Corneal lamellar dissection in ophthalmic microsurgery - Jose Barraquer's merit to ophthalmology

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Abstract

The first scientific and precise procedure for lamellar and even lamellar refractive dissection techniques was developed by Jose Barraquer. His extensive and outstanding research work on this corneal surgical field covers now more than 40 years. Even if the application of lamellar and lamellar refractive dissection techniques is changed and simplified nowadays, Jose Barraquer deserves the honour to be the father of modern corneal lamellar and lamellar refractive surgery. Through his genius the field of lamellar surgery is what it is today.

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The first scientific and precise procedure for lamellar and even lamellar refractive dissection techniques was developed by Jose Barraquer. His extensive and outstanding research work on this corneal surgical field covers now more than 40 years (1, 2, 3, 4, 5). All other surgical techniques for dissecting and shaping the cornea are based upon his ideas and knowledge of operating corneal tissue.

However, in the last three decades, with the availability of better donor material and surgical instrumentation and with the better understanding of the pathophysiology of corneal diseases that require corneal transplantation, the number of lamellar keratoplasties being performed has been dramatically reduced. For most of all optical and curative indications penetrating keratoplasty is still performed nowadays. A considerable part of optical indications, however could be replaced by lamellar keratoplasty leading to equivalent functional results and in the same time avoiding graft rejection and complications or risks due to the necessary opening of the anterior chamber.

On the other hand precise lamellar dissection of lenticles was still very difficult in the last century. The problem in manual lamellar dissection was to obtain a smooth incision surface which was almost impossible due to the discontinous movement of the instruments.

Hallermann's device, developed in the late

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fifties, was an important progress in manual dissection (6). The cornea is pressed into a transparent block with a defined cavity. A Graefe knife is moved horizontally through the cornea under optical control. However, this device can not be used on the recipient eye.

Many further attempts have been made to improve the quality of manual dissection. Castroviejo applied the hairclipper principle (7). His instrument consisted of a rapidly oscillating blade and an adjustable stop to determine the lenticle thickness. Lenticles and surfaces cut with this microkeratome were not very precise in diameter and thickness.

Jose Barraquer deserves the honour for being the first developing an electromechanical microkeratome for lamellar keratectomy. It consists of a detachable head, that incorporates a remanufactured commercial razor blade which oscillates at very high speed. The microkeratome has a series of interchangeable base plates that allows one to vary the depth of the keratectomy, Fig. 1

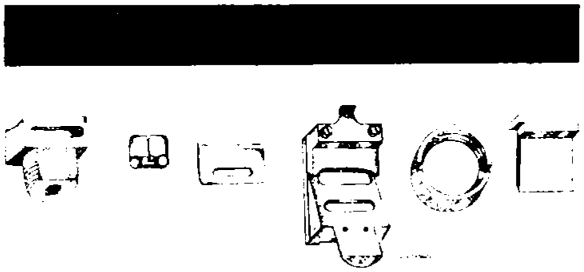

Fig. 1 Barraquer's microkeratome

The microkeratome comes with a set of perilimbal suction rings that vary in height above the limbus. These allow for variable corneal protrusion through the corneal aperture and allow one to vary the diameter of the keratectomy. These perilimbal suction rings are one of the main advantages and progresses in lamellar keratoplasty guaranteeing a stable fixation between eyeball and microkeratome. Slots allow for guidance of the microkeratome. A higher ring allows for less corneal protrusion and will result in a corneal disc of lesser diameter when resected with the microkeratome.

In order to predict the diameter prior to the actual cut, applanation lenses are used. The lens contains a reticle on its lower surface and which lies in the same plane as the cutting blade of the microkeratome. The surgeon compares the diameter of the applanated area of the cornea with the diameter of the reticle and determines if the area to be cut is correct.

Also, a smooth keratectomy is best ensured when the intraocular pressure is at a level of 65 mmHg, or more. A special applanation tonometer is used for this measurement determining if the intraocular pressure is sufficient for the lamellar dissection.

When the parameters of the keratectomy, diameter and intraocular pressure have been chosen, the microkeratome is engaged. The instrument than has to be passed manually in a slow and even fashion avoiding any upward, downward or sideward movement, Fig. 2.

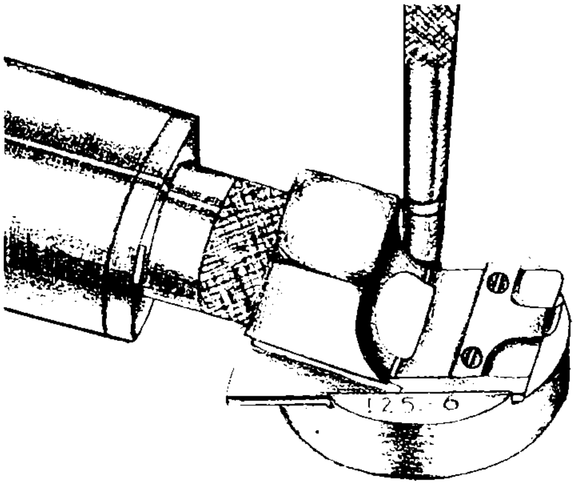

Fig. 2 Barraquer's microkeratome with suction ring

It has been more than 35 years since Jose Barraquer began developing his techniques of keratophakia and keratomileusis, and it is primarily through his genius that the field of corneal refractive surgery is what it is today. He developed a cryolathe with a rotating headstock that incorporates the disc to be modified and the cutting tool are connected separately to carbon dioxide inlets that provide cooling. The cryolathe is equipped with heaters that can elevate the gas pressure, if necessary, and relieves a valve to prevent excessive pressure, Fig. 3.

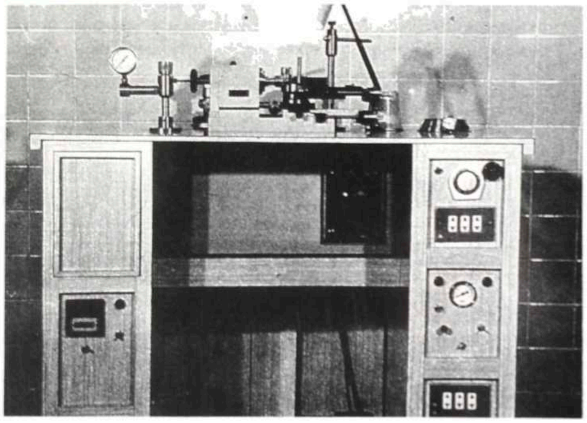

Fig. 3 Barraquer's cryolathe

The resected tissue is placed into a cryoprotectant solution before it is clamped with its epithelium against the concave surface and centered on the plastic base held in the headstock of the cryolathe. The values of the thickness before and after cryoprotectant of the resected disc are entered into the computer. The cryolathe settings are generated in several seconds, Fig. 4.

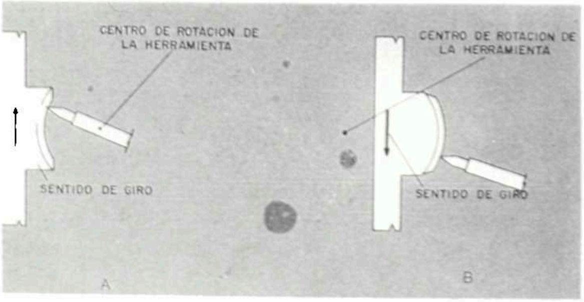

Fig. 4 Tissue modification with the cryolathe

However, the procedure of performing a lamellar refractive keratoplasty with the cryolathe is very complicated and should only performed by excellent trained surgeons. The reasons for residual inaccuracy are many, as the procedure involves many steps, contact of tissue with air and fluid, cryoprotectant solution, complex instrumentation, use by technicians or surgeons and even wound healing.

However, because of the oscillation of the blade and the manual blade advancement the lenticle surface is not perfectly smooth. Based on the work of Jose Barraquer we tried to develop an automatic rotating microkeratome for precise lamellar dissection. We think that only unidirectional motion of the cutting edge results in a smooth surface, 2 different motors, one driving the rotating blade, the other for the automatic blade advancement are integrated into the keratome (8,9,10,11,12).

This microkeratome optimizes the correlation between high blade rotation speed and slow blade advancement. A lamellar dissection is performed automatically. Under lubrication to reduce shearing forces between blade and corneal tissue the applanation plate is moved forward within 20 sec, Fig. 5.

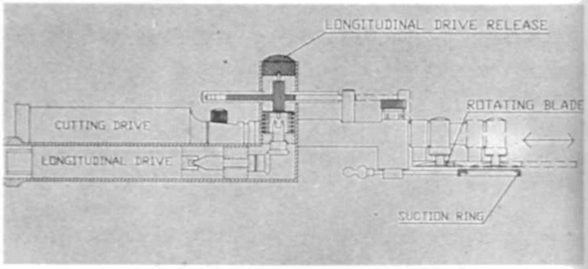

Fig. 5 Draeger's automatic microkeratome

Different thickness spacers at the keratome head determining the distance between blade and applanation plate can be changed easily and determine precisely the lenticle thickness.

A vacuum suction ring is used to maintain a defined relation between eyeball and instrument considering the empirical data of Jose Barraquer that an elevated introcular pressure improves cutting qualities. The inner opening of this suction ring exposes almost the entire cornea so that even extensive dissections can be performed.

In our experimental research on pigcornea we could also demonstrate that the intraocular and suction pressure were found to be very important for the lenticle geometry. The longitudinal and transverse profile of dissections from soft eyes was less homogenous than the longitudinal and transverse profile of eyes with elevated pressure.

The instrument can be placed on the patient eye without problems, Fig. 6.

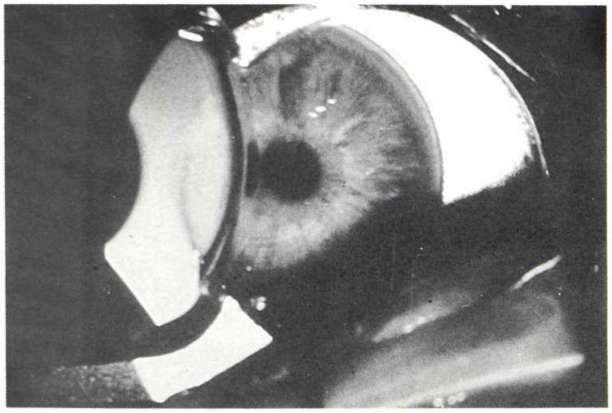

Fig. 6 Draeger's microkeratome on patient's eye

After vacuum fixation on the eye the lamellar dissection is performed automatically. The rotating blade moves unidirectional with constant speed. Apart from the continous change in thickness in the marginal area a lenticle shows an uniform thickness and smooth cutting surface.

Scanning electron microscopy of a lenticle with the rotating blade reveals in contrast to an oscillating microkeratome a smooth cutting surface, however, shows occasionally in periodic intervalls some collagen fibres in the rotating direction.

If donor eyeballs are not available corneoscleral discs from an eyebank can even be used. A simple artificial anterior chamber was developed in which the corneoscleral discs can be clamped. This anterior chamber dissects plano lenticles with the lamellar microkeratome special cutting characteristics. After applanating the corneal surface for determining the lenticle diameter the lamellar keratectomy is performed under sufficient lubrication within 20 sec.

To facilitate refractive dissections in a non-freeze manner a handsome refractive set was developed using again the automatic rotating dissection technique. Thus, a simple instrument with an exchangeable set of molds designed, Fig. 7.

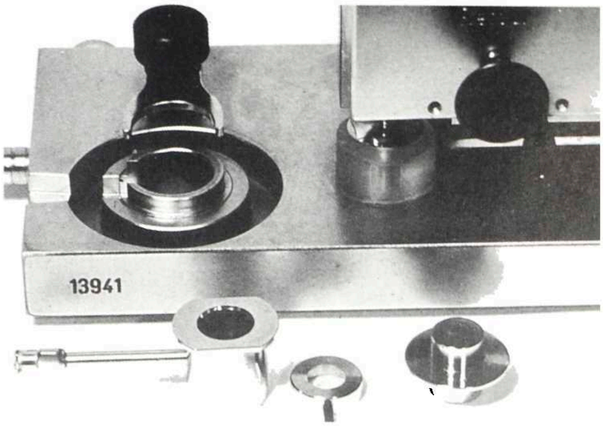

Fig. 7 Non-freeze refractive set

A concave or convexe mold with an optical center of 5 mm retains a plano lenticle dissected with the lamellar microkeratome epithelium downwards with rather low suction. The calculated changes in lenticle curvature are assigned to effective changes in central or peripheral lenticle thickness, Fig. 8.

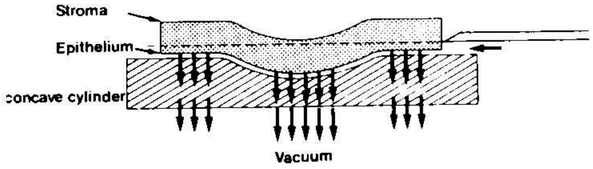

Fig. 8 Refractive mold for non-freeze modification

The following refractive modification is performed within 40 sec again under sufficient lubrication to reduce shearing forces between rotating blade and tissue.

The lenticle center is left intact as almost no mechanical fixation is applied here. The small peripheral indentations at the lenticle periphery disappear after 10 minutes and have no refractive effect.

With ultrasound pachymetry we compared central lenticle thickness with the lenticle thickness of the peripheral parts. From these results it was obvious that a good correlation was observed in tissue modified with a lower change in refraction. Lenticles modified with a higher change of curvature showed less acurate results, which were still within 80% of the desired refractive change.

The results after performing an Epikeratophakia could confirm our measurements with ultrasound pachymetry. For large corrections in the myopic or hyperopic direction 80% of the desired changes could be accomplished. This undercorrection probably could be explained with the corneal collagen structure. Reaching the optical center the rotating blade has the tendency to maintain in one collagen layer which leads to the observed undercorrection.

However, even if the application of lamellar and refractive dissection techniques is changed and simplified nowadays, Jose Barraquer deserves the honour to be the father of modern corneal lamellar and lamellar refractive surgery. Through his genius the field of lamellar surgery is what it is today.

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