# Micro-incisional Cataract Surgery

**Emma Carroll[1], Mr Colin Vize[2]**

[1] 5th Year Medical Student at Hull York Medical School. hyec@hyms.ac.uk

[2] Consultant Ophthalmologist and Clinical Lead at Hull & East Yorkshire Hospitals NHS Trust Eye Hospital

## Abstract

Micro-incisional cataract surgery (MICS) involves the removal of a cataract through an incision of 1.8mm or less. This surgery offers a range of benefits including faster healing time and reductions in eye trauma, surgically induced astigmatism, and risk of endophthalmitis. Many aspects have been considered during the development of the procedure including the simultaneous advances in surgical instruments, phacoemulsification technology and intraocular lens design, alongside surgical techniques. The four key stages to this procedure: wound creation, capsulorhexis, phacoemulsification and IOL insertion have been adapted to be conducted through the micro incision (cut). Despite new challenges arising alongside each stage of progress, the desire for the improved outcomes achieved through smaller incisions, will continue to drive further advances in surgical technology, techniques and confidence.

## Introduction

Cataract is the largest global cause of visual impairment, accounting for 47.9% of all cases – yet most cases of cataract can be treated surgically to restore sight.[1] Due to dramatic improvements in surgical techniques, cataract surgery is now by far the most commonly performed operation in the UK, with around 300,000 procedures performed each year by the NHS in England alone.[2] As a result of this, cataract is no longer the leading cause of blindness in the developed world however due to the high prevalence of cataracts in the developing world, it still remains the leading global cause of blindness.[1]

There appears to be no single cause for developing a cloudy lens, but there are a number of risk factors that contribute to this.[3] These include smoking, diabetes, and the use of some eye drops containing steroids which, if used without supervision over a long period of time, can lead to cataracts.[3] There are, however, a number of risk factors that are not within our control and cannot be reduced if we change our lifestyle.[3] Age is the most important cause of cataracts; this type of cataract is called 'age-related cataracts.[3] Genetic causes are also important as well as a history of severe eye trauma, or if the patient suffers from eye conditions, for instance, severe short-sightedness and inflammation of the eye, these factors may also result in cataracts.[3]

Over the decades, cataract surgery has transformed enormously with new technology driving the development of advanced techniques and equipment.[4] An important factor underlying these advances has been the reduction in incision size for the removal of the cataract.[4] This has resulted in the creation of micro-incisional cataract surgery (MICS).[4]

Micro-incisional cataract surgery is performed through an incision of 1.8 mm or less, the smallest surgical incision on a major organ system.[4-5] MICS is not simply about creating a smaller surgical opening – it also requires careful consideration of its site and structure.[5] A small incision offers many advantages, but the benefits can only be realised through concurrent advances in surgical instruments, phacoemulsification technology and design of the intraocular lens.[5] Each step in the progress of cataract surgery has presented new challenges.

This paper provides a brief overview of the history of cataract surgery, the development of MICS techniques and the practical challenges that have arisen as they have evolved.

### A brief history of cataract surgery

The treatment of cataracts using a technique known as 'couching' was first described in an ancient Sanskrit manual for surgeons as early as 2457-2467 B.C.[6] This involved displacing the cataract from its original position but leaving it intact inside the eye.[6] In 1748, Jacques Daviel first described the extraction of the cloudy lens from the eye with post-surgical optical correction provided by very thick glasses.[6] Known as 'intra-capsular cataract extraction' surgery, this involved making an incision along half of the corneal circumference, enabling removal of the entire lens and capsule. It was reserved only for very mature cataracts to ensure the lens would not disintegrate during removal.[7] This technique was further improved by removing the lens while leaving the intact capsule in situ preventing remnants of cataract escaping into the vitreous cavity.[7] This 'extra-capsular cataract extraction' (ECCE) technique, can be performed on less mature cataracts and uses an incision ranging from 12 to 14mm in length which is then closed by sutures.[8]

The insertion of a replacement intraocular lens (IOL) to provide optical correction was pioneered by ophthalmologist Sir Harold Ridley in the 1950s who observed that injured RAF pilots appeared to tolerate fragments of airplane windshields (made from polymethyl methacrylate (PMMA)) which had penetrated their eyes.[6] Surgical techniques, tools and intra-ocular lenses evolved in the following years, but the operation remained unchanged, until 1967 when Charles Kelman introduced the technique of 'small-incision phacoemulsification surgery'.[9] This procedure involves the use of ultrasonic waves to shatter the cataract into tiny fragments which are then aspirated via a small incision.[9] Although the incision required for phacoemulsification was small, the size of PMMA lenses available meant these had to be inserted via an incision of 5mm which continued to require sutures.[10] The development of intra-ocular lenses which are foldable allowed the introduction of the lens into the eye via a smaller incision of 3mm and further favours phacoemulsification over ECCE.[8] This technique has been credited with considerably improving the speed of recovery and quality of visual outcome following surgery.

The move from small incisional to micro-incisional cataract surgery was first described by Jorge Alió in 2002 who defined this technique as cataract surgery performed through an incision size of 1.8mm or less.[4] A small incision size is itself important, but the further benefit of MICS is that it entails a less aggressive procedure.[11]

### Advantages of Micro-incisional Cataract Surgery

So why does size matter? The smaller wound size results in less eye trauma, faster healing and improved vision outcomes.[11] The incision, through its design and size, is 'self-sealing' eliminating the need for sutures which may otherwise cause post-operative problems.[5] A reduction in surgically induced corneal astigmatism is achieved, and a smaller incision permits a better seal for the surgical instruments resulting in a more stable anterior chamber to work within.[5] Important further benefits include reduced wound leakage and a diminished risk of endophthalmitis.[11] The procedure is designed to be conducted under local anaesthetic thereby removing the potential risks associated with general anaesthesia.[5]

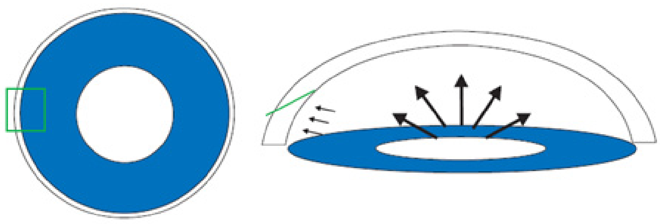
### Evolution of Micro-incisional Cataract Surgery

There are four principal components that contribute to successful outcomes. These are: wound creation, capsulorhexis, phacoemulsification and IOL insertion.[5] As the MICS technique has evolved, each of these components has had to change with a range of adaptations to the surgical equipment and techniques to enable removal of the cataract through such a tiny incision.[5]

### Wound creation

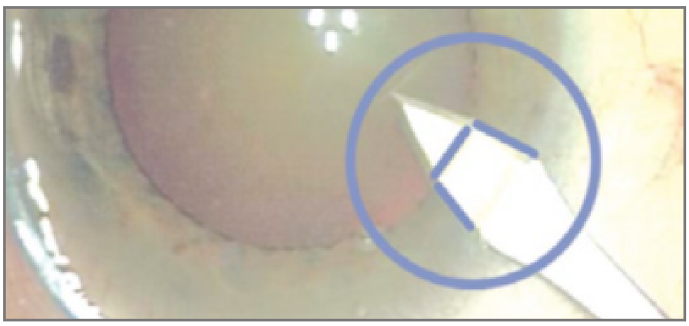
The creation and structure of the incision plays an essential role.[5] It is important that the micro incisions enable movement of the instruments easily as well as maintaining a tight seal and that their width matches the instruments in order to reduce the risk of distorting the incision.[12] The angle and length of the incision are key considerations – and if properly created it will result in the intra-ocular pressure forcing the wound to self-seal (described as a 'trap-door' effect).[13] (Fig 1)

*Figure 1. The angle of incision and IOP will force the wound shut. With thanks to Baush and Lomb.*



The blades used to create the incision have reduced in size from 3mm to 1.8mm and it has been shown that this smaller size creates less surgically induced astigmatism.[14] However manipulating the instruments through this micro incision can be challenging as the limited size creates a greater risk of the instruments oar-locking.[15] This can be overcome by a technique that widens the internal side of the incision, lessening friction within the incision tunnel, improves manoeuvrability of the instruments, and enables easier insertion of the intraocular lens.[15] A trapezoidal shaped incision (Fig 2) offers the optimum choice as it improves instrument manoeuvrability, maintains the seal and mitigates development of surgically induced astigmatism.[16-17]

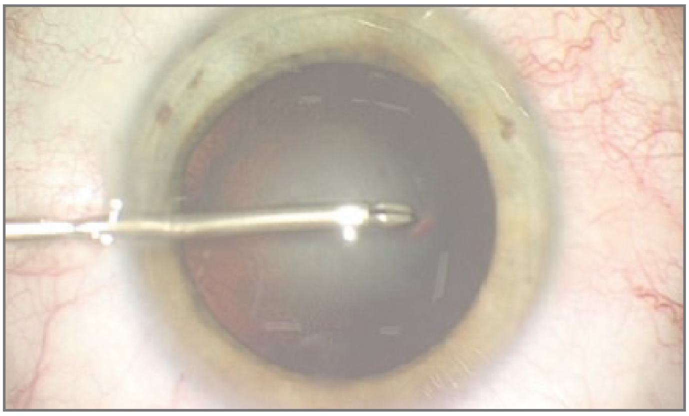
*Figure 2. Clear corneal incision with 1.6 x 1.8mm trapezoidal metal knife. With thanks to Baush and Lomb..*



### Capsulorhexis

Capsulorhexis is the removal of the anterior capsule in a continuous curvilinear motion to allow removal of the lens material is an important stage in phacoemulsification surgery.[11] This can be a challenging step especially through a tighter incision. As a result, new tools have been developed to perform capsulorhexis through the micro incision.[5] For example, fine capsulorhexis forceps that are specialised for MICS (Fig 3)

*Figure 3. Capsulorhexis performed using forceps designed for MICS. With thanks to Baush and Lomb*



**Phacoemulsification**

Diminishing incision size has required the development of micro-pulse phacoemulsification which delivers less energy, a lower needle temperature, reduces the overall operating time and allows the use of smaller sized needles to break down the lens nucleus.[5,20] Not a lot of change to the settings of the phacoemulsification machine has been needed when transitioning from a 2.2mm to 1.8mm incision.[21]

Control of the inflow and outflow of fluids and aspirated materials is an essential part of the surgical technique in order to maintain stable intraocular pressure, and minimise surgical complications.[11] Variables affecting this include infusion bottle height (gravity) and fluidics (aspiration rate and pump system utilised in the phacoemulsifcation machine).[11]

The fluidics appear to have improved when performing MICS.[5] The use of micro-incision phacoemulsifcation needles allows tighter control of the inflow and outflow balance therefore maintaining anterior chamber stability.[5] However it is important to note that the size of the wound must be accurate in order to ensure a suitable fluid inflow.[5] There is a risk of fluid leaking from a too large incision as well as a risk of restricting inflow too much if the incision is too small, therefore disrupting the overall pressure balance within the chamber.[5] This need has resulted in developments such as the Stellaris phaco motion hand piece which has been designed so that the surrounding sleeve fits comfortably through the incision without disrupting structural integrity and therefore maintaining chamber stability.[4]

**Intra-ocular lens insertion**

The IOL ultimately has the greatest influence in the final incision size.[5] There is potential for corneal tissue damage if it is overly stretched when injecting the IOL through the micro incision which may negatively affect the visual outcome.[22] Factors such as the type of insertion, the rate at which the IOL is inserted, the power of the IOL and the insertion system used can impact the integrity of the incision.[5,23,24,25]

These challenges may be overcome with the use of devices that are set to inject at a particular speed as well as the use of a preloaded IOL injectors to ensure the IOL is inserted more carefully.[5,26] To enable insertion of the IOL through a 1.8mm incision, adopting a wound-assisted insertion technique (Fig 4) prevents the cartridge tip going into the anterior chamber thereby limiting corneal damage.22

Also the IOL design enables their application in this technique such as the acrylic Tecnis 1-Piece IOL which can be injected via 2.2-mm incisions and the Akreos MICS lens which fits through a 1.8mm incision. [27]

*Figure 4. Wound-assisted insertion technique of IOL. With thanks to Baush and Lomb.*


**Conclusion**

The potential benefits in terms of improved outcomes mean that the challenge to conduct cataract surgery through ever smaller incisions is likely to continue. While micro-incisional surgery will not be suitable in all cases, as surgical techniques evolve and experience builds, the desire to overcome current limiting factors will increase. It is possible that incisions could become even smaller than 1.8mm in the future, but for this to happen IOL technology will need to further develop.[11]

**Practice Points**

1. Micro-incisional cataract surgery (MICS) involves the removal of a cataract through an incision of 1.8mm or less.
2. This technique results in faster healing time and reductions in eye trauma, surgically induced astigmatism, and risk of endophthalmitis.
3. Advances in surgical instruments, phacoemulsification technology and design of the intraocular lens have enabled the development of this procedure.
4. Each step in the progress of MICS has presented new challenges.
5. Incisions may become even smaller in the future however IOL design will need to further develop to allow this to happen.

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