British Journal of Ophthalmology, 1989, **73**, 657–660

Corneal dioptric power after penetrating keratoplasty

JUAN A DURAN, ANA MALVAR, AND ELIO DIEZ

From the Hospital General de Galicia, Universidad de Santiago de Compostela, Spain

SUMMARY The dioptric power of the cornea (spherical equivalent) was studied in 60 eyes operated on for penetrating keratoplasty. In order to determine the possible influence of (1) the underlying pathology, (2) the presence of neovascularisation, or (3) the size of the graft the sample was divided into four groups, with the following results: group A (keratoconus, same-sized graft)=42·25 D; group B (keratoconus, oversized graft)=45·16 D; group C (keratopathy with minimal or no vascularisation)=45·34 D; group D (keratopathy with significant vascularisation)=45·36 D. The results showed that donor-receptor disparity is the main factor determining the outcome of the postoperative corneal spherical power. There was no demonstrable influence from underlying pathology or the presence of vessels in the receptor cornea.

The so-called triple procedure—combined penetrating keratoplasty, extracapsular extraction, and intraocular lens (IOL) implant—has become an increasingly accepted surgical technique, with excellent reported results and the advantage of performing cataract surgery at the time of the keratoplasty.[1,2] Although the technique involves no serious difficulties, in most cases the aid of a moderate or high spherical and/or cylindrical lens is needed to achieve satisfactory visual acuity.

Postoperative astigmatism has been widely studied and recently reviewed.[3] The spherical defect after the triple procedure is higher than two dioptres in 33 to 74% of the cases, depending on the series, and errors greater than 10 dioptres have been found.[4-8]

Difficulties in obtaining a minimal spherical error lie in the impossibility of determining the final corneal power (K value) before surgery is performed, provided that the implant power calculation formulas include this parameter.[9] In such cases surgeons have used a standard IOL or have taken values from the recipient or the fellow eye or from the mean of previous keratoplasties.[4-8] However, although it is possible to assess the axial length of the eye, surgical technique will determine to some extent the K values of the grafted cornea.[10,11] Other factors such as the previous K value, the age of the donor, and pathological changes in the host cornea (vessels, thinning) might also contribute to the final dioptric defect.

The purpose of this study is to evaluate the spherical equivalent of the K reading from grafted corneas and to consider some of the elements that may affect the result—previous pathology, size of the graft, and suture technique.

Correspondence to Juan A Duran, Hospital General de Galicia, Departamento de Oftalmología, Santiago de Compostela, 15701, Spain.

Material and methods

Clinical records from all patients operated on for penetrating keratoplasty between January 1985 and February 1988 were reviewed. All the operations had been performed by JAD at the Hospital General de Galicia, Spain. A total of 60 eyes from 56 patients were included in the study, with the graft clear for at least six months after surgery. Indications for keratoplasty were as follows (Table 1): Keratoconus (24 eyes=40%), corneal oedema (12 eyes=20%), herpes simplex virus (HSV) keratitis (8 eyes=13·3%),

Table 1 *Indications for surgery*

Indication		*No. of cases (%)*
Keratoconus		24 (40·0)
Corneal oedema		12 (20·0)
Pseudophakic	2	
Aphakic	4	
Fuchs's dystrophy	3	
Failed graft	3	
Herpes simplex keratitis		8 (13·3)
Interstitial keratitis		5 (8·3)
Perforating injury		4 (6·7)
Corneal opacity		3 (5·0)
Chemical burn		2 (3·3)
Stromal distrophy		2 (3·3)
Total		60 (98·8)

interstitial keratitis (5 eyes=8·3%), and others (11 eyes=18·3%).

Preoperative study included, among other data, the degree of corneal vascularisation, interpreted as follows: 0=no vessels, +=fine vessels in less than one quadrant, ++=thick vessels or fine vessels in more than one quadrant, +++=heavy corneal vascularisation. In all cases corneas from adult donors were grafted.

The surgical technique consisted in a manual trephination on a Teflon block (punch) of the donor cornea from the endothelial side, 0·5 mm greater in diameter than the receptor trephination. In only 14 eyes of the keratoconus eyes did we use a same-sized corneal button. Suturing was done with eight interrupted 10/0 nylon plus a running suture with 16 bites in corneas of 0 or + vessels. In eyes with ++ or +++ corneal vessels 16 interrupted sutures (with no running suture) were used. During surgery release of the cornea from the iris synechiae, extracapsular cataract extraction, posterior chamber IOL implantation, anterior vitrectomy, and/or other manoeuvres were performed when indicated. After the knots were buried, gentamicin and triamcinolone were injected subconjunctivally.

Postoperative treatment consisted of topical dexamethasone and gentamicin every two hours during the daytime; in some cases mydriatics were added. Drugs were tapered during the following weeks, the amount depending on the follow-up findings. When possible, control keratometry was started one month after the surgery, and in the following months interrupted sutures were selectively removed, the removal depending on the corneal astigmatism (removal at the steepest axis). A Javal ophthalmometer was used for keratometric measurements.

In this study we did not consider the corneal astigmatic defect, subjective refraction, or visual acuity. The spherical equivalent of the K value was obtained from the mean power of the steepest and flattest curvature axis once postoperatively between the fourth and the twelfth month, with either the running sutures or most of the interrupted sutures in place.

For the statistical study the eyes were divided into four groups: (A) keratoconus with same-sized graft (n=14); (B) keratoconus with oversized graft (n=10); (C) keratopathy with 0 or + vessels (n=24); and (D) keratopathy with ++ or +++ vessels (n=12). The following parameters were evaluated: (1) diameter disparity between corneal button and recipient bed (groups A and B); (2) corneal peripheral rings according to pathology (groups B and C); (3) the presence of vessels (groups C and D); and (4) the varying sizes of the oversized grafts. Thus group C was divided into three subgroups: 7·5–8·0 mm (n=5), 8·0–8·5 mm (n=11), and 8·5–9·0 mm (n=8).

For all quantitative comparisons Student's t test was used.

Results

Dioptric power of the cornea in the 60 eyes studied varied from 40·0 to 49·25 D, mean 44·59 D. Results for the different groups are summarised in Table 2.

In same-sized grafts for keratoconus (group A) the mean corneal dioptric power was 42·25 D (SD 1·13, range 41·25–44·00), while in oversized grafts (group B) the mean power was 45·56 D (SD 1·60, range 43·50–47·75). There was a significant difference ($p<0·001$) between the groups.

Group C (keratopathy with 0 or + vessels) showed a mean corneal spherical power of 45·34 (SD 1·82, range 41·50–48·50). No statistical difference was evident in cases of keratoconus operated upon by the same oversize graft technique as group B.

When significant preoperative vascularisation was present (group D), the mean postoperative corneal power was 45·36 D (SD 2·92, range 40·00–49·25), which was not significantly different from that in group C. However, dispersion in group D was higher than in group C (oversize grafts were also in this group).

Within group C we compared corneas of different diameters, all with a 0·5 mm oversized graft. Thus, for the 7·5–8·0 mm size the mean K values were 45·87 D (SD 1·39, range 44·25–47·00); for the 8·0–8·5 mm size, 45·29 D (SD 1·90, range 42·25–48·50); for the 8·5–9·0 mm size, 45·08 D (SD 2·13, range 45·50–48·00 D). There were no significant differences among the three groups.

Finally, we compared values from 12 normal fellow eyes for which the grafted eye had a mean K value of 45·38 D. Normal eyes had a mean power of 42·43 D, with an individual disparity in comparison with the fellow eye of between 0·25 and 5·50 D.

Table 2 *Postoperative spherical equivalent*

Group	*Dioptres*		
	Mean	*SD*	*Range*
Group A (KC, same-sized)	42·25	1·13	41·25–44·0
Group B (KC, oversized)	45·16	1·60	43·5–47·75
Group C (no vessels or +)	45·34	1·82	41·5–48·5
7·5-8·0 mm	45·87	1·39	44·25–47·0
8·0–8·5 mm	45·29	1·90	42·25–48·5
8·5–9·0 mm	45·08	2·13	41·5–48·0
Group D (vessels ++ or +++)	45·36	2·13	40·0–49·25

KC=keratoconus.

Discussion

A growing number of penetrating keratoplasties are giving excellent results in terms of corneal transparency owing to substantial technical improvements, better recognition and treatment of complications, and an absolute increase in the number of keratoplasties performed in the last few years. But interest in the anatomical results has been in part displaced by interest in the optical results. In this area postoperative astigmatism has been the subject of numerous studies, since it is still one of the most frequent complications of this operation.[3]

The problem of postoperative spherical defects has only recently been raised, and always in relation to the triple procedure. In this operation spherical defects could, at least in theory, be minimised. However, only 26 to 67% of the cases achieve 2 or less dioptres of the ideal refraction.[4-8] Gabel *et al.*[6] thought that axial length could be an important factor, but in most cases it can be determined prior to surgery. Corneal curvature seems to be the single most important source of error.[4 5 7 8] For normal corneas 0·25 D error in keratometric reading corresponds to about the same amount in postoperative refraction, when the IOL power is calculated through the available formulae.[9]

Our results indicated the following: (1) there is no evidence that the previous corneal pathology or the presence of vessels will influence the final dioptric power of the cornea; (2) it is not possible precisely to calculate the IOL power to achieve an ideal refractive status; (3) when the graft is 0·5 mm larger than the recipient bed, the eye shifts to myopia, while when a same-sized button is grafted the K values are similar to standards; and (4) the final dioptric corneal power does not seem to be influenced by the suture technique.

It is therefore unreliable to use standard or fellow eye K values to calculate the IOL dioptric power in the triple procedure. The highest rates of refractive success have been reported by Binder[7] and by Musch and Meyer,[8] with 57 and 67% of their respective patients in the range of ±2 D of emmetropia. These authors based the IOL power calculation of K values of previous grafts performed with a similar technique. Similarly, three groups have reported keratometric results after penetrating keratoplasty.[7 8 11] Although they did not specify recipient corneal characteristics, for oversized grafts the three groups found a postoperative corneal power of 45·89 D, 45·4 D, and 45·69 D, respectively. Since our equivalent result was 45·34 D, it seems reasonable to use a 45·5 D K value in the IOL power calculation for the triple procedure. The first of the studies mentioned used a 0·75 mm oversize button and achieved the highest dioptric power.[7] Oversized grafts are widely used because of the reduced incidence of glaucoma and wound leaks. In addition trephination from the endothelial face provides a corneal button which is smaller than the diameter of the trephine.[12]

For same-sized grafts a recent study reported a mean K value of 42·98 D,[11] while in our study it was 42·25 D. For the IOL formulae standard or 42·5 D K values could be used.

Apart from other problems posed by previously vascularised corneas, they show a wide range of dioptric power in the postoperative period. This could be attributed to the special characteristics of the wound healing process. We can therefore assume that predictability for the final refractive outcome is less accurate for this group of eyes.

Our study did not take into account the presence or absence of an IOL implanted. Keratometry is not supposed to change in the presence of a posterior chamber lens.[13] An anterior chamber IOL can alter the K values but is not indicated in the triple procedure, even in the absence of the posterior lens capsule.[14] Similarly, when sutures are removed or when a surgical procedure is performed to reduce an eventual astigmatism, it is unlikely that the corneal dioptric power will be modified in terms of spherical equivalent.[15 16]

In summary, the most important variable in determining the final corneal spherical power after a penetrating keratoplasty is the disparity between the corneal button and the receptor bed size. It must be pointed out that this is also of relevance to regular keratoplasties, since the residual anisometropia can cause visual disturbances which transform a successful operation into a new problem for both the surgeon and the patient. Myopic shift in oversize grafts for keratoconus has been described as an undesirable effect of surgery.[17] Biometry is thus recommended before performing any penetrating keratoplasty to obtain some valuable data for the refractive prognosis. Possibly by changing the relationship between corneal button and receptor bed size we can achieve a refractive status of the eye close to the ideal one.

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Accepted for publication 12 December 1988.