Goal and results of reedepenening technique in radial keratotomy

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Introduction

The technique of redeepening the incision towards the periphery in an attempt to adjust depth to corneal thickness rises a series of problems regarding the wider field of radial keratotomy in its correcting possibilities, its predictability, its safety and the stability of results. Most refractive surgeons now agree that the correcting effect, i.e. the corneal bulging effect produced by an incision, relates not so much to the amount of incised tissue, but rather to the amount of uncut tissue (1). Hence, the less tissue remains intact with an incision, the greater the correcting effect of a radial keratotomy.

The problem would be easily solved if the cornea were equally thick in all its point, but its thickness varies not only gradually towards periphery but also along the different meridians.

Not taking into account the thickness variation along the different corneal meridians, single-pass incisions, as were those performed in PERK study (2), inevitably yield not only extremely varied results with poor predictability but also disappointing results in terms of visual acuity due to the asymmetrical bulging modifications of the cornea (3).

According to clinical observation, if in an incision there remains uncut tissue bridges or if a perforation is produced, the corneal bulging effect appears reduced in the first case and increased in the second instance. Both situations lead to an asymmetry of the corneal surface if the incision irregularity is restricted to only one meridian.

Generally, the concept now followed is that of performing incisions while leaving at the bottom some uncut tissue as uniform as possible in terms of quantity.

The technical solution to this problem has not been found as yet, and it can only be reached by combining an instrument giving a continuous measurement of corneal thickness with a knife with a tip that can be adjusted in real time depending on thickness variations. For the time being, we must be contented with an approximate incision uniformity, which is the main reason for the not yet satisfactory predictability of radial keratotomy.

In an attempt to obtain the greatest possible uniformity of uncut tissue, the technique of incision redeepenings when the corneal thickness becomes higher has taken root. First proposed by Fiodorov (4), at the beginning the technique of peripheral redeepenings of incisions was not followed by many. Most surgeons preferred to act on the number of incisions rather than on their depth in order to obtain a greater correcting effect. Only a few surgeons suggested the use of the redeepening procedure in their programmes. Sawelson proposed a redeepening with a 6-mm optical zone, increasing incision depth by 0.05 mm (5). Sawelson's technique is used by the school of José I. Barraquer (6) and by Ellis (7). Tate proposed two redeepenings on areas of diameters measuring 6 and 9 mm with a 3-mm optical zone (8). Most likely, now some surgeons have modified their procedures by adopting peripheral redeepenings, but this has not yet been reported in the literature. It his latest book, Waring (9) asserts that there is still no convincing publication on an increased correcting effect of redeepenings.

We have been using this procedure since 1982, and in order to determine the influence of redeepenings on the final correction of myopia we have collected the data on the patients we have operated upon in the last 5 years.

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procedures were used: either to dissect these parts of tissue with a high level of magnification by using Dossi's technique or to rotate the knife performing a redeepening by starting slightly before the point determined for the redeepening.

All in all, this study was carried out on the results of primary surgery on 440 patients ranging from 20 to 40 years of age. This series does not include cases of secondary surgery. The number of patients belonging to one of the subgroups is listed in the table below.

Table 1

Number of cases belonging to different categories according to the type of redeepening

No. redeep	0	1	1	2	2	3	
Diam. redeep	None	6	7	5-7	6-8	5-7-9	Total
No.inc.							
6	8	8	10	15	27	43	111
8	15	10	17	105	48	134	329

Results

Tables 2 and 3 show the mean, the highest and the lowest correcting value and the standard deviation for each group and subgroup, determined as spheroequivalent value. Unfortunately, such marked a division into subgroups caused a decrease in the number of cases in each series, so that, from a statistical standpoint, some date may have only an indicative value. Nevertheless, their importance increases greatly if compared with the results of the other series.

Table 2

Mean correcting effect with 6 radial incisions and redeepenings

Redeep. Diameter	None	1 (6)	1 (7)	2 (5-7)	2 (6-8)	3 (5-7-9)
Average	3,77	3,92	4,24	4,54	4,72	5,24
Max	3,63	2,63	3,13	1,38	2,88	4,00
Min	4,38	5,25	5,50	7,50	6,25	6,25
St. Dev.	0,31	0,83	0,78	1,17	1,42	0,80

Table 3

Mean correcting effect with 8 radial incisions and redeepenings

Redeep. Diameter	None	1 (6)	1 (7)	2 (5-7)	2 (6-8)	3 (5-7-9)
Average	4,38	5,03	4,68	5,20	5,40	6,51
Max	3,25	3,75	3,50	1,75	4,25	-1,75
Min	5,63	6,25	5,75	9,50	6,50	11,00
St. Dev.	0,82	0,79	0,77	1,55	0,70	1,79

Discussion

An examination of the mean correcting values of the individual groups clearly shows that redeepenings increase the correcting effect by up to 1.5 Dpts. for 6 incisions and over 2 Dpts. for to 1.5 Dpts. for 6 incisions and over 2 Dpts. for 8 incisions from single-pass incisions to go against some authors' opinion whereby the correcting effect of radial keratotomy is related basically to the part that is closest to the optical zone and that the rest of the incision has little influence (11).

The redeepening procedure not only yields better results, but it also reduces its variability, since the coefficient of corneal thickening towards the periphery varies from person to person. On these grounds, since redeepenings adjust to thickness variation, these allow a more consistent response.

It is intuitive that the single-pass procedure, even with the same number of incisions, yields a different correcting effect in corneas whose thickness increase towards the periphery varies. Thus, beside offering a greater correction, there is also a higher level of predictability. Incision depths must clearly vary not only in a centrifugal but also in a circular sense, so as to leave the same quantity of uncut tissue in each of the incised areas.

We decided to control the phenomenon of progressive hypermetropy, and we noted

Materials and Methods

Since almost 1987, our technique has been based on the concept of reducing the number of incisions and trying to obtain instead a greater correction with a greater depth, by performing peripheral redeepenings. With the increase of our experience and of our and patient's demands, the concept of uncut tissue uniformity has been applied to the technique of "differentiated depth" both along the various meridians and towards the periphery. This can be obtained by changing the knife tip on the basis of the pachymetric data registered in the different radial markings and with different zone diameters in relation to the desired correcting effect. Thus, the knife tip is changed not only according to the centrifugal increase but also depending on the thickness variation in the different meridians.

Sampling criteria:

The results reported here refer to patients operated since 1987, because since then our technique has been modified with the characteristics reported further on. We have reported those cases in which a simple radial keratotomy alone was performed without other incisions for astigmatism, either transverse or curved.

For a better assessment of the results, all patients over 40 or under 20 years of age have been excluded. For the same reason, cases with a corneal diameter over 11.5 mm or under 10.75 and of a thickness over 0.58 mm and under 0.45 mm were also excluded, since in our experience these variables greatly influence the result.

With the above-mentioned limitations, two main series of patients were gathered with either 6 or 8 radial incisions. Yet, given that redeepenings may vary in number and distance from the centre, subgroups have been formed, dependending on the characteristics of these redeepenings. The system has been used whereby the term "diameter" refers to the point in which the redeepening begins. For instance, a redeepening made at diameter 7 begins at 3.5 mm from the centre of the optical zone. Thus, each group with either 6 or 8 incisions has the following subgroups:

1) With no redeepening;
2) Two subgroups with only one redeepening with a diameter at either 6 or 7 mm;
3) Two subgroups with two redeepenings at either and 5 and 7 mm or at 6 and 8 mm;
4) One subgroup with three redeepenings with diameters 5, 7 and 9 mm.

The procedure has not changed in the course of the last five years apart from an improved control of the scalpel and, obviously, a greater experience and skill. The pillars of the technique we have used are the following:
- All cases were operated by the first Author;
- Alignment of the optical zone with the pupillary axis;
- All cases presented with a 3-mm optical zone;
- Either round or radial marking depending on the surgical plan;
- Intraoperative pachymetry at mark crossing;
- The most central part of the incision was performed with a centripetal movement of the scalpel with an incision depth equal to the most central pachymetric reading, so that the central part of the incision is really perpendicular. Incisions of the same depth are grouped together whenever pachymetric readings are not over 0.02 mm of thickness selecting the lowest value so as to avoid microperforations. Recently, this can be obtained by using a computer programme conceived by Camellin (10).

- All redeepenings were made by the centrifugal technique, by augmenting the blade by 0.01 mm of the pachymetric reading registered at the starting point of the incision, always with the same incision grouping criterium. The use of this technique for redeepenings has drastically reduced down to 3.4% microperforations.
- In the case of a marked pupillary decentering, the criterium of isometric incisions was adopted, according to our previous publications (3).

Obviously, the use of the redeepening technique, in the conjunction of the parts with a different depth there remain parts of uncut tissue or "bridges", which may reduce the correcting effect. In order to dissect these bridges, two

remarkable differences with respect to other scientists' statistics. It must also be said that at least primary surgery is rarely performed with more than 8 incisions.

Yet, the statistics reported in this study only refer to patients under 40 years of age, in which the phenomenon of progressive hypermetropic shifting is less frequent. Beyond this age limit, redeepenings were used with great caution to avoid overcorrection and progressive hypermetropic shifting. As Waring rightly stated (9), this technique requires a greater amount of time with the risk of corneal dehydration and thinning. To avoid this drawback, it is necessary to maintain the same himidity and temperature in the patient's environment and a constant corneal wetting with a Merocel sponge.

Conclusions

The redeepening technique is useful to increase the correcting effect by up to 1.5 Dpts. with 6 radial incisions and by over 2 Dpts. with 8 incisions. When used in patients under 40 years of age, it never presented with noteworthy side effects, considerable daily refraction variations or progressive hypermetropy. Thus, this procedure should also be applied in view of the greater predictability of its results.

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