Visual acuity, residual astigmatism, and graft clarity following penetrating keratoplasty for keratoconus

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A penetrating keratoplasty is performed when the patient can no longer tolerate or achieve satisfactory vision with contact lenses.

Research Abstract
For quality assurance purposes, an indepth search was taken for patients undergoing penetrating keratoplasty surgery at the University of Iowa Hospitals and Clinics in the Department of Ophthalmology.

The patient population group used were patients with a diagnosis of keratoconus who underwent penetrating keratoplasty surgery during a two year period. The patients excluded were those with aphakia, cataracts, glaucoma, and retinal disease. These patients were followed for a period of two years to determine an outcome criteria consisting of visual acuity, residual astigmatism, and graft clarity.

Excluding one case of primary donor failure, the average results found two years after surgery were a visual acuity of 20/20, an average amount of astigmatism of 3.5 diopeters, and one hundred percent clear grafts with no graft rejection.

To assure that our keratoconus patients were achieving satisfactory surgical results, an indepth search was taken through the means of chart review to determine suitable outcomes for patients undergoing penetrating keratoplasty at the University of Iowa Hospitals and Clinics in the Department of Ophthalmology.

Description
Keratoconus describes a condition in which the cornea assumes a conical shape because of thinning, protrusion, and scarring. The management of keratoconus follows a spectrum of therapy ranging from no treatment, to correction with glasses, progressing to contact lens therapy, and finally to surgery. Mild keratoconus can be treated with spectacles. Rigid contact lenses are usually prescribed when glasses can no longer correct the poor vision this disease causes. The contact lenses help to flatten out the cone, thereby decreasing the amount of irregular astigmatism and greatly improving vision. A penetrating keratoplasty’s performed when the patient can no longer tolerate or achieve satisfactory vision with contact lenses. 1

Chart Review
A quality assurance chart review research project was conducted for all keratoconus patients who underwent a penetrating keratoplasty during the period of January 1, 1984 to December 31, 1985. Forty patients initially qualified for the study group. Keratoconus patients with aphakia, cataracts, glaucoma, and retinal disease were excluded from the study to eliminate conflicting variables which might affect the selected outcome criteria.

One patient had a primary donor failure. Our goal was to evaluate the results of penetrating keratoplasty on keratoconus. Since primary donor failure is not related to keratoconus surgery, and since the case would have dramatically skewed the results of the study, the case was also excluded.

This patient population was followed for a period of two years after surgery to determine the following outcome criteria: visual acuity, residual astigmatism, and graft clarity. The patients’ charts were reviewed at seven intervals: preoperative, postoperative one day, one month, three months, six months, one year, and two years.

Ten of the original forty patients were not available by the end of the two year interval for chart review. Of these ten, five patients did not keep their scheduled appointments, three moved out of the state, one was mentally retarded which interfered with accurate assessment of the outcome criteria, and one had a primary donor failure which was later regrafted. This accounts for the two-year end results with a total of thirty patients reviewed.

First outcome criterion
The first outcome criterion reviewed was visual acuity. For keratoconus patients, the most accurate assessment of preoperative visual acuity is that of a “functioning” visual acuity, i.e., the vision a patient has while doing their day-to-day activities. These patients can experience reduction of visual function before the visual acuity loss can be measured on the Snellen chart. We need to remember that performance on the Snellen chart does not accurately reflect the visual acuity of a patient with irregular astigmatism as occurs in keratoconus.

Snellen eye chart values were extrapolated to include preoperative visions of hand motions and count fingers so that these values could be included in the statistical analysis. The preoperative values for the 40 patients reviewed over this two-year period was...
an average best functioning visual acuity of 20/500, with a range measured from 20/4000 to 20/40. (The patients with a 20/20 visual acuity were unable to tolerate contact lenses for correction of their vision due to the steepness and apical scarring of the cone.) One day postoperatively, only one patient's visual acuity had been recorded. The visual acuity for this patient was 20/25. Since discovering the failure to record this date, measures have been taken to remedy this situation. (A chart review can be helpful in many ways.) One month postoperatively, visual acuity was recorded for six patients. Vision ranged from 20/120 to 20/25 with an average acuity of 20/50. At the three-month postoperative interval, acuity for thirty patients was recorded ranging from 20/100 to 20/20, with an average vision of 20/40. At the six-month interval, thirty-one patients' visions were recorded ranging from 20/60 to 20/16 with an average acuity of 20/25. Two-years postoperative the range was from 20/50 to 20/16 for the remaining thirty patients for whom chart review was possible. The average visual acuity for these patient's vision was 20/20.

![Graph showing best corrected visual acuity over time](image)

Second outcome criterion
The second outcome criterion reviewed was residual astigmatism. Residual astigmatism is the amount of astigmatism remaining after penetrating keratoplasty. Intraoperatively, many factors can influence post-keratoplasty astigmatism. Before the patient ever leaves the operating room, much attention is given to these factors and to ways of reducing postoperative astigmatism. A common reason for post-keratoplasty astigmatism is tissue malapposition which can be due to a variety of causes. For example, pressure from the lid speculum can cause distortion of the globe. For all the patients reviewed, a Barraquer wire speculum was used. It is small and easily inserted with minimal corneal distortion.

When the cornea transplant is performed, the support structure of the eye is disrupted. A scleral support ring can be used to help maintain the eye structure. However, improper placement and suturing of this ring can lead to an irregular opening of the recipient cornea causing post-keratoplasty astigmatism. None of the patients selected had the scleral support ring placed during the penetrating keratoplasty procedure. Since all patients were phakic, scleral collapse was most unlikely.

Other causes of tissue malapposition can be irregular trephination and/or scissor cutting of the recipient cornea and the donor cornea. Some surgeons use a trephine with an internal obturator to control the depth of the recipient cornea cut. In keratoconus patients, the apex of the cone may come into contact with the internal obturator, thereby causing increased irregular distortion. For all patients reviewed, a trephine without an internal obturator was used to prevent this distortion of the cornea as it is cut. Thermal cautery can also be used to flatten the apex of the conical cornea before recipient trephination. However, it was elected not to use this method either because the cornea buttons were later used for additional keratoconus research.

Finally, proper suturing is critical in the reduction of post-keratoplasty astigmatism and correct tissue apposition. When placing sutures, tissue distribution and suture tension must be equal for the 360-degree incision. For all patients reviewed, the suturing technique used was as follows. First four cardinal sutures were placed at the twelve, six, three, and nine o'clock positions. These important cardinal sutures accurately anchor the donor button. Eight additional interrupted sutures were placed, one for each of the remaining clock hours. This created a closed wound and reforms the structure of the eye. A continuous running suture was then placed to further aid in evenly distributing the corneal tissue. The bites of the running suture were placed in between the interrupted sutures. For all patients reviewed, an intraoperative keratometer was used to minimize astigmatism at the end of the case.

While leaving the running suture in place to maintain wound strength, the use of selected removal of
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interrupted sutures in the steepest axis results in decreasing astigmatism. As the cornea heals, interrupted stitches are removed to create a more spherical cornea. The residual astigmatism fluctuates from visit to visit. Possibly, a method of controlling and avoiding postoperative astigmatism may be to conform the healing wound into the most spherical configuration as soon as the suture removal process begins.5

Often the preoperative keratometry readings of these keratoconus patients were too irregular or distorted to read or were, once again, not recorded in the charts. Preoperative keratometry readings were extended keratometry readings and only estimations because of the steepness of apical scarring of the cone. Therefore, the preoperative readings were not used in the data collection. Six patients’ readings were recorded one-day postoperatively. The range of astigmatism was from 7.00 to 2.00 diopters with an average astigmatism of 5.00 diopters. At the one-month interval, the range was from 14.50 to 1.00 with an average of 6.00 diopters of astigmatism for the twenty-nine patients recorded. At the three-month interval, thirty patients were measured with a range of readings from 15.00 to 2.00 showing an average of 7.00 diopters. At the six-month interval, twenty-eight patients were recorded with a range of readings from 12.50 to 0.62, and an average of 5.25 diopters of astigmatism. Nineteen readings were recorded at the one-year interval ranging from 12.00 to 0.00 with an average of 4.62 diopters of astigmatism. For the final two-year interval, sixteen ‘patients’ readings were recorded showing a range from 10.50 to 0.75 with an average of 3.5 diopters of astigmatism. [See Figure 2.]

Third outcome criterion
The third outcome criterion reviewed was graft rejection. A graft rejection will most likely occur within the first year after surgery.6 However, a patient with a transplant is never free from the risk of rejection. A rejection may occur at any time throughout his or her life. Patients are taught the three warning signs of corneal transplant rejection: 1) a decrease in vision, 2) redness, and/or 3) pain in or around the eye. If any or all of these warning signs persist for 24 hours, the patient is advised to seek medical attention immediately. If severe, the patient is advised to not wait 24 hours, but to report immediately to the ophthalmologist. With the use of topical steroid drops and ointments, and sometimes with the addition of oral steroids, a rejection can often be reversed and the transplanted graft saved.

Graft rejection occurs in approximately thirty-five percent of grafts after penetrating keratoplasty for keratoconus.7 However, for this particular group studied, with the exception of one primary donor failure, the grafts remained one hundred percent clear with only two patients having a rejection episode. One patient had a graft rejection at the three-month postoperative visit which was totally resolved by the one-year visit. Another patient had a mild rejection at the two-year interval which was resolved in two months.

One patient had a primary donor failure postoperatively due to an unknown cause. Primary donor failure can occur because of poor endothelial cell function of the donor tissue or for other unknown reasons. This patient was successfully regrafted twenty days later. This transplant functions with an excellent result.

Many surgical factors are taken into consideration in the operating room to reduce the possibility of corneal graft failure. The surgeon must perform a reproducible technique of structure and function for the operated eye to maintain a high percentage of successful grafts. Surgery that is too extensive or traumatic may cause the graft to fail. Materials used in surgery such as non-inflammogenic sutures take advantage of the avascular privilege of the cornea and thereby reduce the possibility of graft rejection.8

It is most important to keep in mind that surgical techniques and materials to reduce graft failure are only one part of the corneal grafting process. Mutual cooperation between transplant patient and the health care team are necessary to maintain a clear
transplanted graft. The follow up care is most important for the cornea transplant patient.

Summary
In summary, these finding show us several things. First, we know that with surgery keratoconus patients can be rehabilitated to achieve excellent vision. A postoperative average visual acuity of 20/20 after an average preoperative visual acuity of 20/500 is a most positive outcome. Secondly, the average amount of postoperative astigmatism of 3.5 diopters shows that even after totally removing a corneal button and replacing it with 360 degrees of sutures we can still achieve a relatively small amount of residual astigmatism and a relatively spherical cornea. Thirdly, with the exception of one primary donor failure, a total of one hundred percent clear grafts, even after the occurrence of two graft rejection episodes, indicated an extremely high success rate of keratoplasty in keratoconus.

The author gratefully acknowledges the contributions of the following individuals: Jay H. Krachmer, M.D., Iowa City, IA for providing advice and assistance in the research, editing, and statistical analysis. Peter Gloor, M.D., Iowa City, IA for his assistance in the preparation of the computer graphs.

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