Vibratory microsurgical sectioning

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Today, the ready availability of finer instruments, suture material, and operating microscopes has provided the stimulus to further refinements in ophthalmic and other microsurgical techniques, where, only a decade ago, with adequate operative results from old techniques, interest could not be sustained in new ideas or inventions.

The present paper describes the general features of a new vibratory microsurgical knife, its use in cataract extraction, and its other applications. This instrument has developed from an extension of work on prototypal electromicrosurgical instruments (Parel, Crock, O'Brien, Henderson, and Galbraith, 1970). It has not been described in the medical literature to date.

The instrument

Three main prototypes have been produced (Figs 1, 2, and 3), all of the same basic construction:

- (1) An outer body consisting of a motor case, a shaft with knurled finger grip at its lower end, and a chuck.
- (2) A disposable blade.

The dimensions of the preferred model are shown in Fig. 1. The external diameter of the motor housing is 16 mm. The blade is fixed in the long axis of the shaft and oscillates at right-angles to this axis.

FIG. 1 *Vibratory microsurgical knife with fixed blade*

The instrument is held like a pen (Fig. 4, overleaf); it is powered by a 12 volt D.C. micromotor with skew winding and it weighs 56 g.

The other two models allow for angulation of the cutting blade, either in the plane of oscillation (Fig. 2) or at right-angles to the main direction of vibration (Fig. 3). These instruments are powered by 3 volt D.C. micromotors.

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At a recent meeting of Microsurgical Instrument Designers, organized by Dr. Dermot Pierse of London and held in Copenhagen, Denmark, one of us (L.P.) spoke in broad terms of an automated surgical knife, which has been in restricted clinical use at the Melbourne University Department of Ophthalmology since May, 1970.

FIG. 2 *Vibratory microsurgical knife with blade which can be angulated in the plane of oscillation*

FIG. 3 *Vibratory microsurgical knife with blade which can be angulated in a plane at right-angles to the direction of vibration*

FIG. 4 *Holding position for the vibratory microsurgical knife*

Cutting action

The oscillatory action of the knife was studied by placing a steel blade in the field of an electromagnet, the coil of which was connected to an oscilloscope. Wave-forms were obtained immediately the knife motor was activated. A typical trace is shown in Fig. 5.

FIG. 5 Oscilloscope tracing of blade movement

O-O represents Baseline
AB Excursion peaks

The average frequency is seen to be 170 cycles/second. In addition to the pattern on the oscilloscope, the blade undergoes a rapid, very low amplitude vibration at right-angles to the cutting edge. This can be readily appreciated during surgery under the operating microscope.

Clinical and experimental applications

Vibratory microsurgical sectioning has been used for cataract extraction and for the completion of penetrating corneal trephining in cases of perforated descemetocoele and corneal abscess, where complete ablation of the host corneal button could not be achieved with standard trephines. Experimental surgical applications to deep non-penetrating corneal graft, cyclectomy, and scleral dissection are being investigated at present.

CATARACT SECTION

The use of the vibrating knife requires magnification control, preferably by operating microscope. The recommended type of blade is the Beaver No. 57R which should be brought into contact with the globe only after the motor has been started. Once the limbal surface of the globe is breached by the knife, corneo-scleral lamellae appear to drift apart in response to "a micro whipping effect" of the blade edge, which simply melts through the tissues without any pressure by the operator. The wound edge should be held open at its corneal lip so that the blade tip can be observed at all times. For this reason a limbus-based flap of conjunctiva and Tenon's fascia is made and it is advisable to clear the knife path of the fascial layer before sectioning is begun. Haemostasis is likewise important in ensuring adequate visualization during cutting.

The corneo-scleral groove should be completed in gentle continuous sweeping movements, not by discontinuous jabbing with the knife. The groove should be deepened uniformly almost down to Descemet's membrane before the anterior chamber is entered. When the globe is finally penetrated, Descemet's membrane splits smoothly in front of the advancing knife edge. At this stage excess aqueous should be mopped from the field so that the fine membrane can be cleanly severed from a single point of entry. Incision of Descemet's membrane from multiple unconnected points may give rise to fine tags. Iris prolapse, should it occur, is no bar to completion of the section by the vibrating knife

because the blade does not lacerate iris stroma. However, unnecessary contact should be avoided as it may cause some dispersion of iris pigment.

Discussion

Pierse (1960) designed an oscillating knife appreciating "that little pressure need be made upon the tissues being incised". His instrument incorporated a sharp-pointed blade which was moved by a vibrating coil to produce a very fine rapid oscillation backwards and forwards.

Two years previously, Castroviejo (1958) had produced an electro-keratotome for the dissection of lamellar grafts. However, since the presidential address to the Section of Ophthalmology at the Royal Society of Medicine, London, entitled Oscillo Section (Foster, 1962), little further has been heard of instrument development in this field of eye surgery, except for keratomileusis (Barraquer, 1965) and the circular knife produced by the Klein Instrument Company of West Germany (Draeger, 1971).

During this period, the von Graefe knife has passed out of fashion in most Western countries, and the technique of *ab externo* incision for cataract extraction has gained wide acceptance. Many different approaches are employed, from keratome incision and scissors section to the preparation of a broad groove almost down to Descemet's membrane with penetration into the anterior chamber either by razor blade fragment or by other disposable blade. This type of section is subsequently enlarged by a variety of scissors, including the fine Vanass design.

Vibratory microsurgical section obviates the need for multiple instruments to enter the eye. Virtual atraumatic opening is effected under microscopic control for all major intraocular procedures from simple cataract extraction to iridocyclectomy. The new instrument does not lacerate iris stroma nor distort the scleral shell while cutting. It is therefore ideal for operating on the soft eye in the presence of broad peripheral anterior synechiae. Fixation is not required beyond holding open the advancing wound edge as the knife lays bare the different coats of the eye.

During examination of a random selection of aphakic patients, an interesting trend in postoperative astigmatism was noted (Table). Sections made with the vibrating knife tended to produce astigmatism with the rule, whereas standard section leads to astigmatism against the rule in the majority of cases (Beasley, 1967; Lamba and Sood, 1971).

Table Comparison of postoperative axis of astigmatism cataract sections with the vibratory microsurgical knife and with standard knives

Knife	Oscillating	Standard
No astigmatism	3	3
Astigmatism with the rule	21	11
Astigmatism against the rule	8	18
Total	32	32

*These astigmatic measurements were made 6 weeks after surgery.

Prospective studies are now in progress to analyse results of wound healing and the optical outcome of cataract extraction and deep lamellar corneal grafting after vibratory section.

The use of the vibratory microsurgical knife in frozen tissue preparation for scanning electron microscopy will be described elsewhere in the scientific literature.

Summary

A new electro-mechanical, high-frequency oscillating knife has been designed and manufactured to effect virtually atraumatic incision of ocular tissue.

The general features of the knife are described, with an account of its use in cataract surgery where entry into the anterior chamber can be completed by this one instrument.

Brief mention is made of wider technical applications.

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This instrument is covered by provisional patent no. PA 9440

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