Intraocular Lens Implantation

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On the occasion of the 4th International Cataract, Implant, Microsurgical and Refractive Keratoplasty Meeting, it is a great honor to present the Arthur Lim Lecture.

Introduction

This is a proverb in Japan, which can be translated as "treasure the old and seek for the new". I would like to, therefore, begin my presentation by looking back at how the intraocular lenses (IOL) and their implant-techniques have evolved over these years. Mr. Harold Ridley, having implanted an acrylic lens into the eye following cataract extraction on November 1949, has been accepted as the first to have performed IOL implantation. In July of 1951[1], one and half years after the surgery, he reported his case on the Oxford Ophthalmological Congress, which was then published in Trans Ophthalmol Soc UK 1951, 71:617-621. Just after the Congress, this news appeared in the London Times as a medical topic.

Evolution of IOLs

There are mainly five major generations in the development and improvement of lOLs.

The first generation was Ridley's original lens made of polymethylmethacrylate (PMMA), closely resembling the shape and size of the crystalline lens, though much heavier. The success rate was low and complications such as luxation of IOL, irritation and glaucoma etc. developed.

The second generation in the 1950s was the early anterior chamber lenses (ACL) designed by Strampelli[2] and others. ACL implantation was a secondary lens implant. In these cases, the lens remained in the anterior chamber, supported by the chamber angle. The advantages of ACL included no lens loss into the vitreous and easy implantation. Just as ACLs were beginning to be recognized in Europe, serious complications developed notably, the endothelial corneal dystrophy (ECD), which occurred around 2-3 years post-operatively. Since then, implantation has been regarded as a procedure never to be performed, and most ophthalmic surgeons gave up on IOL implantation all together.

The third generation in the end of 1950s - 1960s was the iris-supported lOLs, which contact neither the chamber angle nor the cornea, designed by Binkhorst[3] and Epstein[4].

The fourth generation was in the 1960s, the Choyce's[5] ACL to prevent complications of the previous ACL.

The fifth generation is the present posterior chamber lenses (PCLs) which are set off by Shearing[6]. In the beginning, PCL was supported by the sulcus. This eventually evolved into the capsular fixation, a fixation which places the PCL where the crystalline lens was originally located.

Extracapsular Cataract Extraction

Because after-cataract was the major complication following extracapsular cataract extraction (ECCE), intracapsular cataract extraction (ICCE) was the method of choice during the 1960s and 1970s. Binkhorst's iris-clip lens could be used in combination with ICCE[7]. However, with this lens, he encountered other complications, including lens luxation, endothelial corneal decompensation (ECD) and cystoid macular edema. Binkhorst analyzed his cases and concluded the following: The eye having undergone ICCE does not have any barrier between the anterior and posterior portion of the eyeball; as a result eye movements cause tremendous disturbance or stress to the iris and vitreous, affecting both the retina and choroid: the implanted IOL enhanced this effect leading to pseudophakodonesis, which causes the encountered complications.

To prevent this complication, he removed the cataract extracapsularly, leaving the posterior capsule intact as a barrier. The IOL could be placed between the iris and the posterior capsule or within the capsular bag.

Innovation on Cataract and IOL-Implantation

In the 1950s, the major innovation in cataract surgery was introduction of the operating microscope, which provided the surgeon with magnified and detailed view of the surgical field. Along with this breakthrough, surgical equipment, surgical beds and other necessities continued to undergo refinement.

Although ECCE became recognized as the method of choice, the problem of residual cortex removal still remained unsolved.

In 1969, Kelman[8] attempted using ultrasound to emulsify the lens and reported their experimental results. The ultrasonic tip inserted through a small incision, emulsified and aspirated the nucleus and residual cortex could be irrigated and aspirated. This procedure, phacoemulsification (PE), was definitely another major innovation.

While classical cataract surgery used to be an open eye surgery, these new surgical techniques have turned it into a closed eye surgery, maintaining intraocular pressure and aiming to perform as atraumatic surgery as possible.

The innovation of viscoelastic materials and the introduction of continuous circular capsulorhexis, a form of entire capsulotomy, have allowed secure fixation of the PCLs. Nd:YAG laser was introduced to non-incisively treat after-cataract, which was the major complication of the ECCE. The newer microscopes were further equipped with two microscopes, with a wide use of the video-systems, surgical details can be clearly observed on a monitor and recorded on a video-tape for the study-education of surgical techniques. All these new innovations greatly contributed in further spreading IOL implantation.

Preoperative Examination

Obviously, surgery can never be performed successfully without preoperative examinations. If surgery itself can be regards as the "Grand show", then the preoperative examinations are the events taking place at the back stage. Some of these important preoperative examinations are as follows.

Besides the intraocular images disclosed by B-scan of ultrasonography, measuring the axial length is of great importance. Using a mini-computer, this value and the corneal refractive power are essential in deciding the correct IOL power.

Specular microscopy holds the key in determining the surgical indication of the cases. Flare cell meter, a new device measuring the anterior chamber protein and cells, has made it possible to objectively and numerically demonstrate the changes occurring in the anterior chamber following IOL implantation. This lead the surgeons to seek for different surgical techniques, lOLs and medications, which best meet the desired postoperative outcome.

Brief History of IOL Implantation in the Asia-Pacific Region

In Japan, Nakamura performed acrylic lens replacing cataractous eye in two patients in 1952[9], and then Kajiura followed in four cases in 1953[10]. The lOLs were made of PMMA which were in the market. Their attempts ended in failure because of the impurity of PMMA. Hayano[11] has been involved with lOLs and its implantation since the mid 1950s. In 1960, his first clinical visual repair cases where he implanted ACL in unilateral aphakia were reported. The ACL was designed by Hayano and was made of cross-linked PMMA. ECD following ACL implantation occurred in 70% within 3-5 years postop in this series[12].

In 1960, Sang Soon Shyn was the first Korean Ophthalmologist who performed implantation of ACL designed by Dahnheim to an aphakic patient who has had good vision for 20 years[13].

In the mid of 1970s, Takeuchi reported his successful iris-clip lens implantation cases and Hayano restarted the implant surgery[14,15]. At that time, in the Asia-Pacific region, only a few ophthalmologists paid attention to this method. Stabbs in Australia, Teng in Indonesia and Bose in India might begin to attempt IOL implantation. They continued quietly because of the extreme negativism and strong criticism for pursuing this method.

Enthusiasm for lOLs began to burgeon in 1974 at the 22nd International Congress of Ophthalmology at Paris, then grew in 1976 at the US Intraocular Lens Symposium at Los Angeles.

In the Asia-Pacific region, interest for lOLs started slowly. In 1978, the 5th International Intraocular Implant Club Meeting at Nagoya was organized by Hayano, the Meeting President. The meeting was one of the satellite symposia of the 23rd International Congress of the Ophthalmology at Kyoto.

From the end of 1970s to the mid 1980s several famous European and American leaders of IOL surgery gave lectures on lOLs and demonstrations of IOL implantation in the Asia-Pacific region.

Arthur Lim is one of the big leaders in this field. He has been working very hard in spreading modern ophthalmology throughout, mainly on the microsurgical techniques and also IOL implantation, by organizing workshops held in Singapore since the mid 1970s.

Knowing the need for communication on lOLs, Hayano organized the Japan Intraocular Lens Implant Club founded by 20 members in 1975. The members contributed greatly to the spread in the use of lOLs in Japan. The club has been changed to the Japanese Intraocular Implant Association and membership has grown to 900 in 1985.

Now we are proud of two world-wide leaders in the field of IOL implantology. One of them, Kensaku Miyake, the President of the IIIC, and the other, Arthur Lim, the President of the APIIA and the Past Congress President of the International Congress of Ophthalmology. We find many active IOL implantologists in Asia, namely Yamanaka, Hara, Nishi, Momose, Kim Jae Ho, CN Naval, JH Waida, SRK Malik and others.

IOL and Medical Polymers

In making the first IOL, Ridley had used Perspex CQ, which was the best form of PMMA available, produced from the Imperial Chemical Industry Co. Ltd. This contributed to the success of the procedure.

The high incidence of the uveitis-glaucoma-hyphema (UGH) syndrome, seen in the US during the 1970s was caused by deformation of the lens haptics, made by injection molding, inside the eye. And the major problem with nylon lens loops of the lOLs was their deterioration within the eye.

Today, all PMMAs used for the IOL are believed to be of a certain quality. Nonetheless, different manufacturing methods of the PMMA result in lOLs of different molecular weights. Further, those PMMA lOLs with low polymerization tend to crack and scar more easily under Nd:YAG laser when compared to those with higher polymerization.

Gifu lOLs designed by Hayano, have optics made of the cross-linked high polymerized PMMA and loops made of poly-vinylyden-fluoride (PVDF). When he was seeking for a macromolecule to be used for the loops, he came across several different fishing lines, 0.2-0.3 mm in diameter. PVDF, a very strong and stable line used for sea fishing, happened to be one of them. The major reason for selecting PVDF was its resistance in ocean salt water, which is similar in composition to the body fluid. Most of Japanese lOLs are produced from Menicon Co. Ltd.

In the Future

Finally, I would like to briefly share with you my prediction and dream for the future of cataract-IOL surgery.

Although once made by hand, almost all products that come into our hands today are factory-made, using N-C machines with some even being made by robots. The application of these advanced machines in manufacturing results in producing materials uniformly and to the best of quality, once only possible in the hands of skilled and experienced craftsmen. And using semi-conductor or I-C-Tips allow even finer and more precise materials to be made, not possible with human hands.

Surgery, on the other hand, depends entirely on the surgeon's skill, knowledge and experience. There may be an ethical problem, if I am to compare surgery to manufacturing products. However, when considering the fact that the N-C robots have taken over manufacturing of the finest products, we can perhaps dream about N-C surgery in the future. To fulfill this dream, there are various problems to overcome: the US and AI tips will need to be equipped with a sensor that will perceive the hardness of the nucleus and with a fiber scope that will allow observations of the tip surroundings: all surgical equipment must be controlled by the machine: and a computer allowing precise movements of each equipment will need to be developed. When solutions to these problems are found, it may be possible to perform "machine-cataract-IOL surgery."

Not too far in the future, there will be experts on the computed machine surgery.

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