A new system of microsurgery for human and experimental corneal grafting

I. The contact lens corneal cutter, stereotaxic eye holder, donor disc chuck, and frame

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SUMMARY A new microsurgical system is presented for human and experimental corneal grafting. The system is based on novel methods of corneal cutting and holding which simplify collection procedures and minimise operator manipulation during transplantation.

This year marks the centenary of von Hippell's trephine, the principle of which still dominates corneal cutting (von Hippell, 1877) despite the array of supportive instruments and materials that have since been developed. The advent of the operating microscope has revolutionised the design and scope of corneal instruments. With the exception of Drews's corneal trephine (Drews, 1974) and the more complex instrument by Lieberman (Lieberman, 1976) the basic cutter has altered little. Several motorised trephines have been developed (Arato, 1951; Kadesky, 1951; Draeger, 1971; Dausch and von der Fecht, 1976).

The cutting instrument and accessories described here form a new system for microsurgical sectioning of the cornea. As a result, the task of donor collection and distribution has been transformed, existing techniques for penetrating keratoplasty have been simplified, and the place of lamellar grafting has been extended both experimentally and therapeutically.

The cutter is hand held and hand operated, the end result of five years' development. During this time a number of automated models were discarded as unnecessarily complicated.

The accessories consist of a stereotaxic eye holder, a donor disc chuck, a corneal frame, and blade forceps. In an age of increasing complexity and cost for surgical instruments this system offers simple design, operation, and maintenance.

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Technical description of instruments

CONTACT LENS CORNEAL CUTTER (CLCC)

The CLCC has a circular funnel-shaped body made of surgical-grade stainless steel. Two knurled rings on the outer facing of the wide upper end of the funnel provide for a firm grip of the instrument (Fig. 1). The narrow lower end of the funnel is closed by a quartz lens designed to fit the cornea. A flanged, interchangeable footplate surrounds the outer rim of the contact lens. The footplate is notched on its inner aspect, which fixes the limbal area of the globe, preventing rotation of the eye during cutting (Fig. 2).

Two control rods project upwards parallel to the side of the body casing. Both rods have a steel shaft to which is attached a length of silicone rubber tubing for fine control. The body is perforated by upper and lower windows. The upper window is open; it is the loading gate for the disposable knife blade. The lower window is occupied by the circular driving mechanism of the knife carriage and is largely obscured from view by a protective cover which prevents tissue entrapment in the gears (Fig. 3).

Of the two control rods, one is retractable and couples with a micrometer screw to set the depth of cut; a full turn advances the knife tip by 0.3 mm (Fig. 4). The other rod is fixed in the lower window and rotates the cutter.

The knife blade is made of hand-honed steel. The non-cutting upper end slots into the micrometer screw (Figs. 3 and 5).

The CLCC is stored on its side in a spring grip,

Fig. 1. The contact lens corneal cutter (CLCC)

Fig. 2. The CLCC viewed from below. The single-point cutter is seen projecting from the knife race formed by a groove in the quartz contact lens. Notching of the foot plate makes muscle holding sutures redundant during surgery

Fig. 3. Side view of the CLCC. On the left is the fixed control rod for the driving mechanism. Centrally the micrometer screw is seen through the open window. Note the knife blade slotted into the grooved upper end of the micrometer. Top right is the retractable control rod which sets the depth of the knife blade

Fig. 4. Internal view of the CLCC with the retractable control rod lowered and engaged into the micrometer screw

Fig. 5 The blade loading procedure using fine forceps grooved at the tips. The flanged upper end of the knife blade is seen prior to engagement into the micrometer screw (arrowed)

Fig. 6 General view of the CLCC system in carrying case ready for autoclaving. Top right, stereotaxic eye holder (SEH). Top left, 9 and 8 mm CLCCs. Bottom right, 7 mm CLCC. Bottom left, blade loading forceps pointing to the 3 donor disc chucks (DDCs) corresponding to the sizes of the CLCCs. Centrally, interchangeable foot plates for the CLCC

Fig. 7 The stereotaxic eye holder (SEH). The circular base is inset into a surgical arm rest. An enucleated cadaver eye is held in the cup of the SEH by a retaining ring

Fig. 8 The donor disc chuck (DDC) is held centrally in the crossbar of the holding bracket. Also fixed on this bracket is the corneal frame (CF) with its 4 suture retaining lugs

one limb of which passes through the upper window of the instrument body. Three instrument sizes of 7, 8, and 9 mm are currently available (Fig. 6).

Care and sterilisation of the CLCC

The instrument is sterilised by flash autoclave. The

disposable blades are prepackaged and sterilised by irradiation. Immediately after use of the CLCC, the blade should be retracted by the assistant and removed from the instrument body. The body itself should be soaked in clean hot water and subsequently dried in a stream of compressed air. The contact lens should be cleansed by standard optical techniques.

Fig. 9 A DDC with corneal donor button in place, endothelial surface uppermost. Note that the chuck is not yet closed

Fig. 10 The DDC has closed around the donor corneal disc, by plunger action. Sutures are placed symmetrically without any gripping forceps

STEREOTAXIC EYE HOLDER (SEH)

Slightly differing models of holder have been developed for human and animal eyes. The SEH is mounted on a circular base which fits into a surgical arm rest. Apart from the main base the holder consists of a cup with retaining ring, through which steady pressure can be applied to an eye. The cup can be rotated full circle and is supported on a horizontal movable bracket (Fig. 7). The place of the stereotaxic holder in routine penetrating graft surgery has been diminished by the development of the donor disc chuck and frame (Fig. 8). However, it retains an important role in surgical training and research, in the preparation of lamellar corneal discs, or when any enucleated donor eye is available for grafting. This holder bears a striking resemblance to the stereotaxic device for experimental eye surgery reported by Arentsen and Duran from the University of Chile (Arentsen and Duran, 1976).

DONOR DISC CHUCK AND FRAME (DDCF)

The DDC holds the corneal button firmly around its sloping stromal edge with the endothelial surface facing upwards (Fig. 9). Opening and closing of the chuck are brought about by simple plunger action. The chuck can also be rotated through 360° and tilted relative to the horizontal plane. Four slots are located symmetrically around the chuck margin so that sutures can be placed without the use of tissue forceps. The path of the needle through the corneal button is determined by the radius of curvature of the needle as it slides through a matching curve in the metal chuck. The clean-cut edge of Descemet's membrane and the endothelial cell layer are free of mechanical interference by the suture threads or the holding device (Fig. 10). Chuck and frame are mounted on a solid-based bracket. Two holes located diagonally on the upper edge of the bracket serve to steady the frame during suturing. Different-sized chucks can be interchanged by adjusting the screw system of the crossbar (Fig. 8).

BLADE FORCEPS

Fig. 5 shows forceps grooved internally near the tips to grasp and load the knife blade into the body of the CLCC.

Donor collection and preparation

From enucleated cadaver eyes. When enucleated cadaver eyes are available for grafting, the donor corneal disc is prepared under the operating microscope with the CLCC (Fig. 11). In those few cadaver eyes where the corneal cut is not full thickness

around 360° of the circumference (Fig. 12), the cut may be completed with the Grieshaber oscillating knife (Crock, 1977).

From cadaver eyes in situ. For donor collection outside the operating theatre, in a morgue, a ward, or at a private residence a loupe is used with the CLCC in place of an operating microscope. Cosmetic

Fig. 11 Preparation of a donor corneal disc from an enucleated cadaver eye. The operator is controlling the CLCC through an OPM16 (Zeiss Oberkochen) microscope. The recipient's eye has been covered by a white gauze square

Fig. 12 Incomplete penetration of donor cornea by the CLCC

Fig. 13 Cadaver eye in situ

Fig. 14 Surgeon removing donor cornea in mortuary with CLCC. Optical control is by COMMIDO

reconstruction of the donor eye is made with a simple haptic contact lens (Figs. 13, 14, 15, 16, 17, 18). Cyanoacrylate (Eastman 910) ensures adhesion of the plastic lens to the globe and firm closure of the lids over the prosthesis. The donor disc is immediately placed in storage medium (McCarey and Kaufman, 1974). Transplantation is performed ideally within a few hours of such collection.

OPERATING THEATRE TECHNIQUE

The patient's head and eye posture have overriding importance in ensuring, if at all possible, that the recipient cornea is centrally located between the open lids without the need for muscle traction sutures. The angle of incision of the corneal cutter makes redundant a preparatory anterior chamber tap for air or liquid injection.

Fig. 15 *Incomplete cut of donor disc which will be completed with corneal scissors*

Fig. 16 *Cosmetic haptic contact lens, coated with cyanoacrylate glue, being fitted to cadaver eye after excision of donor corneal disc*

Fig. 17 *Cosmetic haptic lens glued in place*

Fig. 18 *Cadaver lids closed over haptic lens. Cyanoacrylate glue has been applied to lid margins*

Specific operational instructions for corneal cutting may be obtained from the makers of the CLCC.*

Discussion

A most important step in any corneal grafting procedure is accurate cutting. The following principles should govern such microsurgical sectioning of the cornea.

Continual microscopic visual control through all stages of the operation, including where possible, complete encirclement of diseased tissue, and accurate estimation of incision depth are essential. There should be minimal distortion of the globe and minimal bleeding from vascularised tissues during cutting. Clean wound edges should be produced free from tissue deformation to allow precise wound closure through the apposition of a perfectly matching donor button.

Attention to the foregoing precepts should allow surgical exposure of particular tissue planes, for example, Descemet's membrane, as occasion may demand. Wound edge preparation should be consistently accurate so that, in the event of rupture occurring in Descemet's membrane during attempted deep lamellar grafting, conversion to a penetrating graft can be completed without difficulty.

Most modern trephines use circular cutting edges which hamper precise alignment and viewing under the operating microscope—if not because of the size of automated parts then almost certainly by virtue of their cutting speed. The Lieberman design overcomes some of these basic objections but it is complicated by a suction apparatus.

The new system described here utilises a cutting instrument which fulfils all the precepts for micro-

surgical sectioning, allowing the surgeon to see what he is cutting when he is cutting.

The task of donor collection has been transformed. A recent report advocated the excision of the donor cornea instead of enucleation (Vannas, 1975). The CLCC system extends this concept to a degree which, we predict, will change eye banking practice.

With the CLCC and accessories existing techniques for penetrating keratoplasty have been improved yet simplified. The place of lamellar grafting has been extended for experimental and clinical uses.

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*Grieshaber Company, Switzerland. Patents pending