Charles David Kelman, MD: *Father of Phacoemulsification, Famed Inventor and One of The Great Ophthalmologists of the 20th Century*

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Fig. 1 Charles David Kelman

Charles David Kelman, MD (Fig. 1), the father of phacoemulsification, Laureate of the American Academy of Ophthalmology, passed away on June 1, 2004 at 74 years of age after a long fight with cancer. He is survived by his wife Ann, his children Lesley Kelman-Koeppel, and Jennifer, Evan, Jason, and Seth Kelman. With Dr. Charles Kelman's demise, we have lost a famed inventor with multifaceted talents and one of the great Ophthalmologists of the 20th Century.

Background and Ophthalmic Education:

Dr. Kelman was born in Brooklyn, New York, USA on May 23, 1930. After graduating from Forest Hills High School and Boston's Tufts University, he completed medical studies at the University of Geneva, Switzerland; an internship at Kings County Hospital, Brooklyn; and residency in Ophthalmology at the Wills Eye Hospital, Philadelphia, PA, USA. Dr. Kelman was Clinical professor of Ophthalmology at New York Medical College and worked as a consultant surgeon at many hospitals throughout the world. He worked as an Attending Surgeon at the New York Eye and Ear Infirmary and Manhattan Eye, Ear and Throat Hospital and in private practice in New York City from 1960.

Ophthalmic Inventions:

The cryo-probe was devised by Dr. Kelman in 1962. This freezing instrument was used for the extraction of cataracts with the capsules intact.[1] This became the most widely used method for intracapsular cataract extraction (ICCE) in the world until about 1978, when it was supplanted by extracapsular cataract surgery with irrigation and aspiration. In 1963 Dr. Kelman pioneered the use of freezing for the repair of retinal detachments. Retinal cryopexy remains an important procedure in retinal surgery to this day.[2]

Struggle And Initial Failure While Working On Phacoemulsification

Dr. Kelman introduced phacoemulsification in 1967, which enabled today's rapid outpatient cataract surgery.[3] The innovation of phacoemulsification was fulfilled with struggle and initial failure.[4] In his most recent publication (Kelman CD. The genesis of phacoemulsification. *Cat Refract Surg Today*. March 2004), he stated

"Four years after my residency, I drafted a grant proposal to study the effects of freezing on the ciliary body, retina, and choroid. I went to bed concerned that the Hartford Foundation would not find the topic of interest, awoke in the middle of the night, and, almost in a trance, added an addendum to my application that would affect the rest of my life and the lives of 100 million patients: "in addition to the freezing studies, this investigator will develop a method for removing a cataract through an incision small enough so that no hospitalization will be required." Mr. E. Pierre Roy, the head of the John A. Hartford Foundation, could easily have rejected my application and put an end to this matter. Instead, he had confidence in my abilities and gave me a 3-year grant, although I did not have the vaguest idea of how to realize my idea.

Mr. Roy's confidence was misplaced for 2 years and 8 months, while I tried everything I could imagine. I first attempted to capture the cataract within a folding lens bag (Fig. 2), crush it inside the bag with manual disintegrators, and then remove the device containing the fragmented lens material from the eye. The rotating devices I tried simply spun the cataract around inside the anterior chamber. High-speed cutting needles, a miniature blender, drills, tiny meat grinders, engraving tools—nothing worked. All the devices yielded opaque corneas in animal eyes.

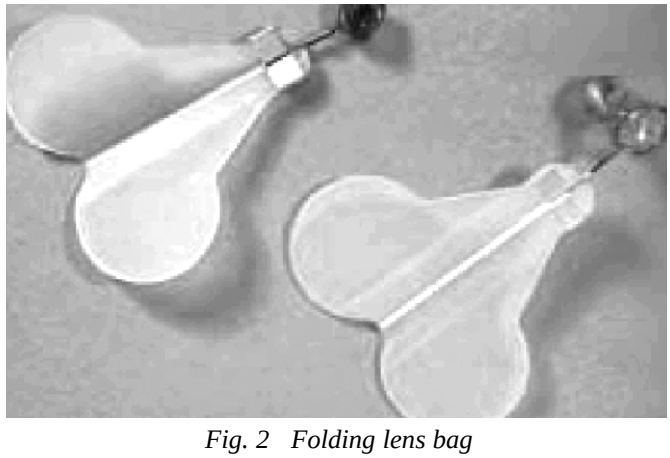

Fig. 2 Folding lens bag

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I had meanwhile allowed my hair to grow down to my shoulders, and my teeth badly needed a cleaning. Sitting in my dentist's chair, I became interested in the ultrasonic tool he was using to clean my teeth. He explained that its high-frequency vibration removed tartar without disturbing the tooth itself. I raced out of his office with the bib still hanging around my neck and returned 1 hour later with a cataractous lens. Because I was able to engrave lines on the lens without its jumping off my finger, I believed that I could break up a cataract inside the eye without its spinning or vibrating against the corneal endothelium. Cavitron Corporation ultimately made a prototype with a handpiece that incorporated Irrigation & Aspiration (I/A) (Fig. 3), rather than only irrigation, as with the original dental instrument. My first efforts with this device resulted in opaque corneas until I began using a physiologic solution, imported from the Barraquer Institute in Barcelona, Spain, in place of the simple saline solution. I also realized that the high temperatures that the procedure created inside the eye would denature the corneal proteins.

Fig 3. Initial Handpiece by Cavitron Corporation

After several months of successful animal testing, I operated on my first human subject, a man suffering from a painful blind eye due to burned-out glaucoma. The strong surge of suction caused the cornea to collapse 30 to 40 times during the 70-minute phacoemulsification. The next day, his eye was a bag of pus that had to be removed. I spent 2 years seeking a way to prevent corneal collapse and finally found a company in North Carolina that manufactured a device that sensed arterial flow. Cavitron Corporation incorporated this feature into the phacoemulsification device's aspiration line with an air-relief valve. If the speed of the current in the aspiration line exceeded the speed of the irrigation, then a valve opened to halt suction immediately.

One year later, I worked up the nerve to operate on the eye of a patient with central retinal artery occlusion and no light perception. If I had failed that time, I probably would have abandoned the project. A specially designed, three-dimensional micromanipulator supported the weight of the cumbersome phaco handpiece and steadied the phaco tip inside the eye for long periods of time. I deemed the operation a success when the patient achieved light perception postoperatively. The severe striate keratitis present on the first postoperative day subsided after 6 weeks.

The next major attack on phacoemulsification occurred when opponents got the FDA to classify the procedure as experimental and, therefore, non-reimbursable. Reversing this decision required thousands of letters from patients and an appearance before the FDA by the renowned television doctor, Marcus Welby, MD."

In addition to aforementioned statements, the AAO committee headed by Richard Troutman, MD put forward it's finding into phacoemulsification reporting that it delivered the same quality of results as ICCE, and it was the preferred and only method to use in many instances. ICCE developed after extracapsular cataract extraction (ECCE) following the advent of the erysophake and cryoprobe. Until that time, ECCE was complicated by retained cortex and iris prolapse, resulting in a return to the operating theatre in up to 25% of cases. In 1962, one of the then illustrious names in Ophthalmology stated- *"Cataract surgery has been developed to its ultimate state, and any improvements from this date will be insignificant."* The speaker was referring to the suction erysophake for intracapsular removal of cataracts at a time when a patients hospital stay averaged 10 days, followed by 6 weeks of recuperation at home. Dr Kelman, in a recent article (Kelman CD. The genesis of phacoemulsification. *Cat Refract Surg Today*. March 2004), was kind enough to acknowledge those opposed to the development of phacoemulsification saying- *"I also thank my opposition for inspiring me to try harder."*

Dr Kelman preferred the term KPE (Kelman Phaco-emulsification). He initially described the phacoe-mulsification procedure for surgery within the posterior chamber, and it was only in 1972 that he switched to anterior chamber phacoemulsification. Outward hostility occurred when in 1973, prominent Ophthalmologists began losing cataract surgery cases to phaco surgeons. These Ophthalmologists began making outrageous statements such as *"Phaco is OK after you learn it, but the first 50 eyes are blinded during the learning curve"* and *"Phaco causes glaucoma"*. Dr Kelman did not help matters when he stated- *"Anyone over 30 is too old to learn phaco"*. He shocked his colleagues by discharging his patients on the same day or the following day and permitting them to return to full activity on the first postoperative day, when most other practitioners kept their patients in hospital for 6 days.

Acceptance and Advancement on Phacoemulsification

Phacoemulsification has been refined by surgeons during the past 3 decades and this technique has now become the preferred method of cataract surgery in the developed

world. Since 2000, 97% of all cataract surgery in the United States is performed using phacoemulsification according to most recent Survey published by Leaming. Over one million operations of phacoemulsification and lens implantation surgery being performed in the United States alone on an annual basis. The transition to outpatient surgery has removed the need for hospital stays of one week and it is estimated that at least seven million hospital days are saved annually. Neurosurgeons have adopted the Kelman phacoemulsification machine for dissecting tumours from delicate brain and spinal cord tissue in children. In this way, the device has saved hundreds of young lives. Phacoemulsification was the stimulus for other small incision surgeries, including gall bladder, lumpectomy, vertebral disc surgery and many others.

Work on Intraocular Lenses:

In 1975 Dr. Kelman began designing lens aphakic and phakic implants for use in cataract and refractive surgery,[5] since then numerous ophthalmic manufacturers have sought his services, including Alcon Surgical, Advanced Medical Optics, IOLAB, Domilens, and Storz Ophthalmics. The approximate aggregate sales of Kelman-designed lenses by these manufacturers totals more than 340 million dollars, making him the world's most successful intraocular lens designer by far. One of us (SKP) was fortunate to contribute some writings in collaboration with Dr. Kelman and also able to pursue some of the research work on Duet intraocular lens designed by him.

Miscellaneous Inventions:

During the past few years, Dr. Kelman worked on several new projects, including artificial blood vessels, artificial corneas and a magnetic cataract extraction procedure that will retain the patient's normal ability to focus on near and distant objects. In other applications, the magnetic technique has been used to remove plaque from arteries and growths from the digestive tract, prostate, bladder and other areas without invasive surgery.

Recognition and Awards:

Dr. Kelman was honoured for his distinguished career and contributions to Ophthalmology. He was the recipient of several prominent awards including the Ridley Medal by the International Congress of Ophthalmology, the First Innovators Award in Ophthalmology and the Binkhorst Medal, both from the American Society of Cataract and Refractive Surgery, as well as the first Outstanding Achievement Award for excellence in cataract surgery from the American Society of Contemporary Ophthalmology. He was awarded the "Inventor of the Year Award" by the New York Patent, Trademark and Copyright Law Association for his development of the Kelman phacoemulsification procedure. In June 1992, Dr. Kelman was awarded the Prestigious National Medal of Technology by President George H.W. Bush and at the International Congress on Cataract and Refractive Surgery in Montreal, Canada, Dr. Kelman was named "Ophthalmologist of the Century" for his pioneering work in phacoemulsification. Most recently, during the 107th Annual Meeting of the AAO in November 2003, Dr Kelman was honoured by the AAO with the Laureate Recognition award.

He was immediate past president of the American Society of Cataract and Refractive Surgeons. In recognition of the ongoing contribution of Dr. Kelman to anterior segment surgery, the Innovators Lecture of the Society was renamed after him in 2003. The Charles D. Kelman Innovator's Lecture honours the work of individuals whose creativity has benefited Ophthalmologists and their patients. The lecture is presented during a special session at the annual ASCRS Symposium on Cataract, IOL and Refractive Surgery. Charles D. Kelman, MD, presented the First Innovator's Lecture in 1985.

Dr. Kelman wrote several articles, papers and scientific books as well as a book for lay readers on cataracts and an autobiography entitled "Through My Eyes" (both from Crown Publishing).

Hobbies and Activities other than Ophthalmology:

Dr. Kelman found time to learn to pilot his own helicopter and avidly followed his hobbies of golf, music and the performing arts. He entertained on The Tonight Show starring Johnny Carson, The Barbara Walters Show, The Merv Griffin Show, The David Letterman Show, The Oprah Winfrey Show and numerous others. He appeared in concert as a musician with Lionel Hampton and Dizzy Gillespie and has performed in concert at Carnegie Hall, Las Vegas, Atlantic City with The Spinners, Glen Campbell, James Darren, Regis Philbin and others. He devoted his spare time to several new projects, including a musical, "The Right Pair of Shoes", and an album that was released by Columbia Records.

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