AKADÉMIAI KIADÓ

Developments in Health Sciences

2 (2019) 4, 88–92

DOI:
[10.1556/2066.2019.00002](https://doi.org/10.1556/2066.2019.00002)
© 2019 The Author

REVIEW ARTICLE

*Corresponding author. Department of Ophthalmology, Semmelweis University, Maria utca 39, Budapest, H-1085, Hungary
E-mail: nagy.zoltan_zsolt@med.semmelweis-univ.hu

History of cataract surgery from ancient times to today

Honorary Lecture at the 13th Conference of the Hungarian Medical Association of America – Hungary Chapter (HMAA-HC) at 30–31 August 2019, in Balatonfüred, Hungary

Z. Z. NAGY*

Department of Ophthalmology, Faculty of General Medicine and Faculty of Health Sciences, Semmelweis University, Budapest, Hungary

Received: October 21, 2019 • Revised manuscript received: November 5, 2019 • Accepted: November 7, 2019
Published online: July 31, 2020

ABSTRACT

Cataract surgery is the most frequently performed ophthalmic surgery worldwide. This year approximately 32 million surgeries will be performed. The journey to modern, quick, and safe cataract surgery has been quite long. This review covers topics from ancient couching to the most modern phacoemulsification and femtosecond laser-assisted cataract surgery. The gain in quality of life is the largest with cataract surgery compared to other implant surgeries (e.g. knee, hip replacement, etc.). Ophthalmology has made huge advancements in recent decades. New microsurgical tools and diagnostic equipment have been developed, together with new surgical methods and foldable intraocular lenses, made from biocompatible material. From monofocal lenses, through aspheric, toric, and multifocal lenses, to multifocal toric lenses, today almost all kinds of refractive error can be compensated, including presbyopia. Teamwork, precise preoperative assessment, and fine surgical technique should also be emphasized in order to achieve the best and most predictable postoperative results for both patient and surgeon.

KEYWORDS

cataract, surgery, couching, extracapsular and intracapsular cataract extraction, phacoemulsification, femto laser-assisted cataract surgery

INTRODUCTION

Good visual acuity was an ancient wish of mankind. In early ages good vision was a presumption of survival because hunting and fishing without it was impossible. Cataract was the main cause of blindness for thousands of years, and there was no effective treatment until recent centuries. Cataract is a pathological opacity of the crystalline lens, which represents a +23.0 D of refractive power within the eye. For object focussing, this lens power is necessary except in cases of high (–20.0 D) myopia, where removal of the crystalline lens makes spectacle correction unnecessary. However, myopia this high is very rare.

In ancient times couching of the lens was the only method to restore the clarity of the optical pathway, but it did not restore the refractive power of the eye. Cataract in humans usually starts forming with a thickening of the lens due to activity of epithelial cells under the anterior capsule, and then continues with an accumulation of water, proteins, etc. All these cause the thickening of the lens and, consequently, increased refractive power and myopisation of the eye. At first, the previously emmetropic patient observes that reading is now

possible without spectacle correction, but visual acuity at a distance is decreased. Thereafter, the patient can read only in strong light, then reading capacity is decreased, and visual acuity at a distance is further decreased. At this point, patients usually seek out an ophthalmologist. The solution is a cataract procedure. At present it is seemingly a simple procedure because people usually do not realize how many people work together to make the surgery a success.

Before surgery a thoughtful preoperative examination is needed. Measurements are taken of the uncorrected and best corrected far and near visual acuity, the overall refraction of the eyes, the refractive power of the corneas, the dimensions of the crystalline lenses, and the axial length of the eyes. A Scheimpflug image, anterior and posterior optical coherence tomography (OCT) imaging, and lens calculations should be performed. In full pupillary dilation, the fundus should be checked for any pathology, especially for macular and optic-nerve pathology, and the intraocular pressure should be measured to rule out glaucoma. Following this, an appointment for surgery should be arranged, as cataract surgery is an elective procedure. The surgery usually lasts 10–20 min without complications, assuming the patient has been prepared with pupil dilation and a blood-pressure measurement, has a normal blood glucose level, and is in good general health. Anticoagulation therapy is not a problem nowadays due to the clear corneal incision. Not even one blood cell should be lost during surgery. Anaesthesia can be retro-, parabolbar, or drop anaesthesia, and in exceptional cases, general anaesthesia. The surgery nowadays is a one-day procedure, so the patient may go home right away. Many people think it is a simple procedure, not realizing how much preparation is required.

In the history of eye surgery, refractive surgery developed at the highest rate during the past two decades. Because it was always a paid procedure, and the patients who wanted it were usually younger than those needing cataract surgery, they were more demanding and wanted better results. At the dawn of refractive surgery, ± 1.5 D postoperative refraction was the aim, then it decreased to ± 1.0 D, then to ± 0.5 D, and nowadays it is ± 0.25 D. Cataract surgery was not so successful in terms of predictable results, especially because for a long time no toric intraocular lenses were available.

Toric, multifocal, and toric-multifocal lenses gave significant momentum to the increasing predictability of cataract surgery [1]. With the appearance of these premium lenses, younger and younger patients wanted refractive lens exchange to correct presbyopia and avoid difficulties in their professional life and outdoor activities. Because refractive lens exchange is a paid procedure, tremendous development of the tools used for preoperative assessment of cataract patients was begun. To increase the satisfaction of both patient and surgeon, new lens calculating devices appeared on the market, and new mathematical formulae became available to increase the predictability of postoperative refraction [1].

Let us review the developments in cataract surgery which led to the modern technology with which patients can have the same visual abilities at 70 years of age, without having other ocular pathologies, as they had in their 20s [1–13].

ANCIENT CATARACT SURGERY

The first written record goes back to 2250 BC, when Hammurabi, the king of Babylon, created a law related to the outcome of cataract surgery: 215. If a physician operates on a man with a severe wound (or makes a severe wound upon a man) with a bronze lancet and saves the man's life, or if he opens an abscess (in the eye) of a man with a bronze lancet and saves that man's eye, he shall receive ten shekels of silver (as his fee) [14]. At that time, a cataract was thought to be an abscess in the eye or in the brain (Fig. 1).

Hammurabi's law shows the value of vision, even in ancient times, and is the first proof that cataract surgery already existed in ancient times [3, 4]. Because sterility and asepsis were still unknown, the results of eye and any other surgery were unpredictable. In the Middle Ages the barbers (what eye surgeons were called that time) had to wander from city to another city to keep their fingers and lives.

In ancient Egypt, the physicians were mostly priests. The Ebers Papyrus described human diseases in 110 pages. Eight of them dealt with eye diseases and natural treatments such as beans, castor oil, onion, pomegranate, and opium.

Asclepius was considered a hero and the God of Medicine in ancient Greek mythology and religion. He was the son of Apollo and a mortal woman. Medical procedures were performed in his temples, which practically served as hospitals during the times of his worship.

1200 years later, in 350 BC, the separation of medicine from ancient temples occurred, and the father of medicine was

Fig. 1. Law-Codex of Hammurabi
(source: https://www.bible-history.com/ancient_art/images/law_hammurabi.jpg)

now called Hippocrates. He was a great observer and considered medicine a science of observation. He treated eye disease with vein section and cupping or local irritants to remove bad humours. Chronic inflammation was treated with breast milk, gall of goats, and ointments made with copper, lead, or iron.

The Greek physician Galenus (Galen, as the Romans called him) contributed substantially to the anatomy of the eye. He described the retina receiving light input from the external world through the lens and thought it of great importance to visual perception. A thousand years later Leonardo da Vinci re-proposed the idea.

In 1268 Roger Bacon, a monk in England with an education in mathematics, physics, and philosophy, wrote his *Opus Magnus*, in which he recommended a convex lens to ease presbyopia. Alexander de Pisa, who had talented glass blowers in Murano make the first spectacles, especially for priests, who could read and lived long enough to develop presbyopia, supported the idea. In the 18th century Benjamin Franklin invented the bifocals. He had myopia and presbyopia, and his bifocal lens could compensate for both [6].

In 1608 Galileo Galilei invented the first telescope, and later in the same century Antonin van Leeuwenhoek invented the first microscope. He was able to visualize microbes, for which he coined the word *animalcules* from Latin, with the meaning “small animals.” He published his results in Latin and is considered the father of microbiology.

Later, Helmholtz created the ophthalmoscope. Albrecht von Graefe discovered its huge potential and used it to describe many diseases of the fundus [8].

An Indian ophthalmologist named Maharishi Sushruta between 800–600 BC wrote the first detailed description of cataract surgery [2, 3]. The method spread, and in 29 AD Cornelius Celsus described it again in his *De Medica*.

The word “couching” is interesting. It comes from the French *coucher*, meaning “to put to bed.” In ophthalmology, it means to sink the crystalline lens into the vitreous or the fundus of the eye. The surgeon would introduce a sharp needle into the eye and force the lens to sink into the vitreous to remove it from the visual field [5]. Sterility was a huge problem. Another was that if the lens capsule was damaged, lens proteins were dispersed. The lens is in a privileged position in the body, the proteins are encapsulated into the lens capsule, so in case of capsular trauma the body does not recognize lens proteins as its own. When dispersed, the proteins cause severe inflammation and a rise of intraocular pressure, and consequently can cause blindness. Couching could be very successful, but also a disaster. Besides these possible serious complications, the refractive power of the crystalline lens was never replaced, so patients were usually not able to focus on close objects, except those patients who were severely myopic preoperatively (Fig. 2).

The next step in cataract surgery was the extracapsular cataract procedure (ECCE), which was first performed by Jacques Daviel in Paris in 1747 [7]. He proved at the Academy of Sciences in Paris that vision loss is related to the opacity of the crystalline lens and not to bad body humours. Daviel created a large wound, punctured the lens capsule,

Fig. 2. Surgical instruments used by Sushruta: the triangular lancet (for corneal incisions) and the couching needles (source: https://haribhakt.com/wp-content/uploads/2015/01/sushruta_surgical_devices_instruments.jpg)

expressed the nucleus, and extracted the lens cortex by curettage. He had a success rate of cc. 50%. Anaesthesia, antiseptics, and antibiotics did not exist in that era. This type of cataract removal came back in the XXth century, using more modern surgical tools (Fig. 3).

Six years later, Samuel Sharp in London performed the first intracapsular cataract extraction (ICCE). He made a large limbal incision and removed the whole crystalline lens, together with the capsule. For about 100 years, ICCE was the method of choice in cataract surgery [6, 11]. In 1961 Krwawicz, a Polish ophthalmologist, invented cryoextraction, in which he used a freezing method to remove the cataractous lens.

Giacomo Casanova also played a role in the history of ophthalmology. In 1775, after consulting Tadini, an Italian surgeon in Warsaw, Poland, he went back to Germany and suggested to Casamata that if a surgeon replaced the crystalline lens with a glass bead, the patient might see much better following cataract surgery. The knowledge of anatomy was not perfect at that time. Nothing was known about the roles the posterior capsule and the lens zonules might play in keeping the artificial lens in place, so Casamata just put the glass bead into the eye, where it sunk into the vitreous without having any refractive effect [10].

MODERN CATARACT SURGERY

In 1967 Charles Kelman introduced the method of phacoemulsification, in which he used the energy of ultrasound to crush the lens and remove it from the eye through a 3.0 mm incision [12]. The first trial was not very successful. Many corneas decompensated because excessive ultrasound use warmed up the aqueous, which was harmful to the non-regenerating endothelium.

Fig. 3. Daviel's technique of cataract extraction

(source: <http://www.mrcophth.com/Historyofophthalmology/cataracthistory.htm>)

The artificial lens was developed by Harold Ridley during the Second World War [1]. He observed that pilots who suffered eye injuries from the shattered windscreens of their aeroplane had no inflammation or immune reaction from the pieces of acrylate. He started to use this material to replace the refractive power of the crystalline lens. Of course, it was a long way to the modern intraocular lenses used today, but the first step was definitely taken by Ridley. Various other materials for fabricating intraocular lenses, materials which could be considered biophilic and not to cause harmful reactions, have been tried, including

hydrophobic and hydrophilic and silicon materials. Silicon is no longer used. Hydrophilic materials have been found more effective against posterior capsule opacification (PCO). The PCO rate is about 10% using hydrophobic material and perfect surgical technique.

Phacoemulsification was spread worldwide but is used for cataract removal almost exclusively in the developed countries (Fig. 4). In 2008, the femtosecond laser was created for cataract surgery. This development was the work of Tibor Juhasz (a professor of physics). The first femtosecond laser-assisted surgery on a human was performed by Zoltan

Fig. 4. Phacoemulsification (Kelman 1967) and artificial lens

(source: <https://steemkr.com/health/@himal/a-brief-history-of-cataract-surgery-from-ancient-couching-method-to-the-latest-femtosecond-laser-surgery-part-1>)

Nagy in Budapest Hungary [13]. This method also spread quickly, and millions of eyes have been operated on by the method. It is estimated that 32 million cataract procedures will be performed globally in 2020.

Since the 90s, newer types of intraocular lenses have appeared in the market. First the monofocal lens appeared, then the aspherical lenses, then the toric, multifocal, and multifocal-toric lenses [1]. The accommodating lenses were a great promise, but they did not fulfil the requirements, so the idea was abandoned about a decade ago. Multifocal lenses survived, and now tri- and quadrifocal lenses provide good far, intermediate, and near visual acuity. All multifocal lenses decrease the contrast sensitivity somewhat. This is the price of good far and near vision. Most patients accept it and have no problem. A glare effect may disturb night driving, so for drivers of public-transport (taxis, buses, and lorries), multifocal lenses are not fully recommended. Besides the cataract procedures refractive procedures have also been developed. For lower myopia and hyperopia, refractive surgery is now recommended, and for a large dioptr range, a refractive lens exchange may be a good solution.

DISCUSSION AND CONCLUSIONS

Cataract surgery is nowadays the most frequent transplant procedure. It provides the highest gain in Quality of Life with the lowest cost, and the highest gain compared to artificial replacement of the hip, knee, or heart, etc. It should be emphasized that during a 20–30 min procedure, full visual acuity can be restored, and that, with premium lenses, astigmatism and presbyopia can also be compensated. Ophthalmologists use the latest advances in computer technology to provide the best visual results for patients. Artificial intelligence offers great promise in achieving optimal and customized results for every patient. Surgical procedures are not perfect, even today. To have the best refractive results and happy patients, ophthalmologists, and care providers, other pathologies of the eye should be ruled out and treated effectively before cataract surgery. Ophthalmologists need a lot of equipment for preoperative and postoperative assessment. Sterility and asepsis have the utmost importance, and well organized team work in the operating theatre is also a prerequisite to predictable and expected postoperative results. In this way ophthalmologists can provide perfect vision for patients of any age. Ophthalmology has come a long way in order to provide a safe and quick procedure that restores lost visual acuity and

the patient's quality of life. But it requires good team work, continuous surgical practice, and constant education, including an awareness of the literature and technical advances. Last but not least, it requires a profound dedication to patients and a respect for the fine anatomical structure of the eyes.

REFERENCES

1. Feigenbaum A. Early history of cataract and the ancient operation for cataract. *Am J Ophthalmol* 1960;49:305–26.
2. Yarrington CT, Jr, Yarrington D. A history of the surgical treatment of cataract. *New Physician* 1963;12:354–60.
3. Nieves-Moreno M, Asorey-García A, Santos-Bueso E, García-Sánchez J. History of cataract surgery (I): from destruction to removal. *Arch Soc Oftalmol* 2015;90(1):e3–5. <https://doi.org/10.1016/j.oftal.2014.04.020>.
4. Jacob KH. Couching for cataract in Ethiopia. [Article in German]. *Klin Monbl Augenheilkd* 1973;162(3):407–11.
5. Zwolakiewicz H. History of cataract treatment. [Article in Polish]. *Klin Oczna* 1973;43:331–5.
6. Hildreth HR. Daviel. Modern surgeon. *Am J Ophthalmol* 1953;36:1071–4. [https://doi.org/10.1016/0002-9394\(53\)91888-1](https://doi.org/10.1016/0002-9394(53)91888-1).
7. Wachholz EA. Cataract knife and cataract incision from Jean Jacques Daviel to Albrecht von Graefe. *Ber Zusammenkunft Dtsch Ophthalmol Ges* 1972;71:709–12. [Article in German].
8. von Graefe A. Clinical remarks on modified linear extraction. *Br Med J* 1867;1(336):657–61. <https://doi.org/10.1136/bmj.1.336.657>.
9. Taieb A. Des mémoires de Casanova á l'opération de Ridley. [Article in French]. *Arch Ophtalmol Rev Gen Ophtalmol* 1955;15(5):501–3.
10. Krwawicz T. The cryoextraction of cataract and its influence on cryo-ophthalmology. [Article in German]. *Klin Monbl Augenheilkd* 1970;157(5):593–604.
11. Kelman CD. Phaco-emulsification and aspiration. A new technique of cataract removal. A preliminary report. *Am J Ophthalmol* 1967;64(1):23–35.
12. Kohnen T. How far we have come: from Ridley's first intraocular lens to modern IOL technology. *J Cataract Refract Surg* 2009;35(12):2039. <https://doi.org/10.1016/j.jcrs.2009.10.019>.
13. Nagy Z, Takacs A, Filkorn T, Sarayba M. Initial clinical evaluation of an intraocular femtosecond laser in cataract surgery. *J Refract Surg* 2009;25(12):1053–60. <https://doi.org/10.3928/1081597X-20091117-04>.
14. Harper RF. The code of Hammurabi, king of Babylon: about 2250 B.c. Lawbook Exchange, Ltd.; 2010.