgery. The main advantage of a 2-stage procedure is that it provides patients with refractive errors closer to emmetropia. Its disadvantages include a delay in visual acuity and an increased risk for graft failure. In the case of a 2-stage procedure, all sutures should be removed to better determine the final
corneal shape and better plan for astigmatic surgery before IOL exchange. In addition to the risks of simultaneous surgery, there is a risk for endothelial dysfunction from trauma, which can result in recurrence of graft failure with the 2-stage procedure.

Performing DSAEK would help minimize many of the drawbacks of a PKP regraft. The main advantage of DSAEK is that it provides more rapid visual recovery and an easier postoperative course than PKP. Patients with a failed PKP are typically appreciative of their rapid recovery after endothelial keratoplasty. When treating a failed PKP, I prefer to use an endothelial keratoplasty donor diameter a bit larger than that of the original PKP. This should give the patient a larger pool of healthy endothelial cells to delay future endothelial failure as long as possible. Another advantage of treating eyes with DSAEK instead of a PKP regraft is that the patient's ocular surface would not be completely desensitized again, as it was when all the corneal nerves were severed during the original PKP. Furthermore, DSAEK does not significantly alter corneal topography or increase the mean refractive cylinder. This is a welcome improvement over PKP, which commonly results in high refractive cylinder. Thus, treating this patient with DSAEK would negate the need to consider toric IOL exchange during the surgery. The only drawback of endothelial keratoplasty in this case is the epithelial irregularity. When the corneal surface has significant irregularity, it is not unusual for the condition to worsen after DSAEK because the epithelium was not removed at the time of surgery. However, epithelial irregularity is not so severe in this case.

In summary, compared with a standard PKP regraft, endothelial keratoplasty, in particular DSAEK, would offer significant safety and functional advantages for this patient.

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With the toric IOL in place, a PKP regraft would lead to induced astigmatism even if the transplant were perfectly spherical. If the regraft were not spherical, it would lead to complex astigmatism in combination with the IOL. Therefore, placement of an endothelial keratoplasty under the failed PKP is a better choice if the patient had acceptable visual and refractive results before PKP failure, which this patient did. This case is a great example of why toric IOLs should be implanted after PKP only when the PKP failure can be treated with endothelial keratoplasty.

The topography shows marked irregular astigmatism that was caused or worsened by the corneal edema. Without a refraction before the graft failure, this topographic cylinder is not useful in trying to manage residual astigmatism.

I have treated similar cases with various endothelial keratoplasty techniques, including DSEK, Descemet membrane endothelial keratoplasty (DMEK), and Descemet membrane automated endothelial keratoplasty (DMAEK). The DMEK and DMAEK techniques provide the best visual recovery, while DSEK provides easier surgery and postoperative care. All 3 endothelial keratoplasty techniques provide more rapid visual recovery than a PKP regraft, and none should significantly alter the astigmatism present before PKP failure. Stromal vascularization should not influence immunologic reactions for any of the endothelial keratoplasty techniques. Descemet membrane endothelial keratoplasty has a significantly lower risk for immunologic rejection than PKP or DSEK.

I would not strip Descemet membrane and would place the endothelial keratoplasty graft against the previous donor graft, unless DMEK is performed. I would then use the standard methods of a temporary air fill for DSEK or a nearly complete air fill with an inferior iridotomy for DMEK or DMAEK. Trying to strip Descemet membrane can lead to rupture of the PKP wound. I would take that risk only if the graft's Descemet membrane is scarred.

It is not clear whether the iris is dilated from the examination or whether it is fixed and dilated. If the pupil is fixed and dilated, I would suture it to a smaller size (approximately 3.0 to 4.0 mm). If the iris is fragile or cannot be constricted, I would propose placing an artificial iris implant. This would improve vision by creating a smaller pupil (increasing depth of focus) and reducing incapacitating glare and light sensitivity. If the iris is left fixed and dilated or if an artificial iris is implanted, I would not perform DMEK. Instead, I would perform DSEK or DMAEK because these techniques allow placement of an air bubble underneath the graft as soon as it is inserted into the eye, preventing the corneal endothelium from coming in contact with the IOL.

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