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The History of Cataract Surgery

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1. Introduction

Cataracts were undoubtedly very common in antiquity (Aruta et al., 2009; Bernscherer, 2001; Muhkopadhyay & Sharma, 1992; Shugar, 1997). The current word *cataract*, which means both an opacity of the lens and a torrent of water, comes from the Greek word *υπόχυσις* (kataráktēs) meaning the fall of water. The Latins called it *suffusio*, an extravasation and coagulation of humors behind the iris; and the Arabas, *white water* (Ascaso & Cristóbal, 2001). The old Egyptian name for the lens is not yet known and the medical literature does not let us conclude that old Egyptians were able to diagnose cataracts (Ghalioungui, 1973). The only possible reference to cataract is the *ᶜh.t* disease mentioned in the Ebers Papyrus (about 1525 B.C.). Ebbel translated the *ᶜh.t* disease as cataract (Ebbel, 1937). However, other distinguished linguistists interpreted it as a discharge or accumulation of water in the eyes (Hirschberg, 1899; Deines et al., 1958; Andersen, 1997). According to Ebers Papyrus, the old Egyptians tried to treat cases of *ᶜh.t* disease by eye ointments and magic spells. It is hardly believable that such remedies had any effect on the cataract, since the extraction of the lens is the only effective measure.

2. Cataract surgery in ancient cultures: *"Couching"* technique

The oldest documented case of cataract throughout history was reported in a famous and small statue from the 5th dynasty (about 2457-2467 B.C.) contained in the Egyptian Museum in Cairo, Egypt. This statue, discovered in 1860 in Saqqāra, dates from the Old Kingdom and represents a male figure, the priest reader Ka-āper, also called Cheikh el-Beled (Figure 1A).
We found an obvious white pupillary reflex in the left eye (Figure 1B). This finding, in an aged man, probably indicates a mature cataract; moreover, it does not appear in the right eye. We suggested that the author carefully inspected a man with cataract and accurately reproduced the physical sign in wood (Ascaso & Cristóbal, 2001). This fact confirms that old Egyptian knew the disease. By analysis of ancient surgical instruments it is possible to define the history of medical specialties, and acquaint the evolution of specific surgical techniques and operations through the centuries (Aruta et al., 2009). Scientists have often discussed whether cataract was firstly operated in Ancient Egypt (Bernscherer, 2001). This hypothesis seems plausible (Ascaso et al., 2009). Thus, a wall painting in the tomb of the master builder Ipwy at Thebes (about 1200 B.C.) reveals an oculist treating the eye of a craftsman. Because of the length of the instrument, the scene might also be interpreted as a cataract surgery by couching of the lens into the vitreous cavity (Figure 2).

A B

Fig. 1. A: Ka-aper´s statue *(Egyptian Museum, Cairo, Egypt)*. B: Detail of the white pupillary reflex in the left eye indicating a mature cataract *(taken from J Cataract Refract Surg 2001;27(11):1714-5)*

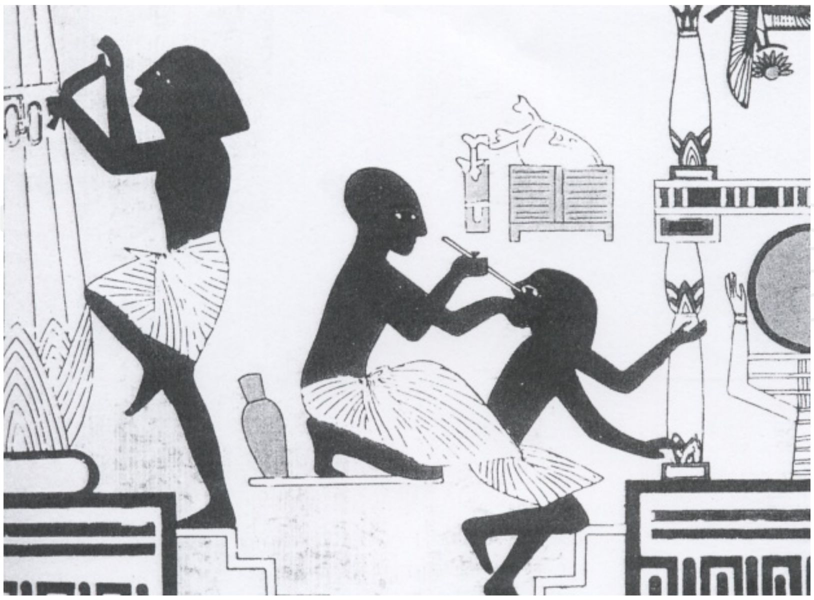

Fig. 2. A wall painting in the tomb of the master builder Ipwy at Thebes (about 1200 B.C.). An oculist treats the eye of a worksman. *(Modern copy of the painting at the entrance to the Cornea Bank at Ain Sham´s University Hospital, Cairo, Egypt).*

The temple of Kom Ombo, constructed by Tutmes III (1479-1425 B.C.), shows a relief on the internal facade of the second wall, which depicts a series of surgical instruments carved in stone, including several needles (Figure 3).

Fig. 3. Detail from the relief on the internal facade of the second wall in the temple of Kom Ombo, Egypt.

National Museums in Liverpool, England, contain a series of ancient cooper needles having neither hooks nor eyes. They were found in 1900 by Flinders Petrie in the tomb of King Khasekhemwy (c. 2700 B.C.), in the Royal Necropolis at Abydos, Upper Egypt (Petrie et al., 1900) (Figure 4).

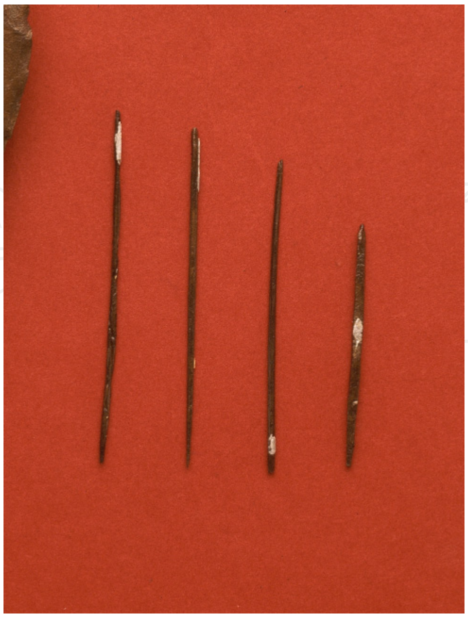

Fig. 4. A series of cooper needles from the tomb of King Khasekhemwy at Abydos, Egypt (c. 2700 B.C.). *(Courtesy by National Museums Liverpool, England).*

In 2001, near the Saqqara pyramid complex (built *c*. 2630 BC), about 19 miles south of Cairo, archaeologists made a fascinating discovery: the oldest-known tomb of a pharaonic surgeon, dating back more than 4000 years. This was the tomb of Skar, the chief physician of one of Egypt's Fifth Dinasty rulers. In the writing on its walls was a hint that surgery had actually been practised in ancient Egypt, the first hard evidence of it being performed as early as this. It contained about 30 bronze surgical tools used by the ancient Egyptian doctor, the oldest ever found, including several needles. The above mentioned findings confirm the high surgical skill level achieved, and the possibility that old Egyptian and Babylonian used, before Indian surgeons, the couching operation for dislodging the cataract away from the pupil. The surgeon used a lancet to push the clouded lens backward into the vitreous body of the eye. The relative simplicity of this technique was probably the major reason why it was the procedure of choice through thousands of years until 1748, when the French doctor Daviel performed the first known cataract extraction (Floyd, 1994).
Cataract surgery by "couching" (lens depression) was, without a doubt, one of the oldest surgical procedures. This technique involved using a sharp instrument to push the cloudy lens to the bottom of the eye. Perhaps this procedure is that which is mentioned in the articles of the Code of Hammurabi (Cotallo & Esteban, 2008; Ascaso et al., 2011). Hammurabi (ca. 1792-1750 BC), the greatest ruler in the first Babylonian dynasty became king of all Mesopotamia, the land what is today known as Iraq. He established the greatness of Babylon, transforming a small Mesopotamian city-state into the world's first metropolis (Horne, 2010). His long reign was for about 40 years, extending his empire northward from the Persian Gulf through the Tigris and Euphrates river valleys and westward to the coast of the Mediterranean Sea. Although he was a successful military leader and administrator, Hammurabi is primarily remembered for his celebrated codification of the laws governing Babylonian life called the Code of Hammurabi (*Codex Hammurabi*) (Bartz & König, 2005). This primitive form of what would be now known as a constitution began and ended with addresses to the gods, and regulated in clear and definite strokes the organization of society. The ancient law code, based on older Sumerian codes, was engraved on a large upright black stone monument which was set in front of one of the major temples, where it could be seen by the public. One nearly complete example of the Code survives today, inscribed on an eight feet high basalt stele in the Akkadian language in the cuneiform script (Hammu, 2010; Graves & Graves, 2010). This noted stone was discovered in 1901 by the Egyptologist Gustav Jéquier, not in Babylon, but in a city of the Persian mountains- in what is now Khūzestān (ancient Elam) in the southwest of Iran, to which some later conqueror must have carried it in triumph in the 12th century BC (Bartz & König, 2005). It is currently on display at the Louvre Museum in Paris, France (Hooker, 1996) (Figure 5).
The Code of Hammurabi contains 282 laws, each usually no more than a sentence or two. Thus, the law number 196 says: *"If a man put out the eye of another man, his eye shall be put out"*. There, we can see where the Hebrews learned their law of "*an eye for an eye*". Medical information included in King Hammurabi´s Code gives a picture of a highly organized society where medical care was regulated. Moreover, it contained a number of sections related to the eye which let to understand the state of ophthalmological knowledge in the Ancient River Cultures (Bieganowski, 2003). So, the code shows the first known sliding fee schedule for services, where the amounts are specified according to how prosperous the patient was. *"The surgeon who has successfully operated on a patrician´s eye with a bronze lancet, shall charge 10 shekels of silver. The fee will be only five shekels and two shekels in the case of a*

plebeian and owned slave, respectively". Five shekels (Jewish silver coin) was equivalent to the yearly rent of a good type of house and represented 150 times the daily wage of a workman (1/30 shekel) (Albert, 1996). However, Hammurabi´s Code discouraged the pursuit of a career in Ophthalmology specifying the penalties for "medical malpractice". They varied with the economic status of the patient: *"If a doctor operates (…) on the eye of a* patrician *who loses his eye in consequence, his hands shall be cut off". In the case of a slave, if the surgeon has caused his death the penalty was to replace him by another, and if he made the slave lose his eye, he shall pay half his value*" (Fishman, 1999). At the dawn of civilization, about 4,000 years ago, the Codex Hammurabi already prescribed the concepts of managed care for the practice of medicine. Tempered by time, its managed care mandates can still be considered the genesis of the current concepts of managed care (Spiegel, 1999).

Fig. 5. Detail of the stela inscribed with Hammurabi´s code, showing the king before the Mesopotamian Sun God Shamash; bas-relief from Susa, ancient Elam (Khūzestān, southwest of Iran), 18th century BC *(Courtesy of the Louvre Museum, Paris, France)*.

However, there are some doubts about the real meaning of the term "na-kap-tu", which someone translated as "cloud", and other directly as "waterfall." It is even possible that these articles of the Code of Hammurabi made some reference to treatment of corneal pathology instead of cataract (Gorin, 1982).

So, couching for cataract is one of the most ancient surgical procedures; however, Maharshi Sushruta, an ancient Indian surgeon, first described the procedure in "Sushruta Samhita, Uttar Tantra", an Indian medical treatise (800 B.C.) (Duke-Elder, 1969; Chan, 2010) (Figure 6).

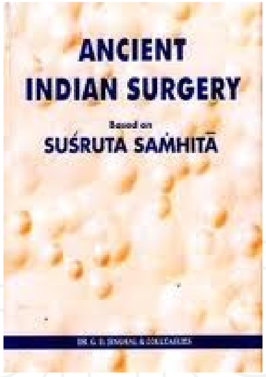

Fig. 6. Sushruta Samhita, Uttar Tantra, an Indian medical treatise (800 B.C.)

This text describes an operation called "couching", in which a curved needle was used to push the lens into the rear of the eye and out of the field of vision. The eye would later be soaked with warm clarified butter and then bandaged. Sushruta claimed success with this method but cautioned that this procedure should only be performed when absolutely necessary. This method may have been brought to the West by Greek travelers from India and the Middle East (Wales, 2010). The removal of cataract by surgery was also introduced into China from India (Lade & Svovboda, 2000). The procedure, also known as *jin pi shu* in Mandarin, was introduced to China via the Silk Road during the late West Han Dynasty (206 B.C.-9 A.C), and it spread throughout China during the Tang Dynasty (618-907 A.C.). As the procedure was combined with the Chinese concept of acupuncture, *jin pi shu* was integrated into Chinese medical practice until the founding of the Republic of China in 1911 (Chan, 2010).

In the Western world, bronze instruments that could have been used for cataract surgery have been found in excavations in Babylonia, Greece, and Egypt. The first references to cataract and its treatment in the West are found in 29 B.C. in *De Medicinae*, the work of the Latin encyclopedist Aulus Cornelius Celsus (Figure 7), which also describes the couching operation (Wales, 2010)

Fig. 7. Aulus Cornelius Celsus

"Couching" technique continued to be used throughout the Middle Ages and is still used in some parts of Africa and in Yemen (Savage-Smith, 2000). However, it was an ineffective and dangerous method of cataract therapy, and often resulted in patients remaining blind or with only partially restored vision.

3. A New revolution: Cataract extraction surgery

Later, *"couching"* technique would be replaced by cataract extraction surgery. The lens could be removed by suction through a hollow instrument. Bronze oral suction instruments that have been unearthed seem to have been used for this method of cataract extraction during the 2nd century A.C. Such a procedure was described by the 10th-century Persian physician Muhammad ibn Zakariya al-Razi, who attributed it to Antyllus, a 2nd-century Greek physician. The procedure "required a large incision in the eye, a hollow needle, and an assistant with an extraordinary lung capacity" (Savage-Smith, 2000). This suction procedure was also described by the Iraqi ophthalmologist Ammar ibn Ali of Mosul, in his *Choice of Eye Diseases*, also written in the 10th century (Savage-Smith, 2000). He presented case histories of its use, claiming to have had success with it on a number of patients. Extracting the lens has the benefit of removing the possibility of the lens migrating back into the field of vision (Finger, 2001). A later variant of the cataract needle in 14th-century Egypt, reported by the oculist Al-Shadhili, used a screw to produce suction. It is not clear, however, how often this method was used as other writers, including Abu al-Qasim al-Zahrawi and Al-Shadhili, showed a lack of experience with this procedure or claimed it was ineffective (Savage-Smith, 2000).

The French ophthalmologist Jacques Daviel (1696–1762) was the first modern European physician to successfully extract cataracts from the eye. He performed the first extracapsular cataract extraction on April 8, 1747. It was the first significant advance in cataract surgery since *couching* was invented. Daviel earned his medical degree from the Medical School of Rouen. He was on the staff of Hospital d'Invalides and became oculist to Louis XV. He died of apoplexy in 1762 while on a trip to Geneva, Switzerland. His technique marked the beginning of the modern era in cataract surgery (Dolezalova, 2005; Obuchowska & Mariak, 2005) (Figure 8).

Fig. 8. The French ophthalmologist Jacques Daviel (1696–1762) performed the first extracapsular cataract extraction on April 8, 1747.

The increasing importance of the "extraction" versus traditional "couching" of the lens made both entered in competition. None of the two techniques was free of complications. Thus, in 1750, the famous German composer Johann Sebastian Bach (1685-1750), underwent bilateral cataract surgery by the British surgeon John Taylor (1703-1772), who employed the standard couching. A week later, Bach was reoperated due to cataract recurrence. Nevertheless, the musician was blind and died four months later (Zegers, 2005). Another example is the famous composer George Frideric Händel (1685-1759), who underwent “couching” cataract surgery by the same surgeon and suffered blindness during the last years of his life (Figure 9).

Fig. 9. John Taylor (1703-1772)

John Taylor was a coucher, or cataract surgeon, who performed removal of cataracts by breaking them up into pieces. His major talent was that of self-promotion, becaming the self-proclaimed personal eye surgeon to King George II, the Pope and number of European royal families. He was as famous for his womanizing as for his surgical skills. Prior to performing each surgical procedure, he would deliver a long, self-promoting speech in an unusual oratorial style. He traveled throughout Europe in a coach painted with images of eyes. His arrival in a town would be publicised several days in advance to draw the largest crowd and he claimed to be able to cure misaligned eyes with his surgical skills. His trick was to make a small incision in the conjunctiva of the eye and cover the other eye. He would then instruct the patient to leave the eye covered for seven days. During this interval he would contrive to leave town and be as far away as possible, when the eye covering was removed. Not even the extraction guaranteed the result. So, in 1775, the poet Goethe witnessed the failure of a bilateral cataract extraction performed in Frankfurt to a distinguished patient, by the famous German surgeon Johann Heinrich Jung-Stilling (1740-1817) (Figure 10).

Albrech von Graefe (1828-1870), who was of tremendous importance in Ophthalmology, died at the early age of 42. By the age of 39 Von Graefe was internationally a unique figure and presided and dominated over the entire 3rd International Congress of Ophthalmology held in Paris in 1867. He read four papers including a classic description of choroid tubercles, but his most important contribution was his exposition of his “modified linear extraction” as a new technique for the operation of cataract. His contributions to Ophthalmology were multiple. His name is eponymously remembered in the von Graefe sign in exophthalmic goitre and the von Graefe extraction knife. Ophthalmology developed through the application of the ophthalmoscope by von Graefe.

Fig. 10. Johann Heinrich Jung-Stilling (1740-1817)

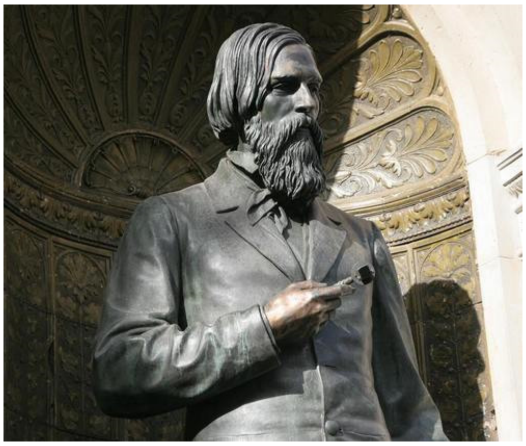

Fig. 11. Monument to the memory of the great German ophthalmologist Albrecht von Graefe, which can be admired on the Charité-Medical University terrain (Berlin)

John Louis Borsch Jr. (1873-1929), was an ophthalmologist from Philadelphia who spent most of his career in France. During his lifetime he was probably best known as the inventor of the first fused bifocal lens, which was marketed very successfully as the Kryptok lens. He may be better known today for performing cataract surgery on Mary Cassatt (1844-1926), the American Impressionist artist, and on James Joyce (1882-1941), the Irish author (Ravin, 2009; Ascaso & Bosch, 2010).

4. The era of Intraocular Lenses (IOLs)

Sir Nicholas Harold Lloyd Ridley (1906, Kibworth Harcourt, Leicestershire – 2001, Salisbury, Wiltshire) was an English ophthalmologist who pioneered artificial intraocular lens transplant surgery for cataract patients. He worked as a surgeon at Moorfield Eye Hospital and St Thomas' Hospital in London, specialising in Ophthalmology (Figure 12).

Fig. 12. Harold Ridley, circa 1950, at the time of the first IOL

Dissatisfied with the poor acuity and loss of binocular single vision following unilateral cataract extraction and the poor outcome, particularly in children, with the contact lenses then available, he had early in his career envisaged using an artificial lenticulus. His research was catalysed by the now famous remark of a medical student, that it was a pity that the cataract he had seen extracted could not be replaced by a clear lens. Ridley described his threefold problem. Firstly, he had to find an inert material for what would be an intraocular foreign body. He was inspired in his choice of polymethylmethacrylate (PMMA) which became the gold standard of implant materials. This lack of inflammatory response to glass and plastic intraocular foreign bodies, provided they did not touch the iris, had been observed in the eyes of injured aircrew who survived aerial combats. Ridley thought to use an artificial lens after observing the eye's tolerance of PMMA following eye injuries in Royal Air Force pilots. When the pilots' plastic canopies were struck with bullets, they shattered, leaving small pieces of PMMA in the pilots' eyes. Ridley observed, however, that the pilots' eyes were compatible with them and did not reject the inert PMMA substance. This inspired him to use this material in early intraocular lens (IOL) implantations to correct cases of cataracts (William, 2001). In the 1940s, he introduced the concept of implantation of the intraocular lens which permitted more efficient and comfortable visual rehabilitation possible after cataract surgery. Thus, on 29 November 1949, Harold Ridley successfully implanted the first IOL at St. Thomas' Hospital in London (Figure 13).

The implant was made of an inflexible material called PMMA. It was not until 1950 that he left an artificial lens permanently in place in an eye. The first lens was manufactured by the Rayner company of Brighton & Hove, East Sussex (Spalton, 2009). Despite Ridley's success, the technique did not catch on in the wider ophthalmic community for a number of decades, as many were adverse to the idea of replacing the eye's natural lens with an artificial one. During the years since 1949, however, IOL technology continued to advance. In 1951, Ridley presented his paper *"Intra-Ocular Acrylic Lenses"* at the Oxford Ophthalmological Congress, which was met with significant opposition from Ridley's professional colleagues. Furthermore, Ridley's work was condemned as reckless the following year, at the American Academy meeting in Chicago. In 1952 the first IOL implant was performed in the United States, a Ridley-Rayner lens implanted at the Wills Eye Hospital in Philadelphia. After years

of progress, as Ridley and others continued to work to refine the surgery, the first international symposium on intraocular lenses and implants was held in 1966 at the Royal Society of Medicine in London. Through this, the Intraocular Implant Club (IIC) was formed, with Ridley as the first President.

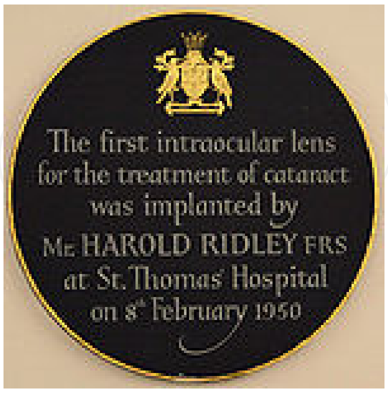

Fig. 13. First permanent insertion of intraocular lens, 8 February 1950

Ridley went on to develop comprehensive programmes for cataract surgery with intraocular implants and pioneered this treatment in the face of prolonged strong opposition from the medical community. He worked hard to overcome complications, and had refined the technique by the late 1960s.

Harold Ridley with his pupil Peter Choyce (Figure 14) cofounded the International Intraocular Implant Club in 1966, which was responsible for the gradual acceptance of artificial lens implantation. Peter Choyce developed several models of IOLs, but did not patent the majority of them. The Choyce Mark IX, manufactured by Rayner Intraocular Lenses, became the first US Food and Drug Administration-approved IOL in 1981.

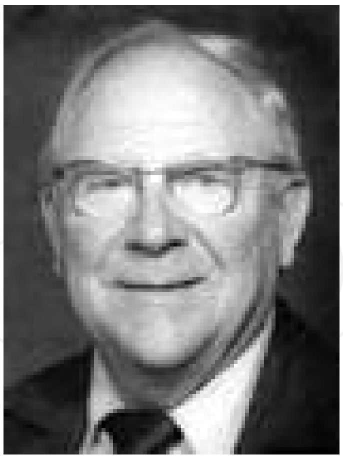

Fig. 14. Peter Choyce

Cataract extraction surgery with IOL implantation is now the commonest type of eye surgery. Ridley retired from NHS hospital service in 1971 and received many awards over the next 29 years. He was a Fellow of the Royal College of Surgeons and a Fellow of the Royal Society. In February 2000, Harold Ridley was knighted by HM Queen Elizabeth II at Buckingham Palace in London. Sir Harold Ridley resided in Wiltshire until his death on 25 May 2001 (Encyclopaedia Britannica, 2010; Apple, 2006).

In so doing he changed the practice of Ophthalmology. Ridley's invention provided not only superior visual rehabilitation to cataract patients for generations to come, but also, without it the IOL has been a major factor in changing the way Ophthalmology is practiced. The fact that lens implantation is by far the commonest and one of the most successful of all eye operations has virtually created a medical-industrial complex. In business terms, the IOL procedure – and its cousin, refractive surgery – have become "products" that can be marketed and sold to a wide base of consumers. In the United States, the economic fallout of these procedures changed ophthalmic practice patterns and accelerated the pace towards managed care (Apple & Sims, 1996).

Now, his discoveries affect virtually all human beings. Over 14 million individuals annually worldwide who have their vision restored with the Ridley-cataract-IOL-operation across the globe. The procedure has came a long way to mean that patients are treated now under a local anesthetic meaning that the visit to the clinic is an out-patient basis and they can return home as soon as the day of the procedure. Visual recovery tends to be very fast, and many patients achieve an excellent level of visual acuity the same day of surgery. Unfortunately, in poor countries around the world, there are still over 25.000.000 unoperated people with cataracts who cannot receive this treatment because of financial/logistical reasons.

Ridley's invention is of much more than historical interest. It is now possible to take plastic implants analogous to his designs and embed high technology micro-devices such as silicone microchips micro-telescopes, mini-cameras and the like, into them. These can then receive light and images from the environment and transmit, visual impulses to a blind person's brain, thus at least partially restoring vision. With such gadgetry it would be possible to treat blindness of all possible conditions and diseases, for example, macular degeneration and retinitis pigmentosa, glaucoma, destruction of the eye by severe eye trauma and many others. This is the concept of the "*eye transplant*" or "*bionic eye*" (see USA Today "Tiny Chip May Restore Vision to Patients", by Kathleen Fackelmann, August 1, 2001) that is now under intense research. Such futuristic devices that can be implanted in the eye are no doubt going to be developed and applied. Therefore, complete eradication of blindness - only a dream until now - will become a reality. Ridley's contribution has been to provide the needed break-through towards successful intraocular prosthesis implantation.

In large part because of his invention, the last half-decade of the 20th century has been termed the Golden Age of Ophthalmology and visual sciences. His discovery has indeed changed the world so that we might better see it with our eyes. It has brought forth a miracle by helping all of us see better by preserving our gift of sight. Even when a miracle might appear to become routine over time, it still remains a miracle (Apple et al., 2002; Kohnen, 2009).

5. The modern phacoemulsification technique

In 1967, Charles D. Kelman (1930, Brooklyn, New York–2004, Boca Raton, Florida), an ophthalmologist pioneer in cataract surgery, introduced phacoemulsification after being inspired by his dentist's ultrasonic probe. This technique uses ultrasonic waves to emulsify the nucleus of the crystalline lens in order to remove the cataracts without a large incision. This new method of surgery decreased the need for an extended hospital stay and made the surgery less painful. Dr. Kelman did his residency (1956-1960) at Wills Eye Hospital in Philadelphia, then worked as an ophthalmologist at the Manhattan Eye, Ear and Throat Hospital in New York. He received the National Medal of Technology from President

George H. W. Bush in 1992, was inducted [in February 2004] into the National Inventors Hall of Fame in Akron, Ohio (Figure 15).

Fig. 15. Charles D. Kelman (1930-2004), best known as the father of phacoemulsification

6. Conclusion

In conclusion, cataract surgery is a technique described since recorded history. Nevertheless, it has greatly evolved only in the latter half of the past century. The development of the intraocular lenses and phacoemulsification as a procedure for cataract extraction could be considered as the two most significant strides that have been made in this surgical field (Ashwin et al., 2009).

Before the introduction of modern ophthalmic surgical technology following World War II, cataract surgery was easier and safer to perform if the cataract was mature and both eyes were involved. The surgeon was constrained from early surgery by the frequency of severe complications, the long recovery period, and the distortions secondary to aphakic glasses. Now it is easier to perform phacoemulsification and implant lenses in the early stages of cataract formation when the nucleus is soft and the posterior lens capsule has not been weakened with age. Also, modern small-incision extracapsular cataract extraction has a low rate of complications and a short convalescent period. It is feasible to extract a clear lens or one with minimal opacifications and have a grateful patient. The surgeon is able to improve the refractive state of the eye by selecting the IOL power (Jampel, 1999).

The techniques and results of cataract surgery have changed dramatically during the past four decades. We have moved from intracapsular cataract extraction as the preferred technique to exclusively extracapsular procedures. Smaller incisions have become the standard, with phacoemulsification now being the method of choice for all surgeons. Along with these advances have come improved IOL materials and designs, especially well suited for use with smaller incisions. Phacoemulsification as a method to remove the cataractous lens was first proposed more than 30 years ago. Advances in techniques and equipments have led to a dramatic increase in the popularity of phacoemulsification with increased safety and efficiency. Viscoelastic agents have been developed synchronously with modern phacoemulsification techniques, playing an integral role in the success of this new technology. Improved surgical techniques for removing the anterior lens capsule have

decreased the incidence of both intraoperative and postoperative capsular complications. Nucleus removal, formerly performed primarily in the anterior chamber, is now performed in the posterior chamber, decreasing damage to the corneal endothelium. Improved wound construction allows many wounds to be left unsutured, and smaller wounds allow shorter recovery time and greater intraoperative control and safety. IOLs can have smaller optic sizes and still maintain accurate centration. Foldable IOLs can take advantage of the smaller incision, even further shortening the time to visual recovery. Continual evolution of this technology promises to further improve patient outcomes after cataract surgery (Linebarger et al., 1999).

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