Arch. Soc. Amer. Oftal. Optom. (1982)-16-221

KERATOMILEUSIS FOR THE CORRECTION OF MYOPIA

JOSE I. BARRAQUER, M. D.
Bogotá - Colombia

Myopic keratomileusis (KMM) is an extraocular autoplastic surgical procedure designed to reduce the dioptric power of the cornea, by flatenning the radius of the anterior surface of its optical zone, in order to correct myopia (Fig. 1).

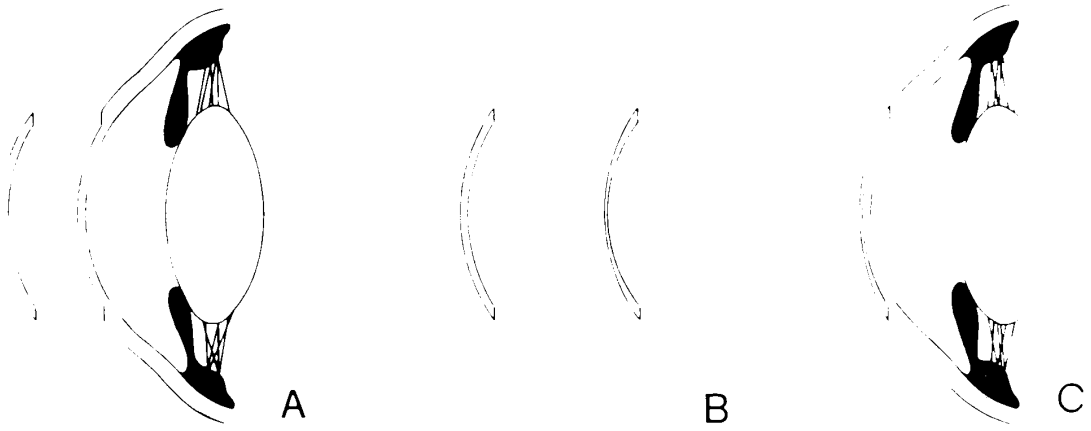

Fig. 1

Sketch of myopic keratomileusis.

A. A corneal tissue disc of parallel faces is obtained with the microkeratome.

B. The frozen disc of parallel faces is carved to obtain a negative lenticule.

C. The eye is reconstructed

Since a detailed description of the technical procedure, calculations infraestructure, etc. has already been given often in other publications, we will only point out the fundamental steps and some of the improvements made in the technique and results during the last years.

The surgical procedure begins with the resection of a corneal tissue disc of parallel faces from the anterior layers of the cornea. This disc is obtained with the microkeratone and should measure 7.25-7.50 mm in diameter and 0.25-0.30 mm in thickness. After measuring its physical conditions, the disc is preserved, in order to reduce the damage inherent to the freezing process to which it must be subjected. At the same time, the disc is tinted with a vital dye, in order to improve its visibility during the extracorporeal steps. Once cryopreserved, the disc is measured again and placed on a concave surface of known radius —called base— where it is frozen, to make is hard enough to be optically cut by its parenchymal face. The cut is performed with a cryolathe, adjusted by a computer fed with data of the patient and of the corneal disc.

Although for many years a mechanical device had been used to measure the thickness of the corneal disc, we decided to try an ultrasonic measuring device, in order to avoid erros that could be caused by pressure of the tissue with the spring of the mechanical device. Since the results obtained with both methods were identical, we went back to the use of the mechanical means, mostly because of its greater simplicity.

Looking into the cause for some operating accidents of past series led us to design ways to prevent them. In the first place, it was found that some of the perforations of the lenticule during the optical cut were caused by a gas bubble that had escaped from the freezing circuits and passed through the delrin base to remain included between the base and the lenticule. To prevent this accident, the heat exchanger was redesigned and several safety holes were made in the fixation ring, to provide an exit way for any excess gas.

On the other hand, some detachments of the lenticule during the cut were found to be due to insufficient freezing. Since this took place even when there was enough pressure in the cylinders, we found that is happened because the contents of the cylinders was only gaseous CO_2 and that it could be prevented by making sure there remained at least one or two kilos of liquid CO_2. For this, a scale was placed under each cylinder, to measure exactly the amount of CO_2 left inside each cylinder.

Finally, other detachments of the lenticule during the cut, as well as the astigmatisms greater than usual, were found to be due to a faulty adaptation of the disc to the base, caused by the contraction undergone by the tissue during freezing. Up to the time, the disc had been kept in place by capillarity alone. Since this was not enough, we designed a device that houses a small rubber balloon full of air, to press the disc tight against the base (Fig. 2). Once the disc is frozen, the balloon is punctured with a needle and removed from the frozen disc, along with the fixation device. The surgical procedure then continues in the usual way.

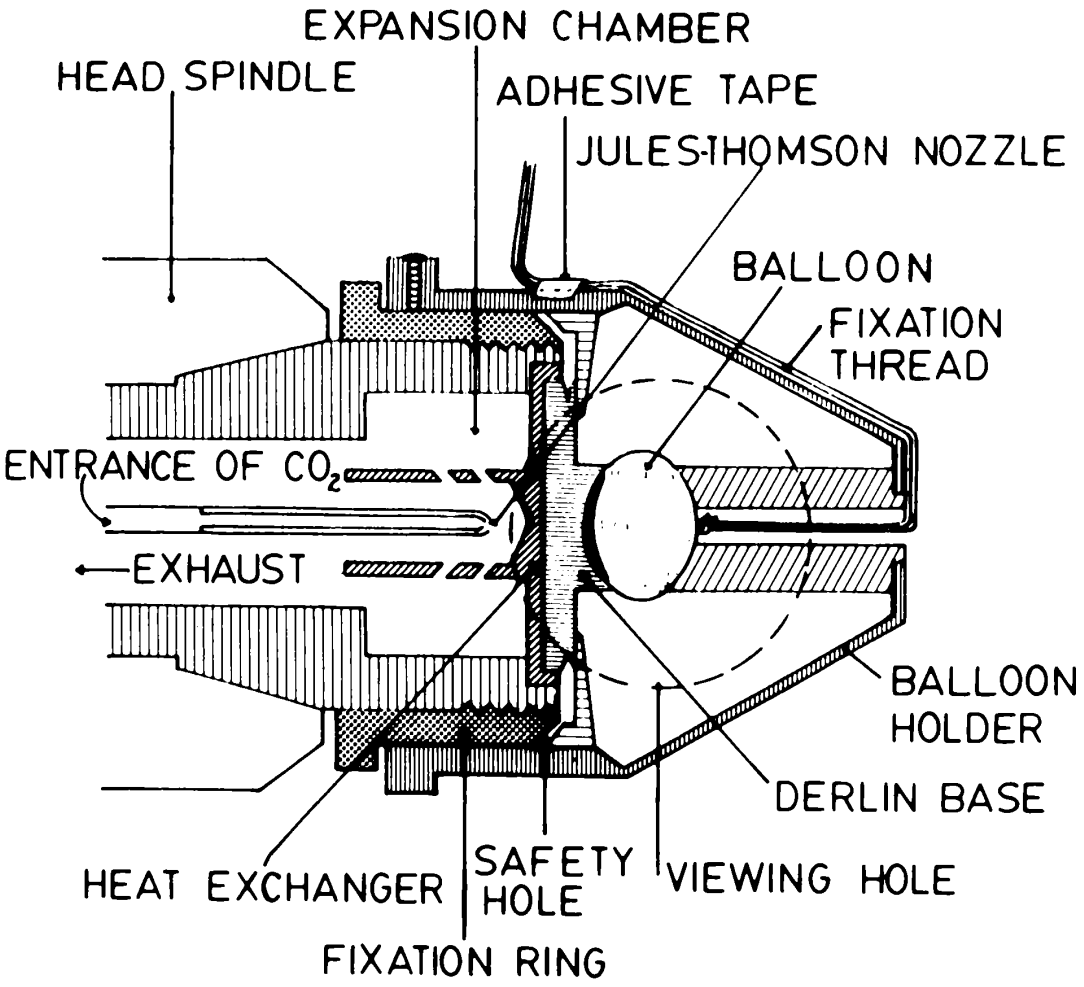

Fig. 2

Sketch of the holder and rubber balloon for the fixation of the corneal disc during freezing.

With the exception of the safety balloon, which just began being used in 1982, the results presented in this paper were obtained with the use of the mentioned safety devices.

INDICATIONS

This procedure is indicated only in cases of myopias of more than 4 diopters which, for one reason or other, cannot benefit from the traditional methods designed for the correction of ametropia. Its main indications are anisometropia and myopies who must have a minimun amount of vision in both eyes without the use of prosthetic devices, to carry on certain professions, as well as patients for whom thick eyeglasses present a strong handicap.

CONTRAINDICATION FACTORS

Myopic keratomileusis is contraindicated in all cases in which by any reason a corneal procedure is contraindicated. In addition, other contraindications are ametropias of less than 4 diopters, irritated eyes, decentered pupils, pathological corneas or corneas that have had inflammatory processes, corneas whose thickness is irregular or less than 0.50 mm, corneas whose curvature radius is less than 7.2 or more than 8.5 mm, glaucoma, marked lacrimal hyposecretion, irreductible amblyopia and palpebral fissures that are not large enough for the pneumatic ring. Since in axial myopias the aniseiconia induced by the correction in corneal vertex must be taken into consideration, it should always be measured preoperatively with a trial contact lens.

The reason for the contraindications are obvious and, although some are relative, should nevertheless be taken into account, in order to consider each case carefully before setting the indication for surgery.

POSSIBILITIES OF CORRECTION

The possibilities of correction are set by the value of the initial radius of the cornea to be operated. More diopters can be corrected when the cornea is steep preoperatively than when it is already flat. Table I shows the amount of correction possible in each case, taking into account that the cornea can be flattened up to a radius of 10.06 mm (33 diopters). It follows then that if the initial curvature of a cornea is 8.30 mm (40 diopters), only 7 diopters can be corrected (40.00 - 33.00), whereas if the initial radius of a cornea is 7.30 mm (45.48 diopters), it is possible to correct up to 12.48 diopters in vertex (45.48 -

33.00). In other words, 14.68 at 12 mm. Besides the limits set, however, the diopters that should be corrected also depend on the amount of aniseiconia that the patient will be able to tolerate, as well as by the refractive condition of the fellow eye. These aspects can be tried preoperatively with trial contact lenses. As a rule, an overcorrection of 20% above the correction necessary should be requested, in order to obtain some amount of hypercorrection to compensate for the postoperative progression of the myopia during the first years after the surgery.

Results

The study of cases with more than 10 years followup shows a decrease of 20% in the correction during the first postoperative year. From then on, in 92% of cases the average myopia progession is 0.37 diopters per year in monocular myopias and 0.50 diopters per year in binocular myopias. In the latter, the average progression is 0.22 diopters per year in the non operated eye (due to axial growth), while in the operated eye from the 0.50 diopters of annual progression 0.20 correspond to corneal steepening and 0.30 to elongation of the anteroposterior axis of the eye.

From the remainder 8% of cases, in half there was no progression of the myopia in either eye, while in the other half there was a late strong progression of up to 3 diopters per year, with posterior staphyloma and Fuchs spot, as well as loss of central vision in half of the cases. This great progression occurred in 70% of operated eyes and 30% of non operated eyes. Such difference may be explained because in all cases the operated eye was the most myopic.

Apart from a sligh Hudson-Stahly line that appeared somewhat under the pupillary border in 77.9% of cases, no late secondary corneal complications have been observed up to the present.

In this paper, the 33 cases operated during 1980-1981 will be analized. From these, 22 cases have an average followup of 8.7 months (3-18) and 11 an average followup of only 30 days. The results are classified by preoperative corrected visual acuity in tables II and III, respectively.

Table IV gathers the averages of both tables (33 cases), with a mean followup of 6.6 months (1-18). These results show the persistance of a slight hypercorrection of 0.04 diopters, an improvement of the uncorrected visual

acuity of 1.100.00%, a decrease of the corrected visual acuity of 10.90% and a decrease of the astigmatism of 0.36 diopters.

The average results of the 22 cases with 8.7 months followup are gathered in Table V. These results show that the difference between the correction requested and the correction obtained is minimal and that there is a marked increase in the uncorrected vision.

If the same 22 cases are classified by preoperative visual acuites of more than 0.40 (Table VI) and less than 0.40 (Table VII), we can see that during the mentioned period of time in the former there is a decrease of 0.15 in the corrected vision, as compared with preoperative figures, while in the latter there is an increase of 0.16 in the same respect. It should be noted that in previous statistics the improvement of the visual acuity persisted in spite of the myopia progression of subsequent years, so long as no myopic choroidoretinal lesions appeared. This improvement can only be explained by the recuperation of some amount of amblyopia and the increase in the size of the retinal image.

Table VIII gathers only the 8 cases with 1 year folloup or more, from the total 33 cases of the study. This group shows that as a whole the corrected postoperative vision in higher than what it was preoperatively and that the cases with a preoperative visual acuity of less than 0.40 have tripled their vision.

In all cases, the pre and postoperative refraction and visual acuity was taken by someone other than the surgeon.

COMPLICATIONS

Although the operative and postoperative complications possible in the procedure are several, all can be reduced to very low percentages through proper team work and a strict attention to details. In the series presented, no operating complications were observed. The only postoperative complication was one case of epithelialization of the interface (Fig. 3, Case 10), in which it was necessary to perform a homoplastic keratomileusis, with good results.

SUMMARY

The results of keratomileusis for the correction of myopia are satisfactory, so long as the indications and limits set for the procedure are respected and the highly specialized infrastructures and human team are gathered to meet the different medical and extra-medical requirements of the procedure.

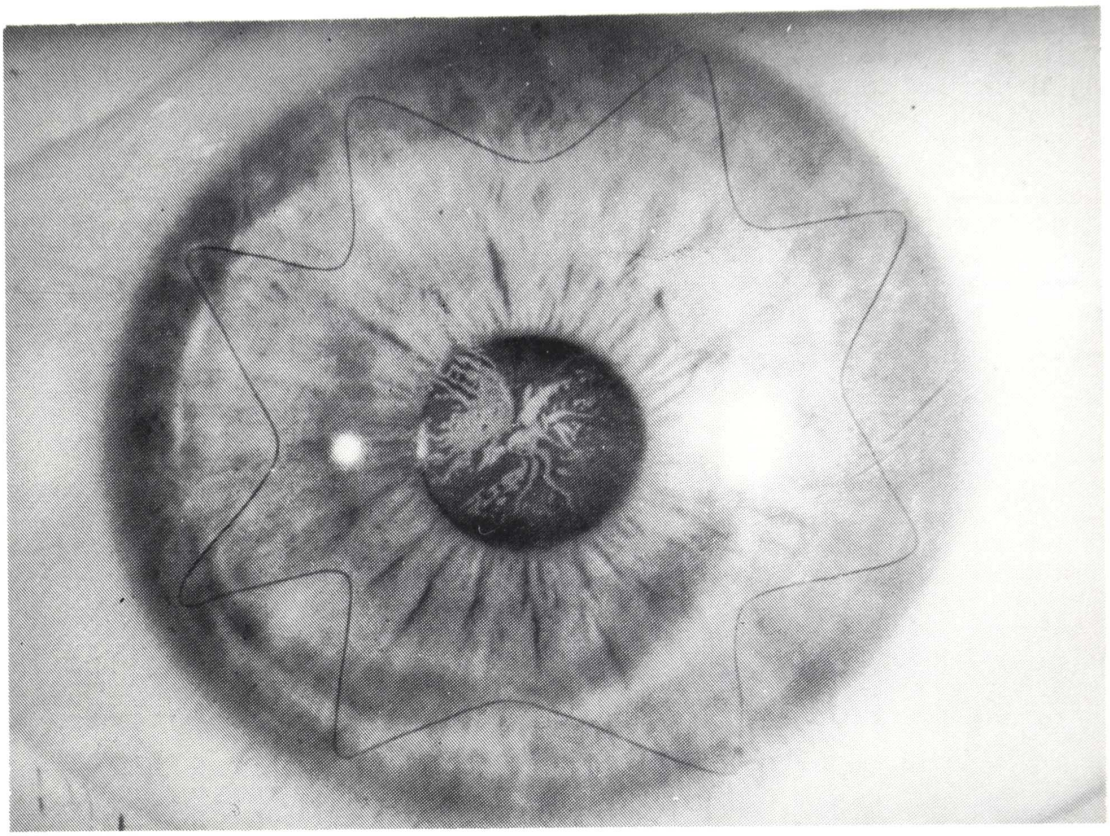

Fig. 3

Epithelial ingrowths in a case of myopic keratomileusis.

Table I

LIMITS OF CORRECTION IN KMM

Radius (mm)	Diopters	Radius (mm)	Diopters
10.06	33	8.30	40
9.76	34	8.10	41
9.46	35	7.90	42
9.22	36	7.72	43
8.97	37	7.55	44
8.74	38	7.38	45
8.51	39	7.22	46

Table II

MYOPIC KM 1980-81

CASES WITH 8.7 MONTHS FOLLOWUP (3-18)

Case No.	Preop C/V.A.	Sph. Equiv.	Months	Postop U/V.A.	Postop C/V.A.	Postop Sph. Equiv.	Acuity Change
1	1.00	— 8.62	12.00	0.67	1.00	1.25	0.00
2	1.00	— 7.00	6.00	0.30	0.60	1.50	—0.40
3	1.00	—12.00	3.00	0.40	0.60	1.08	—0.40
4	0.80	—13.00	18.00	0.40	0.67	— 1.50	—0.13
5	0.80	—11.75	3.00	0.25	0.60	— 2.00	—0.20
6	0.80	—13.25	18.00	0.40	1.00	0.25	+0.20
7	0.75	— 8.75	5.00	0.33	0.62	—3.50	—0.13
8	0.67	—12.00	18.00	0.25	0.50	— 0.75	—0.17
9	0.67	—13.25	11.00	0.10	0.50	2.75	—0.17
10	0.62	—11.25	10.00	0.30	0.50	0.50	—0.12
11	0.62	—11.50	3.00	0.33	0.50	— 2.00	—0.12
12	0.50	—20.00	15.00	0.10	0.40	— 2.25	—0.10
13	0.33	—15.12	5.00	0.10	0.33	— 4.37	0.00
14	0.25	—14.00	4.00	0.10	0.50	0.00	+0.25
15	0.25	—10.75	5.00	0.05	0.20	— 7.00	—0.05
16	0.22	— 9.00	12.00	0.25	0.50	1.75	+0.28
17	0.20	—17.50	5.00	0.03	0.29	—10.62	+0.09
18	0.15	— 7.25	7.00	0.12	0.15	— 0.50	0.00
19	0.10	—18.00	12.00	0.40	0.67	0.37	+0.57
20	0.10	—16.87	12.00	0.10	0.15	— 4.50	+0.05
21	0.05	—14.00	4.00	0.03	0.10	— 3.87	+0.05
22	0.01	—10.50	5.00	0.05	0.40	— 5.37	+0.39
Gen. average	0.50	—12.52	8.77	0.23	0.49	—1.76	—0.01
With. VA > 0.40	0.77	—11.86	10.00	0.32	0.62	—0.39	—0.15
With. VA < 0.40	0.17	—13.30	7.10	0.12	0.33	—3.41	+0.16

Table III

MYOPIC KM. 1980-81

CASES WITH 1 MONTH FOLLOWUP

Number	Preop C/V.A.	Preop Sph. Equiv.	1 Mos U/V.A.	1 Mos C/V.A.	1 Mos Sph. Equiv.	Acuity Change
1	1.00	— 8.50	0.50	0.67	0.25	—0.33
2	1.00	— 7.00	0.25	0.62	3.25	—0.38
3	1.00	— 5.75	0.40	0.50	—0.12	—0.50
4	1.00	—6.75	0.30	0.50	0.12	—0.50
5	0.80	— 8.62	0.55	0.67	—1.12	—0.13
6	0.80	—11.25	0.10	0.33	6.00	—0.47
7	0.45	— 7.50	0.33	0.40	1.00	—0.05
8	0.40	—14.75	0.08	0.40	—6.75	0.00
9	0.40	—14.25	0.33	0.40	2.67	0.00
10	0.29	— 9.00	0.08	0.40	4.00	+0.11
11	0.20	—17.50	0.05	0.20	—8.12	0.00
General average	0.67	—13.00	0.27	0.46	0.11	—0.20
With V.A. >0.40	0.86	— 7.91	0.35	0.53	1.34	—0.34
Whith V.A. <0.40	0.32	—13.88	0.14	0.35	—2.05	+0.03

Table IV

MYOPIC KM. 33 CASES 1980-81

6.6 MONTHS FOLLOWUP (1-18)

CORRECTION OBTAINED	+0.04D
UNCORRECTED V.A.	+1.100.00C
CORRECTED V.A.	10.90C
ASTIGMATISM	0.36D
AXIS MODIFICATION	23.75°

Table V

MYOPIC KM. 22 CASES WITH 8.7 MONTHS FOLLOWUP. 1980-81

	Preop		Postop
Myopia (Spher. Equiv.)	—12.52		— 1.76
Astigmatism	— 2.32		— 1.96
Uncorrected V.A.	0.02		0.23
Corrected V.A.	0.50		0.49
Correction Resquested	—10.59	Obtained	—10.76
Loss of corrected V.A.			0.01
Increase of uncorrected V. A.			0.21

Table VI

MYOPIC KM. 12 CASES WITH PREOP V.A. MORE THAN 0.40

8.7 MONTHS FOLLOWUP. 1980-81

Preop ametropia	—11.87
Corrected V.A.	0.77
Postop uncorrected V.A.	0.32
Residual ametropia	— 0.39
Postop corrected V.A.	0.62
Loss of corrected V.A.	0.15
Increase of uncorrected V.A.	0.30

Table VII

MYOPIC KM. 10 CASES WITH PREOP V.A. LESS THAN 0.40

8.7 MONTHS FOLLOWUP. 1980-81

Preop ametropia	—11.30
Corrected V.A.	0.17
Postop uncorrected V.A.	0.12
Postop ametropia	— 3.41
Postop corrected V.A.	0.33
Increase of corrected V. A.	0.16
Increase of uncorrected V.A.	0.10

Table VIII

MYOPIC KM 1980-1981

8 CASES WITH 12-18 MONTHS FOLLOWUP

Case No.	Preop C / V.A.	Preop Sph. Equiv.	Followup Months	Postop U / V.A.	Postop C/V.A.	Postop Sph. Equiv.	Acuity Change
1	1.00	— 8.62	12.00	0.67	1.00	+1.25	0.00
4	0.80	—13.00	18.00	0.40	0.67	—1.50	—0.13
6	0.80	—13.25	18.00	0.40	1.00	+0.25	+0.20
8	0.67	—12.00	18.00	0.25	0.50	—0.75	—0.17
12	0.50	—20.00	15.00	0.10	0.40	—2.25	—0.10
16	0.22	— 9.00	12.00	0.25	0.50	+1.75	+0.28
19	0.10	—18.00	12.00	0.40	0.67	+0.37	+0.57
20	0.10	—16.87	12.00	0.10	0.15	—4.50	+0.05
Gen. avera	0.52	—13.84	14.63	0.32	0.61	—0.67	+0.09
With VA>0.4	0.75	—13.37	16.20	0.36	0.71	—0.60	—0.04
With VA<0.4	0.14	—14.62	12.00	0.25	0.44	—0.79	+0.30

JOSE I. BARRAQUER

REFERENCES

AINSLIE, D.: *Unilateral myopia.* Personal observations. Arch. Soc. Amer. Oftal. Optom, 10, 373, 1975.

AINSLIE, D.: *The surgical correction of refractive errors by keratomileusis and keratophakia.* Ann Ophthal., 8, 3, 1976.

BARRAQUER, J. I.: *Resultados de la queratomileusis en corrección de miopía y queratofaquia en corrección de afaquia en 1976.* An Inst. Barr., 14, 351.

BARRAQUER, J. I.: *Queratomileusis y queratofaquia.* Bogotá: Litografía Arco, 1980.

SWINGER, C. A., BARRAQUER, J. I.: *Keratophakia and keratomileusis. Clinical results. Ophthalmology, 88, 709, 1981.*