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BY DAVID J. APPLE

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Sir Harold Ridley (figure 1) invented and refined the modern miracle of replacing lenses obscured by cataracts with plastic optical lenses, thus rendering a complete cataract cure. This operation, broadly termed the cataract–intraocular lens (IOL) operation, has since brought sight to many millions of people throughout the world, and continues to improve the quality of life of more than 10 million patients worldwide each year.

Ridley not only launched this powerful and irreversible forward movement in the field of ophthalmology and the visual sciences, but through it he also helped give birth to the exciting new field of artificial biodevice implantation as well as transplantation techniques now applied to many other organs and tissues of the body. He has therefore been credited with helping to create the relatively new specialty of biomedical engineering.

Few of the millions of patients worldwide who now enjoy the benefits of the modern cataract–IOL operation are aware of the origin of this innovation. Indeed, few eye care professionals—even ophthalmic surgeons who implant them almost daily—are aware of the origin of the IOL—an invention that, as Harold himself liked to say, ‘cured aphakia’. (The word aphakia comes from the Greek, meaning absence of lens, the situation that occurs when a cataractous lens is surgically removed.)

ANCESTORS AND EARLY LIFE

A plaque was placed in recent years at Pembroke College, Cambridge University, at a site that is known as the Ridley Walk. It was erected in memory of two former students at that college, both Ridleys but separated by approximately 400 years. The earliest of the two was the Rev. Nicholas Ridley, a senior proctor of Cambridge University, who in 1540 was made one of the King’s Chaplains and was presented with a Prebendal Stall in Canterbury Cathedral. He
succeeded to the office of Bishop of London in 1549–50 and became a leader in the Reformation. However, unwilling to adopt theological principles he believed were wrong, he and two colleagues came into sharp conflict with the Queen (Mary I, also known as Bloody Queen Mary) and were burned at the stake on 16 October 1555.

The more recently born Ridley memorialized by the plaque on Ridley Walk is Sir Nicholas Harold Lloyd Ridley. He was born in Kibworth, Beauchamp, in Leicestershire on 10 July 1906, to Nicholas Ridley and Margaret Parker. His paternal ancestors—the Ridleys of the Bishop Nicholas Ridley line—were known historically as country gentlefolk who helped protect part of Hadrian’s Wall. Almost all of the male Ridleys were involved in either medicine or the Church. Ridley’s immediate ancestors were no exceptions: his father was a physician and his father’s father was a schoolmaster before taking holy orders. The Parkers, Ridley’s
maternal line, were known as practical, hard-working, efficient gentry. Their family’s ancestral motto was ‘Do it and it’s done’.

Harold’s father, Nicholas Ridley, was commissioned as a surgeon in the Royal Navy; however, he was diagnosed with haemophilia, which resulted in his mandatory discharge in 1891. Because of his ill health he was not able to pursue his chosen career as a general surgeon. He therefore chose what he believed to be a less strenuous pathway: a career in ophthalmology, including eye surgery. Despite his health problems, Nicholas Ridley successfully practised ophthalmology until his death from a cerebral haemorrhage in 1937.

The Ridleys had two sons, of whom Harold was the elder. They lived in a middle-class home in Kibworth, a village near Leicester. Shortly after the birth of their second son, Allder, Nicholas and Margaret sought a legal separation and the two boys were raised by their mother.

At the age of six years, Ridley had an experience that had a lasting, positive effect on him. He had the opportunity to sit on the knee of the founder of modern nursing, Florence Nightingale, who was a friend of his mother’s. He was of course too young to remember the event, but he cherished hearing his mother reminisce about it.

Following a year or so at boarding school in Hove, he attended Charterhouse, a prominent boarding school near Godalming, Surrey. He entered when he was about 14 years old, and remained from about 1920 to 1924. In 1924 he entered Pembroke College, Cambridge University, where his strength was in the sciences. He completed his studies there in 1927, receiving an honours degree.

MEDICAL TRAINING AND EARLY PROFESSIONAL YEARS

In 1927 Harold began his medical training at St Thomas’ Hospital in London. His scholastic success there assured him of a house surgeon’s position at his teaching hospital. He completed his basic medical education in 1930. He then spent six months as a casualty officer at St Thomas’ Hospital, followed by a year of general surgery at the same location. During this period he completed a very significant segment of his training: a six-month sojourn under the legendary Mr A. Cyril (‘Huddy’) Hudson. In July of 1932, at the youngest eligible age of 25 years, he received the designation FRCS (Fellow of the Royal College of Surgeons).

The time that Ridley spent with Hudson in ophthalmology at St Thomas’ played a pivotal role in his ophthalmological training and his choice of making that his specialty. Harold’s father also influenced his decision to enter ophthalmology. Mr Geoffrey Doyne was another surgeon who influenced Harold during his training years at St Thomas’. Doyne had advanced his career by recommending that he do further training as a registrar at Moorfields. Consequently, Harold was exposed to the best eye surgeons in London from the beginning, and he learned well from them.

Soon after his qualification, Harold spent his time as a temporary house surgeon and anaesthetist at Derby Royal Infirmary. In addition, recalling that his father had wanted him to see the world before he became too busy, he served as a ship’s surgeon on various vessels in 1933 and 1934. This included a four-month voyage to Japan.

After these adventures, through a recommendation by Doyne he was offered an 18-month period of ophthalmology residency training at Moorfields Eye Hospital in 1934–35. He
performed 109 cataract extractions during 12 months of active time in the operating theatre. In those days the average number of operations performed by young residents was 30 to 40.

The preferred single technique in mainland Europe and England during Harold’s early years was intra-capsular cataract extraction (ICCE). However, even though he was not permitted to perform the technique of extracapsular cataract extraction (ECCE) until somewhat later, he recognized at this early stage that the ECCE technique was generally safer and preferable to ICCE. Fortuitously, ECCE turned out to be the best technique for use with the IOL—the invention that would later make him a giant of ophthalmology.

In 1938 Harold was appointed full surgeon and permanent consultant at Moorfields Eye Hospital—the youngest person ever to receive such an appointment.

A REALIZATION THAT BECAME A REVOLUTION

World War II began in September 1939. Harold expected to be immediately inducted into the Royal Army Medical Corps. However, as soon as the German forces consolidated their gains in Poland, Belgium and elsewhere, they halted and a year passed with little active conflict. This became known as the ‘phony war’. The paucity of military actions between Britain and the Axis powers meant that physicians on active military service had little to do.

He was not called for service during this period, but was much busier as a civilian than he would have been as a military medical officer on active duty. As time passed it became clear that the ‘phony war’ would eventually turn brutally hostile. The British authorities decided that St Thomas’ Hospital in London, one of the sites where Harold had trained and thereafter one of his places of employment, was a likely prime target of Nazi bombing raids, or at the very least would be in the path of destruction. After all, it was a venerable and important part of Britain’s health care establishment and was located on the River Thames just across from the Houses of Parliament.

This view was proven correct. Much of St Thomas’ was, in fact, damaged by bombs throughout the war. Many sections of the hospital were evacuated to satellite medical facilities to the south and some of these satellites were grouped around and within a few miles of a centrally located airport: RAF Tangmere.

Harold apparently did work at several facilities in the region around RAF Tangmere, including a St Thomas’ satellite near Godalming in Surrey, the Emergency Medical Service at St Luke’s Hospital in Guildford, and the Royal Buckinghamshire Hospital near Aylesbury.

RAF Tangmere was a site destined to be in the middle of the air battle of 1940. The authorities, military and civilian, in the medical facilities around RAF Tangmere expected heavy casualties if and when real hostilities began. This occurred on 10 May 1940 as the ‘phony war’ became a real war. One of the squadrons at RAF Tangmere was 601 Squadron—a Hurricane fighter pilot squadron also known as the ‘Playboy’ and ‘Millionaires’ Squadron.

Flight Lieutenant Gordon ‘Mouse’ Cleaver (figure 2) had served with 601 Squadron throughout the Battle of France and the evacuation of Dunkirk. Before the war he had been a world-class skier and by the early days of the Battle of Britain he had become a flying ace. By August 1940 his active military career as a pilot was about to end, but fate had positioned him in a unique situation where he unknowingly helped Harold with the development of the IOL. While he was flying back to the base after a sortie during the critical ‘Adlertag’ (‘Day of the Eagle’) battle on 14 August 1940, a bullet smashed through the Perspex acrylic material that
formed the sidewalls of his cockpit. Without the protection of his flight goggles, which he had
forgotten in his rush to his plane earlier that day, he was immediately blinded in both eyes by
multiple fragments of plastic from the canopy. Surprisingly, he was able to maintain control
of his aircraft long enough to turn it upside down, positioning it so he could parachute to
safety. Landing on the English flatlands, he was rushed to the Salisbury infirmary for emer-
gency treatment.

The pieces of plastic shrapnel that had been blown into Cleaver’s eyes had blinded his left
eye completely and seriously reduced the vision in his right eye. He was first seen in various
satellite hospitals. It is not clear whether Harold first attended to Cleaver outside London
before he was sent to Moorfields Eye Hospital. It is known that Cleaver had 18 operations on
his eye and face to try to preserve some vision and make plastic surgical repairs on his face.
Harold performed several if not all of Cleaver’s eye operations over the next several years at
Moorfields. Some of these operations consisted of removing pieces or portions of the plastic
fragments embedded in the coats surrounding his eyes or within the eyes.

One eye was saved and he was eventually able to return to civilian life with several small
pieces of plastic still embedded in his eyes.

What, then, did Flight Lieutenant Cleaver’s injuries have to do with the invention of the
IOL more than eight years later? Harold had long believed that it would be possible to replace

Figure 2. (a) Flight Lieutenant Gordon ‘Mouse’ Cleaver, of 601 Squadron, RAF Tangmere. Without realizing it,
Cleaver played a major role in helping to launch one of the major advancements in eye surgery. Ridley saw
several pilots with the same type of injury, and this was crucial to the invention of the IOL. However, Cleaver
is the only pilot for whom records were available. (b) Harold Ridley in the late 1940s. Ridley recognized the
significance of Cleaver’s injuries with respect to his idea of an IOL, and this began the ‘count down’ that
would culminate in the invention of the IOL.
cataractous lenses with artificial lenses. (As early as 1935 or possibly earlier, he had discussed the idea of an artificial lens or lens transplant with his father and with his professor, Mr Hudson.) He believed that such a transplant would complete the existing cataract surgical procedure.

Before Harold’s invention, the only means that a surgeon had to rehabilitate an aphakic patient (one without a lens) who had just had his or her cataractous lens removed was to prescribe very thick spectacles termed aphakic spectacles. The lenses were so thick that they resembled the bottom of a soft-drink bottle or a carnival funny mirror—which usually precluded good visual restoration.

Harold’s extended work with Cleaver’s eye injuries (and very probably similar injuries sustained by other pilots) led him to a realization that would result in what some have called the most important advance of the century in the field of eye surgery. As Harold followed Cleaver for months and then years he gradually realized that the embedded splinters of cockpit plastic were tolerated by human eye tissue without causing inflammation or other adverse effects. That realization led Harold to believe that biocompatible artificial lenses could be made of a similar material to replace the natural lenses, thus restoring much improved vision to patients with cataracts.

Many opponents later criticized Harold for not doing animal studies before implanting a lens in humans. They were wrong. He did not need a test-tube study to come to this realization, nor did he need experimental animals. He had the best of all possible study specimens, namely a human being whom he carefully followed for eight years. Companies today would have to pay millions of dollars to perform such studies within the parameters of modern regulatory agencies. In effect Flight Lieutenant Cleaver represented an ideal preclinical study for testing the biocompatibility of the implantable material. However, the time and opportunity to turn his ‘discovery’ into an actual, vision-saving medical advancement would not be available to Harold until after the war.

Harold stayed busy with other pursuits during the remaining years of the war. On 10 May 1941 he married Elisabeth Weatherhill in Surrey. Elisabeth had grown up in India, where her father was employed. World War II had already broken out and their marriage took place during the Blitz. In due course the couple had three children: Margaret (born in 1942), Nicholas (born in 1943) and David (born in 1951).

On the same month as his marriage, Harold was appointed temporary major in the Royal Army Medical Corps. In that year he was sent to Ghana in the Gold Coast of West Africa (figure 3) by Sir Stewart Duke-Elder (FRS 1960), then the ranking ophthalmic officer in the British Army. Initially, Harold was disappointed with the appointment because, as he later said, ‘West Africa was not likely to be a fighting area where surgical experience would be of value.’ Nevertheless, he took full advantage of his time in the service. In fact, he was responsible for advancements in the areas of onchocerciasis (river blindness), the establishment of cataract–IOL surgical facilities, and activities in the treatment of vitamin A deficiency.

During the war, the Ridleys purchased a home at 53 Harley Street, which later functioned as his ophthalmology rooms or practice on the ground floor. The family’s living quarters were in the two floors above.
THE BIRTH OF THE INTRAOCULAR LENS

In 1948 a young medical student, Stephen Perry, asked Ridley during postoperative rounds whether he was planning to put a new replacement lens back into a patient’s eye from which a cataractous lens had just been removed. Harold later emphasized how important this event was to him. This comment gave him the courage he needed to proceed with the dangerous undertaking he had been contemplating. His eight-year follow-up of Flight Lieutenant Cleaver was complete and his long-incubating plans to develop the artificial lens and the procedure to implant it were about to come to fruition.

He began his formal planning and the mobilization of forces he deemed necessary to form the team to design and manufacture an implantable IOL. As soon as he made the personal decision to proceed with an IOL, he proceeded to assemble a team to help him design and facilitate the fabrication of a lens. He turned to Mr John Pike, an optical scientist who worked for Rayner & Keeler Ltd, a leading optical company in England that had previously specialized in spectacle manufacture. Harold and Pike were already well acquainted, having worked together frequently on other projects. Harold was very well acquainted with the high-quality precision work of Rayner & Keeler (figure 4).

Just a few hundred yards from Harold’s home and rooms at 53 Harley Street, sitting in Harold’s Rolls Bentley parked on a street bordering Cavendish Square, Pike and Harold had their initial discussion on the IOL. Harold explained the project and invited Pike to join in this new and exciting venture. Pike enthusiastically agreed and ‘within perhaps half an hour, the cure of cataracts was established!’ They agreed to use an implant made of the time-tested
acrylic material that had been followed for so long in Cleaver’s eyes. It was chemically sterilized and made suitable to be implanted in the eye’s posterior chamber—‘where God had placed the human lens’. Pike was to calculate the necessary optical values required and he would ask his friend, Dr John Holt at Imperial Chemical Industries (ICI), to produce and provide some high-quality acrylic.

Pike took the ideas he and Harold had discussed for the IOL back to his company. Being an expert in the field of optics, Pike knew very well the myriad disadvantages of the aphakic spectacles. He knew that his IOL would eliminate the need for the thick spectacles that had been used to rehabilitate patients after cataract surgery. The various distortions, aberrations, unwanted magnifications, blurred peripheral vision and other visual impairments they caused were all too apparent.

John Holt produced the needed acrylic (Perspex, or poly(methyl) methacrylate (PMMA)) material. Under his direction, the company synthesized a pure form of the aeroplane cockpit material, which they termed Perspex CQ (clinical quality), the same material (or a very similar variation of it) that is still often used for the manufacture of some IOLs today.

This was an extremely busy time for Ridley, who was working on several other projects to which he had applied the insights and information he had gained during World War II. Among
other things, he was working on a project on televising eye operations for the first time. This involved frequent trips to Marconi Wireless, near Cambridge. His operating theatre nurse, Ms Doreen Clarke, often recalled the fear she endured on several occasions as they drove at high speeds between London and Cambridge, trying to get everything done.

Harold made plans to perform the world’s first IOL implant operation on 29 November 1949 at St Thomas’ Hospital. There are various theories as to why he chose St Thomas’ Hospital. Some of his detractors feel that he was maliciously trying to hide his work from others and would have a better chance of doing it there than at Moorfields. Harold himself offered a more credible reason, pointing out that St Thomas’ offered a quieter setting where he could do his work in a scientific fashion without interruption. In addition, he had chosen a select staff at St Thomas’, including Ms Clarke. His long-standing emotional attachment to St Thomas’ Hospital, based on his training there, not to mention his fond remembrance of Florence Nightingale, whose nursing work was in part done there, were perhaps other reasons why he decided on that location.

Finding the first patients for Harold’s new IOL surgery was a somewhat more difficult task. For more than a year many elderly men and women with strictly monocular cataract were interviewed and invited to risk, from an untried operation, the possible loss of their defective eye in the hope that their personal contribution would widen the parameters of ophthalmology and benefit countless future cataract sufferers. Eventually two people, one each from two hospitals, volunteered after the objectives and the dangers of the operation were explained. They displayed not only personal courage but faith in the venerable institutions and trust in those who worked there.

**The First IOL Implant**

In London, on 29 November 1949, early risers were treated to a crisp, fair morning—a welcome change from the drizzly, overcast weather that haunts Britain during the season’s passage from autumn to winter. It had been almost four and a half years since Victory in Europe (VE) Day. Repairs and renovations were a constant reality as the city laboured to deliver itself from the wreckage of war. Since the end of the awful days of the Blitz in the early 1940s, articles in London’s newspapers, such as *The Times*, had documented the efforts of a brave and tenacious citizenry to rebuild their city. Perusal of the newspaper headlines on that November day revealed no evidence that a particularly important event had occurred or was impending. All seemed quiet and routine. Actually, nothing could have been further from the truth!

Early in the afternoon of this otherwise ordinary day, Harold and a small cluster of colleagues assembled in an operating theatre at St Thomas’ Hospital and began performing their assigned duties around the operating table. They did not yet have operating microscopes with high-power magnification and built-in illumination. They used a simple flashlight (torch).

The operation Harold had been preparing for months was performed in secrecy. The brave person who volunteered to be operated on was a 45-year-old hospital nurse named Elisabeth Atwood, who had a cataract in one eye. Harold chose a very simple design, intended to mimic a patient’s normal crystalline lens. It was a disc, impeccably manufactured by Rayner & Keeler from the same basic plastic material used to manufacture cockpit canopies in aeroplanes of that era.
The operation went well, with no complications. No photograph or film was made. Harold had specifically asked his nurse to write the following in the surgical log book: ‘extracapsular ext.’ (an abbreviation for extracapsular extraction). He told her not to mention the IOL, intending to keep the entire project secret at that time. He had scientific reasons to do this, but also, as he explained years later, he was afraid of professional and perhaps even legal retribution if things had gone wrong.

And so, on that quiet day of 29 November 1949, a new and daring initiative had begun—an advancement that would not only usher in a golden age of ophthalmology but would also change medicine in general and indeed the world. This operation and the series of operations performed soon thereafter by Harold’s team were the very first of their kind. They were hugely important in that they proved the feasibility, potential safety, and efficacy of the IOL—the invention that finally made possible a complete cure of cataract.

A STORM OF REACTION

The ultimate brilliance of his work is that he broke through a heretofore impenetrable barrier: implanting a new lens. Although this allowed him to achieve a complete cure of cataract, it also placed him in the cross-hairs of intense criticism and professional jealousy.

Before 29 November 1949, surgeons were always trained to take things out of the eye, such as cataracts, blood, pus, and foreign bodies that had penetrated into the eye. Now surgeons were about to be asked to put a foreign material into the eye—a complete reversal of their past reality. This change caused extensive controversy for many years as people attempted to either criticize or rationalize the operation. Before Ridley, no one had seriously considered the concept of putting different kinds of artificial solid or semisolid substance into the eye. Today it all seems so simple, but 50 or more years ago it was, in the minds of many, heresy.

Although the IOL biomaterial had been studied in Cleaver’s eye for eight years, the IOL was only slowly accepted. Many of his colleagues, especially in what is termed the academic establishment, strongly rejected him and his work. Many people looked for anything negative they could find.

What Harold implanted in his first patient and in the first five or six shortly thereafter did not remain secret for long. He and his co-workers, the companies with whom he worked, most importantly Rayner & Keeler, were not enriched by these original IOLs. Harold did not patent them. It was his goal to provide a gift to humanity. Ridley had planned on keeping his landmark operation under wraps for about two years. This would give him follow-up time before making the surgery public. He wanted to have the time to evaluate his results.

The planned period of preparation was cut short when one of his patients apparently misread a telephone directory. Seeking a postoperative visit, the patient mistakenly rang the number of Frederick Ridley—also an ophthalmologist, but not related to Ridley. When he appeared at Frederick Ridley’s office, announcing that he was there for his follow-up, the news was out.

Realizing this, Harold decided it was best to accelerate his plans and tell the world about his invention. He submitted his first publication about the IOL in *St Thomas’ Hospital Reports* to establish priority. He then published three important original IOL articles—one in the *Transactions of the Ophthalmological Society of the United Kingdom*, one in *The Lancet*, and the third in the *British Journal of Ophthalmology* (13, 14, 17, 18)*.

* Numbers in this form refer to the bibliography at the end of the text.
Harold’s problems with the British establishment began almost immediately after his work on the implant became public knowledge. In an effort to help the medical community realize the value of the IOL, he decided to make his first major presentation at the Oxford Ophthalmological Congress in July 1951. The Congress was typically held in early July, usually in the facilities of one of the ancient colleges on the university campus. The records from that time are unclear but it is believed that the 1951 meeting was held at Balliol College.

Harold had high expectations for this meeting. His first implant had been performed about 18 months earlier, and this meeting gave him an opportunity to present clinical results to a large and well-informed audience. He planned to take two patients who had excellent clinical results to the assembly to present them for examination by the delegates. In addition, he prepared a cine film of an early operation. (This was another innovation he had developed at the Marconi Wireless Manufacturing facility near Cambridge in the later months of 1949.)

Harold drove two of these patients and his wife to Oxford from London on the day of the meeting. The patients had enjoyed virtually perfect results from their surgery, even compared with today’s standards. One was 20/20; the other was 20/15 (better than the standard ‘normal’). Therefore, in Ridley’s mind, there was absolutely no reason for him not to feel confident and comfortable, with a real expectation that this was to be a landmark day in the history of ophthalmology and eye surgery.

Indeed, it was a landmark day—but not in the way he expected. Instead, it was the beginning of more than 30 years of personal trials and tribulations that led to health problems that plagued him for the rest of his life. Worse, it was the beginning of an unconscionable delay in the implementation of this new procedure—a delay that deprived an entire generation of patients of the benefits of the IOL.

Harold’s lecture was well prepared and presented, and the clinical results were impeccable. Examinations of the patients’ eyes, and a viewing of a film of the operations that Ridley had prepared, would have substantiated the excellent results. However, the examinations did not take place.

The response to Harold’s lecture was disheartening. Although many observers were impressed, several ophthalmologists from the USA and Britain showed little interest. Indeed, the doyen of British ophthalmology, Sir Stewart Duke-Elder, repeatedly refused even to look at the implanted lens. An American visitor jumped over a chair and left the hall. In sharp contrast to Harold’s perhaps naive expectations, as morning passed and lunchtime approached, the future of the IOL was suddenly in jeopardy.

Interestingly, as the news of his IOL operation spread, Harold enjoyed better acceptance by surgeons in several foreign countries than he did in his homeland. In England, only a select few admitted the genius of his work, including Peter Choyce and Edward Epstein. Physicians overseas seemed to be more open to the IOL. For example, Dr Svyataslav Fyodorov of the Soviet Union heard about the operation and immediately recognized its promise. He promptly made the long trip to England to meet with Harold and see the procedure at first hand. Fyodorov became a loyal lifelong supporter of his work and the IOL.

Harold’s invention was potentially career-threatening. Had his early IOL surgery on humans failed, he might have been discharged from his hospital and lost his certificate to practise. Although medical–legal actions were unusual at that time, he still had an understandable fear that in the event of failure he might have had to face a court and jury.

Even though his IOL was successful, Harold faced intense rejection, jealousy and scorn, and was almost ostracized by some of his peers. In most cases these reactions were driven by
professional jealousy, fear of the new, or unjustified scepticism. This followed him in his career at St Thomas’ Hospital as well as at Moorfields Eye Hospital and in his private practice throughout the rest of his career.

For many years he suffered from severe depression resulting from his gift to humanity. He endured numerous attacks and rejections, often leading to periods of depression that required medication.

**TURN OF THE TIDE: SLOW ACCEPTANCE**

In 1966 the International Congress of Ophthalmology met in Munich. A group of ophthalmologists who supported the IOL, led by Peter Choyce, wanted to make sure that there was a place for IOLs on the programme. Although the organizers were very polite, they rejected the request to give IOLs a place. They would not even promise that Choyce’s group would be officially recognized.

Choyce and his colleagues lost their patience and decided to bypass the main meeting and form a society of their own, which they named the Intraocular Implant Club (IIC). Actually, it was called a club rather than a society because Harold, its first president, wanted to keep the membership small and to focus on medical–clinical discussions on IOLs.

The club’s first meeting took place in 1966, at the Royal Institute of Medicine in London. The venue was just a few hundred feet from Ridley’s home and rooms on Harley Street.

By the early 1970s IOLs had earned somewhat more acceptance, but the situation was still very precarious. The next large meeting of the International Congress of Ophthalmology was to occur in Paris in 1974. Two anti-Ridley academicians had a high profile at that meeting and Choyce again was unsuccessful in securing a venue for an IOL meeting or even recognition.

Anticipating such problems, he had decided to try another strategy. On the last day of the main meeting, he scheduled a satellite meeting in a building adjacent to the congress centre, not under the congress organizer’s control. He invited all those interested in the future course of implants to attend. Not only did the small core group of club members attend, but numerous doctors, mainly from America, actually filled the hall. They were not disappointed. Harold Ridley himself was a surprise guest at that meeting!

After this meeting, the IOL, so long in the doldrums, seemed to be on the road to recovery. The club became international and its name was changed to the International Intraocular Implant Club, or IIIC. By the beginning of the twenty-first century this group boasted more than 300 members, and very informative clinical/scientific and social meetings now occur each year.

In 1980 the existence of the IOL in the USA was jeopardized when it became the subject of a Food and Drug Administration (FDA) hearing. Harold’s 1949 IOL was the very first model developed and perhaps the FDA felt that this lens and the modifications made during the period between 1949 and 1980 did not provide sufficient precedent and sample size for adequate analysis. The actor and film star, Robert Young (who had appeared in the television series *Father Knows Best* and *Marcus Welby, MD*) had had a successful IOL operation about four years earlier. At that time, Young was watched by millions of people each week on the television in his role as a doctor. In fact, he was known as ‘America’s doctor’. He enjoyed consistently good vision from his implant surgery. He was 20/20 in both eyes and considered the operation to be an important factor in his ability to continue as an actor. Doctors who were
advocates of the IOL asked Young to testify at the FDA hearing and he accepted enthusiastically.

On the morning of the hearing, several physicians pleaded the case of the IOL, testifying to the excellent results that had been obtained from the implants. Then, in front of the austere FDA panel, and surrounded by a full house of reporters who had expected Mr Young’s participation, the actor took the stand, looked directly at the audience and stated, ‘Look, I am America’s doctor and indeed what is good for America’s doctor is good for America.’ That immediately brought down the house.

However, perhaps his most effective commentary occurred in the hallway outside the meeting room after the meeting. A huge audience, including the numerous reporters in attendance, gathered outside the room. One reporter said, ‘Dr Welby, do you really believe that implants are as useful as you implied?’ Mr Young retorted, ‘Sir, I am not Dr Welby. I am only an actor who plays the part of Welby.’ He then actually tugged at the man’s necktie and continued: ‘Let me tell you, IOLs saved my career and should be available to all Americans!’ The crowd erupted in applause, the press corps dispersed to their typewriters and telephones, and these stunning events were almost immediately flashed on the afternoon network news shows. Members of Congress who had influence over the FDA immediately became caught up in the rapidly unfolding events. Even though the FDA had already made up its mind to ban IOLs, Congress sent a mandate to the FDA to make IOLs available. They were approved without delay.

The IOL’s forward momentum that followed the meeting at the 1974 International Congress of Ophthalmology, along with Robert Young’s testimony at the FDA hearing, was

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Figure 5. These two images are photographs through the plane of patients’ lenses, a technique developed by Dr Kensaku Miyake of Nagoya, Japan, and myself, termed the Miyake–Apple technique. The investigator accesses human eyes obtained post mortem containing IOLs or other devices. The technique was devised to obtain photographs from behind the lens or IOL, thus helping to analyse various features of the lens, including how well the lens is centred and how successful the surgeon was in minimizing various surgery-induced opacifications of the media. This is useful both as a research tool and for providing images for use in teaching. (a) An unoperated cadaver eye viewed from behind (looking from the brain), showing an intact lens that has a cataract, as demonstrated by the discoloration and haze that is visible. (b) A different cadaver eye showing an IOL in place. It was placed within the residual capsular sac (almost invisible in this photograph) after ECCE (see figure 4). The lens is beautifully centred, and the optic is clear. The lens is held in place by the two loops, or haptics.
backed by mounting scientific evidence. Suddenly, a bright new world for IOLs had come into being. Some bumps in the road were still ahead, but Harold’s innovation had finally climbed from the abyss to the forefront and was not to be stopped (figures 5 and 6) (19–21, 23, 24, 26, 27, 29–32, 34–36, 37).

Harold retired from Moorfields Eye Hospital in 1971—a retirement that was officially prescribed by the medical system in which he worked. Because he was not well accepted by some of his colleagues at Moorfields (and also at St Thomas’) after his invention of the IOL, Ridley felt that he was being put ‘out to pasture’.

Thereafter, Harold sold his home in London and moved with his wife to their beloved Keeper’s Cottage in Stapleford, near Salisbury. Their former holiday home became their retirement home.

RECOGNITIONS AND ACCOLADES

After decades of abuse and professional ostracism, Harold finally received recognition and honours for inventing the IOL.

In 1979 recognition came from a group that meant very much to Ridley, namely the surgeons who actually tried and evaluated his invention. Thanks to the efforts of his colleagues at the Intraocular Lens Implant Society (today the American Society of Cataract and Refractive Surgery (ASCRS)), he received a very meaningful recognition at the 1979
American Academy of Ophthalmology and Otolaryngology meeting in San Francisco, California. He was presented with a large leather-bound volume entitled *Salute to Dr. Harold Ridley*. The book had been signed by 4000 or so appreciative American ophthalmologists, who by that time were beginning to recognize what he had done for their specialty.

The first major award that Harold received from a scholarly institution was undoubtedly the one of which he was most proud. In 1986, three years after his 80th birthday, he was elected to the Fellowship of the Royal Society.

In 1989, 40 years after the first IOL implant, the Medical University of South Carolina, where I was serving as Chairman of the Department of Ophthalmology, conferred an honorary doctorate on Harold.

An event that brought him to a new and improved relationship with his colleagues in his own country took place on 29 November 1999, precisely on the 50th anniversary of the implant. The meeting was organized by Rayner & Keeler Ltd, the manufacturers of the original IOL and many thereafter. The event was scheduled to be held, quite appropriately, among the exhibits of World War II aircraft in the Science Museum in London.

In 1999 Harold was inducted into the Ophthalmology Hall of Fame at an event held in Seattle, Washington, at the annual meeting of the American Society of Cataract and Refractive Surgery. I was extremely grateful to ophthalmologists worldwide who elected me to receive this honour, one of only 39 individuals to have received it. (The specialty of ‘modern’ ophthalmology and visual science took root in about 1870.) This was based largely on my work on helping to improve Harold’s mid-twentieth-century invention.

These awards were only the tip of the iceberg. He received several other distinguished awards later in his life, including the Gullstrand Medal and the Gonin Medal, awarded every four years. Ridley lectures were established in several countries.

Recognitions flooded in from all over the world as the IOL was finally accepted. One full-page magazine tribute announced: ‘Mr. Ridley’s vision gave us ours’. Such accolades became common—a far cry from the often vicious criticism of the past.

Harold was knighted by Queen Elizabeth II in Buckingham Palace on 9 February 2000. When he knelt before the queen to be knighted, he was 92 years old and partly deaf. After the ceremony, he was asked what she said. Ridley answered with a smile, ‘I couldn’t hear a damn thing!’ In spite of that, he had become a knight: Sir Harold Ridley.

In 2006 *Sir Harold Ridley and his fight for sight*, the book authored by me as his official biographer, was published (Apple 2006).

A PIONEER IN THE FIELD OF BIOENGINEERING

Modern devices such as heart implants, or dialysis machines to replace kidneys, are no longer particularly novel concepts. The world is now benefiting from the advances of technology that occurred through the twentieth century. However, in Harold’s time, artificial implants were the stuff of science fiction. Even the most cutting-edge thinkers in 1949 considered that inserting foreign material such as plastic, silicone, nylon or Teflon into the body to take the place of vital organs such as the heart or eye was a heretical idea.

Harold’s implantation of a plastic IOL on 29 November 1949 seems to have been one of the first forays, if not the first, that anyone in any specialty had made in implanting prosthetic devices into the delicate, vital tissues of the body. Clearly, he began something revolutionary
on that day that was far beyond simply beginning the era of inserting a sliver of plastic into the eye. It was an excursion into unknown territory: the birth of implantation of foreign devices into vital body tissues or organs. In short, Harold broke ground to become a pioneer in the special field now designated as biomedical engineering, with special application in this case to transplants (transplantology) and artificial devices.

Although Harold was probably unaware of this more universal significance of his invention, history will probably show that the introduction of these broad conceptual ideas and innovations was as important as the basic visual rehabilitative benefits of the IOL itself. In the long run, this may be his most important contribution to the world—even transcending the benefits of the IOL.

BEYOND THE IOL: OTHER ADVANCES AND SERVICES

Although Harold’s invention of the IOL provided a procedure that finally made cataract surgery successful and complete, he also showed foresight, creativity and innovation in several other areas related to the science of the eye.

River blindness

Harold’s first assignment in the military was in a non-combat region of Ghana, West Africa, where he was appointed part-time sanitation officer and headquartered at the capital city of Accra (5, 6, 9, 11, 15, 16). Rather than dwell on his disappointment at not being assigned to any area where combat was taking place, and before sinking into disappointment and boredom, he took advantage of his time with characteristic enthusiasm and purpose and turned his attention to a detailed study of onchocerciasis, a disease transmitted by a certain type of fly. Also called ‘river blindness,’ onchocerciasis is recognized as the fourth most common cause of blindness on Earth. The river banks in the regions where this condition occurs teem with the black flies whose multiple bites distribute microscopic parasitic worms into victims. The worms’ offspring swarm through the tissues of the afflicted individual’s body, especially the skin and eyes.

In Accra, Harold met a British officer, Brigadier G. M. Findlay of the Army Military Service, with whom he pursued investigations on onchocerciasis. Harold, Brigadier Findlay and a Captain John Holden journeyed to Funsi, 90 minutes’ drive north of Accra, to study the disease.

Harold immediately established excellent relations with the inhabitants of the region. They helped him move his personal items and paraphernalia to his field hospital. His most important possessions were his boxes of medical equipment. His slit lamp (biomicroscope) was powered by a primitive electrical supply with a 12-volt battery that was barely sufficient to provide the illumination required.

They worked for two weeks. The conditions on site were primitive. Most of the work was done by Harold himself. This included not only the actual clinical examinations, diagnoses, documentations and treatments, and pathological analyses, but also fundus (retinal) paintings. They discovered that 90% of the region’s patients had onchocerciasis, and 10% of these were blind.

Harold was able to obtain tissue samples from affected patients; he presented these to a colleague, who was able to make photomicrographs that showed the organisms. After he returned from the bush, Harold made a sketch of the posterior pole (fundus, retinal region) of a typical eye with this condition, showing the intense pigmentation that occurred surrounding the optic
nerve and macular region. This region is blinded by the degeneration caused by the disease process. This is now called the ‘Ridley fundus’ by most workers in the field.

He wrote a classic monograph entitled ‘Ocular onchocerciasis’ (5). It was published in 1945 in a supplement to the British Journal of Ophthalmology and became a landmark publication. In it, Harold described the condition, illustrated important clinical and pathological features and changed the way in which many people think of this disease. This groundbreaking article stimulated further research throughout the years that is now leading to an increase in our ability to treat the disease.

While in Africa, Ridley did not confine himself to his work with river blindness. He also investigated the condition termed xerophthalmia—a corneal condition that afflicts people, especially children, throughout the underprivileged world. He noted that a small dose of vitamin A could have a massive effect on xerophthalmia. This finding was another that gave him great satisfaction throughout his life. Today vitamin A is being used with immense success by the World Health Organization and other groups to fend off this disease.

Harold also treated ocular leprosy, a disease commonly regarded as incurable. He often spoke to me about his attempts to do surgery for leprosy, performing what he felt may have been the first successful corneal graft on a leprosy patient.

**Nutritional amblyopia**

After serving for 18 months in Ghana, completing his studies on river blindness, Harold was transferred to India for a short time and then to Rangoon, Burma, where he treated more than 200 released Allied prisoners of war in Rangoon and Singapore who had nutritional amblyopia (7, 8) while Japanese prisoners of war.

A major catastrophe of the Burma military campaign, as well as conflicts in Thailand and elsewhere in the Pacific theatre of war, was the capture and enslavement of thousands of Allied soldiers, who were forced to labour on such projects as the Burma Railway. Starved and ill-treated, they had developed sudden central scotomas, sometimes relieved by good diet if available. Some developed optic atrophy. Some of these made at least a partial recovery within six weeks of release. However, the advanced cases, although given a vitamin-rich diet, were irreversible.

Harold’s examinations of the recently released prisoners of war revealed an involvement of two eye tissues: the optic nerve and the macula, as viewed by examination of the eyes with the ophthalmoscope. He believed that vascular involvement of both of these tissues caused nutritional amblyopia, a loss of vision due to malnourishment.

He therefore appears to have been one of the first, if not the first, to imply that vascular lesions affecting both tissues were related to age-related macular degeneration (ARMD). It has now been confirmed that vascular problems at the level of the choriocapillaris (the small capillary-sized vessels that supply the retina and its associated pigmented layer) are at least partly the cause of ARMD. It is possible that the malnutrition suffered by these servicemen affected their maculae in a fashion analogous to that which occurs with ARMD, the very common and important disease, often referred to in the literature as disciform degeneration of the macula, which is is being intensely researched today, with a huge allocation of resources.

Regardless of the details regarding the aetiology of these conditions, the therapy initiated on the returning prisoners by Harold and his colleagues anticipated some of the principles of therapy used today, almost 65 years later. He spoke of using ‘multivitamin therapy’ for his patients with ARMD, many of whom showed an improvement. This was a logical treatment
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and he was probably not the first to consider it. However, his linkage of the process to ‘chorio-
capillaris’ involvement associated with the choice of therapy revealed a thought process that
was new at that time.

The use of this type of therapy was logical because the problems were obviously nutrition-
based. Ridley noted in his paper that the virtual epidemic of starvation that occurred in this
large theatre of war was the first that made possible a study of a large population of individu-
als with this disease—more than 500 within his region, 200 of whom he examined personally.

In some ways, Harold’s multivitamin therapy can be seen as a forerunner to today’s prac-
tice of treating eye conditions with various forms of multivitamins and other pharmacological
agents.

His work on nutritional amblyopia with the released prisoners of war in Burma, like his
work on river blindness in Ghana, once again proved his thoughtful determination to serve
humanity wherever he was, in whatever way he could.

Breakthroughs in non-surgical areas of ophthalmology

Harold had a knack of working successfully on the topic at hand, taking advantage of the situa-
tions that came his way. His many successes included excursions into non-surgical areas of oph-
thalmology—something that few people are aware of. A few of these successes involved
innovations in the field of noninvasive diagnosis of the optic nerve and retina. He published sev-
eral papers related to the optic nerve and retina after the end of World War II. He was able to apply
new technology developed during those years to enhance the diagnostic and treatment capabili-
ties for posterior pole diseases (conditions affecting the back of the eye, the retina and the optic
nerve). These have become increasingly important today because there are now many options
available for the treatment of diseases affecting the retina and optic nerve, especially ARMD.

While working in close concert with his colleagues, who were doing brilliant work in the
technical department at St Thomas’ Hospital, Harold participated in the development of several
electronic devices that were of particular use in the eye sciences—too many to describe here.
However, three of these advancements led to innovations and inventions that are still very use-
ful today and have had a marked impact on diagnosis, education and patient care.

Harold was working on these innovations in the field of electronics (10, 12, 22, 25, 28, 33)
during precisely the same period of time when he was making final preparations for the
implantation of the IOL. It is amazing that he was able to keep up with the demands of proj-
exts, but the world is fortunate that he did. They turned out to be beneficial not only to the field
of ophthalmology but also to medicine as a whole.

First, it was possible to televise operations on the exterior of the eye, both in black and
white and in colour. However, with the early technology, it was only possible to film opera-
tions inside the eyes in black and white. After Harold’s successes in surgery of eyes viewed
on the outside, he worked on being able to televise operations deep within the eye. He called
this ‘intraocular television’.

To gain a proper perspective of the cutting-edge nature of his work with television, it must
be remembered that although television had been around for decades, experimentation with
the new and viable technology at that time was still quite new. It is not clear exactly who tel-
evised the first eye operations. Although Ridley did not claim this honour for himself, there is
no doubt that he was at least an early pioneer in this field.

Second, it was Harold’s full intent to develop a system of telediagnosis. This would allow,
for example, a doctor in Salisbury to send a televised image of a patient’s problematic eye con-
dition to an expert in London and receive a diagnosis immediately. He was quite precise with this idea. This technique is of course now used routinely, with the excellent advantages and results that he predicted.

Third, Harold published his team’s original work on what evolved into a paper that provided a classic description of his ‘flying spot’ ophthalmoscope. This work then evolved into the laser scanning ophthalmoscope (LSO; also termed a scanning laser polimeter). This is now a well-accepted method of noninvasive examination of the back of the eye.

Nerve fibre layer analysis in both the optic nerve and retina was improved by the introduction of computed tomography. These were huge advances compared with what Harold had experienced as he entered the field in the 1930s (1–4).

The latter two techniques—the LSO and computed tomography—now provide the examiner with, in essence, the ability to generate histological cuts of the tissue, providing the same advantages that microscopy would but without any need for biopsy or other invasion into the tissues.

Harold also conducted a brief clinical study on intraocular tumours—namely, an attempt to destroy or remove them without removing the eye. He was not the first to experiment in the area. He reported on two techniques: he successfully performed local surgical excisions of small tumours and he used radiation or even photocoagulation (light therapy). He presented one set of cases at a meeting in Budapest demonstrating several successful outcomes.

After his first IOL operation in November 1949, Harold decreased his research efforts in almost all subspecialties except for the IOL. In fact, it was difficult after that to concentrate at all on other projects, because the task of improving and defending IOLs occupied the lion’s share of his time and energies during the rest of his life.

**HUMANITARIAN SERVICES**

Harold’s experience in the underdeveloped world instilled in him a deeply felt need to help underprivileged populations. Long after his war service, Ridley set up a foundation for two main purposes. One was to help needy people, such as nurses and their families, who found themselves in dire financial situations. The other was to promote ophthalmological services to underprivileged countries.

He registered a charity, designated the Ridley Foundation, in March 1967. It was financed by all the money that he had inherited from both his parents, amounting to about £21,000.

Part of his humanitarian work consisted of making personal visits to countries that were in need because local ophthalmic services were inadequate. He did this in cooperation with the Royal Empire (later Commonwealth) Society for the Blind, which was set up largely as a result of his monograph on ocular onchocerciasis.

To set this work in motion, Harold, his wife and a nurse from St Thomas’ Hospital travelled to various needy countries, demonstrating surgical techniques and afterwards helping to assist local surgeons in performing the operations. These ‘pastoral’ visits, as he called them, had many wonderful results. He singled out one that made him very proud: the reduction of blindness in children in the Luapula Valley by 90%.

Today, medical missions to developing countries are common, but this was not true in Harold’s time. Harold’s foundation was a no-nonsense organization, dedicated solely to humanitarian and charitable causes.
DEATH

In May 2001, at the age of 94 years, Harold was taken into hospital in Salisbury because of a severe cerebrovascular haemorrhage. He passed away two days later. A small funeral service was held at the 1100-year-old St Mary’s Church in Swinstead, East Anglia. Several weeks after the funeral, a memorial service was held for him at the chapel in St Thomas’ Hospital, only a few dozen feet from the clinical area where he had served for many years. The service was well attended. Harold’s eldest son, Nicholas, spoke, as well as the minister. Numerous obituaries were written and published around the world, including one in The New York Times.

Sir Harold once said, ‘I would have on my tombstone, “He cured aphakia”.’ He then questioned his own suggestion by musing, ‘And people will ask, ‘Who was Mr Aphakia?’’

Notwithstanding his self-effacing modesty, Sir Harold’s work in the field of ophthalmology places him at the forefront of not only the eye sciences but also the entire field of medical science. Dr Robert Drews, a prominent American cataract–IOL surgeon, spoke for colleagues throughout the world when he said,

No matter what brilliant achievements are made in the future, Sir Harold’s place in history remains secure. Ridley has stated that he looks forward to meeting Daviel* in heaven. I think that Daviel will be flanked by millions and millions of people who have had their cataractous lenses replaced with the ultra-clear vision of lens implants.

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