CORNEAL TREPHINING FOR PENETRATING KERATOPLASTY*

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MANY complications following corneal grafting procedures may be attributed to the technical and biological problems associated with this type of surgery. It is generally agreed that accurate apposition of the graft to the margin of the incision in the recipient cornea is of the greatest importance.

Manual trephining for penetrating keratoplasty frequently results in badly cut grafts, and for this reason many modifications of the simple Elliot trephine have been made. Mechanically driven trephines have been used by Castro-viejo (1941) and Green (1945). Punch devices have been employed by Wiener and Alvis (1940), Clark (1954), and Pittar (1954). Other special techniques have been devised by Amsler and Verrey (1948) and Franceschetti (1955) to reduce the discrepancy between the shape of the graft removed from the donor eye and the place prepared for it in the recipient.

These techniques have not been widely accepted, however, and Stansbury (1949) states that "considering that the much-to-be-desired complete incision is not likely to be obtained with any of the more complicated instruments yet devised, the simplicity of the manual trephine warrants its further employment". Michaelson (1954) describes the variation in the bevel of the graft and recipient bed which occurs when trephining is performed under conditions of altered intra-ocular pressure. A high pressure increases the corneal curvature, so that when the elasticity of the graft restores the curvature to normal the internal diameter of the disk is greater than the external diameter (Fig. 1). Thus the bevel of a graft cut under high pressure slopes outwards, and conversely, when the pressure is low, it will slope inwards. Therefore, to perfect a technique of corneal trephining, not only must a complete disk be obtained, but also one whose bevel is constant.

FIG. 1.—Effect of high and low intra-ocular pressure on shape of corneal grafts.

*Received for publication November 22, 1955.

It is extremely difficult to align a manual trephine so that the inner layers of the cornea are instantaneously incised at all points below the cutting edge of the instrument. As a result a change occurs in intra-ocular pressure before the incision has been completed owing to aqueous leakage. The resistance to the cutting action of the trephine is thus altered, and an incomplete disk, or one with an irregular bevel, is obtained.

In view of these considerations, and in an effort to improve the standards of corneal trephining, a mechanical trephine and two instruments for immobilizing the donor and recipient eye under conditions of constant intra-ocular pressure have been constructed. Rabbit and monkey eyes were used as experimental material. The grafts were studied with a dissecting microscope after formalin fixation, because a freshly-cut graft was found to be so pliable that its true shape could not be properly assessed.

Trephining the Donor Eye.—The mechanical trephine constructed for these experiments bears a functional resemblance to a small drill press. The rotating trephine can be moved towards or away from the cornea with considerable precision. The rigid frame facilitates retention of alignment once this has been achieved by means of the ball-joint mountings. A 5.5-mm. trephine is employed and a wax plug is inserted 1.5 mm. inside the cutting edge to reduce aqueous leakage.

The immobilizer (Fig. 2 *a, b*, overleaf), designed for holding the donor eye securely and controlling the intra-ocular pressure, consists of a cylindrical chamber (A) covered at one end by a removable, centrally perforated, methacrylate cap (B). At the other end is a metal baseplate through which a channel is drilled connecting with a fluid reservoir. Sealed to the junction of the chamber wall and the base-plate is a loose rubber diaphragm (C) which rises as water enters from the reservoir. The eye to be trephined is placed on the diaphragm and the methacrylate cap is brought down to its locating ring so that the cornea herniates through the central hole. Intra-ocular pressure is varied by raising or lowering the reservoir, thus altering the hydrostatic pressure exerted upon the thin rubber diaphragm in contact with the eye.

Preliminary experiments showed that a minimum intra-ocular pressure was necessary to prevent undue deformity of the cornea during the trephining operation. If the pressure were too low, variable dimpling of the cornea occurred, producing a change in the angle of bevel. The monkey cornea is thicker than that of the rabbit and offers more resistance, so that the pressure had to be raised to a greater degree.

Grafts cut by various methods are shown in Figs 3-8 (overleaf).

Figs 3 and 4 illustrate grafts cut under high and low pressure respectively. The difference in bevel is easily appreciated. In Fig. 5 the bevel of the graft changed owing to dimpling of the cornea as resistance to cutting increased. Fig. 6 shows the smooth uniform edge of a well-cut graft. Figs 7 and 8 show a graft taken from a monkey eye by manual trephining; scissors were necessary to complete the circular incision and at this point the graft has an abnormal bevel and frayed edges.

Figs 2 (a) and (b).—Immobilizing chamber designed to control movement and intra-ocular pressure of donor eye. $\frac{1}{4}$ actual size.

A series of sixteen eyes was trephined with the help of the instruments described above. Twelve of the grafts obtained were complete disks, and only small remnants remained when cutting was incomplete. A careful examination of these disks revealed a few abnormal bevels, which were due to incorrect alignment of the trephine. In subsequent work, with increasing operative skill, these defects were largely eliminated.

Trephining the Recipient Eye.—It was difficult initially to apply to the recipient eye the principles of trephining established by experiments on the donor eye. Pressure could not be applied from below because of the risk of lens dislocation. Lindner (1951), Amsler (1951), and Schreck (1953) have used a needle placed in the anterior chamber to increase the intra-ocular

FIGS 3 to 8.—Grafts removed by different trephining techniques (indirect illumination). $\times 9.8$.

pressure during trephining, but the chief drawback to their technique is the difficulty of immobilizing the eye. There is a constant risk of injuring the

the lens, should the eye or needle move independently of each other. For this reason a metal ring and handle were designed for immobilizing the recipient eye. The shape and construction of the ring made it possible to suture it firmly and quickly to a rabbit eye, just outside the limbus (Fig. 9). A needle, inserted in the anterior chamber and connected by polyethylene tubing to a pressure system, was used to increase ocular tension to the same level as that employed in trephining the donor eye. Once the needle had been inserted into the anterior chamber, it was firmly attached by an adjustable clamp to the handle of the ring. The eye and needle could then be moved together in any direction without endangering intra-ocular structures, and this was of great assistance in accurately aligning the trephine. It is surprising, as Schreck and Amsler have pointed out, how deep the anterior chamber becomes, through slight bulging of the cornea and depression of the iris lens diaphragm, when pressure is increased. This minimizes the chances of injuring the lens by a penetrating trephine.

FIG. 9.—Immobilizing ring and anterior chamber needle attachment designed to control movement and intra-ocular pressure of recipient eye.

A series of eighteen rabbit eyes was trephined by this method and in all but one a complete disk of corneal tissue was obtained. The inner edges of three disks had a very small tag, as if Descemet's membrane had been stretched at this point before cutting was completed. In three others the bevels were steeper on one side, as in Fig. 7, through poor alignment of the

trephine. The remaining grafts were quite uniformly cut. Five animals had recently recovered from vaccinia keratitis, and the corneae were irregular in thickness. Another animal had been previously grafted and the corneae were bulging and thinned out. Thus the conditions of trephining were comparable to those found in diseased human eyes.

Summary

Many attempts have been made to improve upon the technique of manual trephining for keratoplasty in view of the importance of accurate apposition of the graft to the recipient eye. It has been recognized that manual trephining entails many inherent technical difficulties, such as immobilization of the eye, control of intra-ocular pressure, alignment of the trephine, and accurate use of scissors. These problems place great demands on the surgeon's skill and a solution was sought in the form of mechanical aids.

The donor eye is held inside a special immobilizing chamber which permits a controlled uniform pressure to be applied to the eye. The recipient eye is held by an immobilizing ring, and fluid loss during trephining is replaced through a needle inserted into the anterior chamber. By means of these devices it is possible to control the intra-ocular pressure and the movement of both donor and recipient eyes. When the trephine is accurately aligned very satisfactory results are obtained.

Experiments with rabbit and monkey eyes have shown that by these methods complete disks of corneal tissue, with uniformly bevelled edges, can be trephined in a high proportion of cases from both donor and recipient eyes.

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