Minimizing technology provides an opportunity to progress with new surgical techniques. The surgical tools have become slimmer and better designed. The lenses have advanced optics and have become thinner. Therefore, the evolution of the lens surgery is due to the minimization of the surgical trauma and incision, and maximization of the visual outcome. Returning to a 3–4 mm incision is impossible [1–3]. The Kelman concept of cataract surgery has been improved [4]. Now surgeons aspire to do phacoemulsification almost without ultrasound energy. The concept of MICS (Microincisional Cataract Surgery) and 0.7 mm MICS may be the way to merge the idea of the small incision corneal surgery with the new lens technology. MICS has catalyzed the design of a new set of instruments which can be used in minimized incisions.

In 2003, Jorge Alió registered MICS as a name of the new operating method. The definition of the MICS is the surgery performed through incisions of 2.0 mm or less [T.M. 2.534.071, March 2003, Spain] (Fig. 2.1).

Understanding this global concept implies that it is not only about achieving a smaller incision size but also about making a global transformation of the surgical procedure towards minimal aggressiveness [5].

The idea of separating infusion and aspiration is not new. Shearing did a cataract surgery using bimanual irrigation – aspiration tools 20 years ago [6]. Nevertheless, the concept was based on a wider incision and different flow of the fluidics.

The basic concept of MICS is to diminish the energy required for disassembling the cataract lens and implantating the artificial lens with less corneal damage. To achieve this goal, many different authors have been looking for new instruments or they made the existing instruments more efficient [7]. Thus the idea of bimanual prechopping or irrigating choppers came into being.

The premises of MICS tools are that they should:

- Allow better fluidics
- Fit through minimal new incisions
- Be ergonomic
- Allow multiple functions
- Be safe
- Be easy to use
Fig. 2.1 Trade Mark 2.534.071, March 2003
By using surgical instruments to disassemble the cataract using prechoppers, one can diminish the use the phaco energy and decrease EPT. Bimanuality and separation of irrigation-aspiration functions help in using the tools parallelly in both hands and they can act together to improve the efficiency of the maneuvers. Therefore, many surgeons are creating new instruments in the search for new techniques of operation.

MICS instruments can be divided into the following sections:

- Incision instruments
- Capsulorhexis instruments
- Prechopping instruments
- Irrigation/aspiration instruments
- Auxiliary instruments

Converting the standard phacoemulsification mode to the MICS surgery would not be a problem for the ophthalmologist surgeon because the principle idea of manipulation inside the eye remains unchanged. The main aim of MICS is to understand the principles and to use proper tools. In this chapter, we present the instruments that are presented in various papers about MICS surgery and the instruments recommended by tool manufacturers that conform to the requirements of MICS.

### 2.2 MICS Incision

The surgery starts with two corneal equal incisions with a distance of 90–110° angle steps. The shape of the wound is very important. The basic conditions of the incision are that it has to be watertight and allow correct tool manipulation. The MICS incision should have a trapezoidal shape with two different size of incisions; one with a small measurement of 1.2 mm breadth inside the wound near the Descemet membrane, and the other with a wider measurement of 1.4 mm, outside near the epithelium. This is essential as the structure of the wound will allow us to insert the tools easily, it will protect against leakage, and at the same time, it will provide an opportunity to work with minimal anxiety and tissue injury. The lateral manipulations are very easy and safe in this type of wound. The mechanical injury of the tissues can suppress and extend the time of healing, and lead to leakage and hypotony. If the incision is too small, it will prevent us from correctly manipulating inside the anterior chamber and if the incision is too big it will lead to an unchecked leakage from the wound. The watertightness of the wound guarantees holding stability and the right depth of the anterior chamber, and it also reduces the possibility of exchanging liquids between the anterior chamber and the conjunctiva sack. It is essential for the minimization of the risk of endophthalmitis [8–10]. The great advantage of this incision is the optical result. The clinical data of MICS incision and surgically induced astigmatism suggest that three months after the MICS surgery, there is no statistically important change in the corneal astigmatism. The MICS incision is a neutral incision and this means that the size and shape of the incision do not affect on the postoperative corneal shape and astigmatism. It is important to say that no changes in astigmatism are caused by MICS incisions. To assure the reduction of the existing astigmatism, relaxing incisions can be made on the corneal periphery [1, 11, 12].

To carry out 1.5 mm MICS, we use trapezoidal knives, which have a changeable gauged breadth of the incision from 1.2 mm on the peak to 1.4 mm by the base (Katena Inc, Denville, NJ). To achieve this target, two kinds of knives can be used: Alio’s MICS Knife (Cat. No. K20-2360, Katena Inc) and MICS Diamond Knife (Cat. No. K2-6660. Katena Inc) with trapezoid shape 1.25/1.4/2.0 mm angled, double bevel (Figs. 2.2 and 2.3).

This size of the wound is adapted to phacoemulsification tip with 0.9 mm breadth. For smaller phacoemulsification tips the breadth of the incision should be appropriately smaller. Through this incision, we can inject anesthetics and ophthalmic viscoelastic devices (OVD) without any problem, using standard infusion cannulas.

Sharpoint ClearTrap trapezoidal angled knife has different breadth of edge (1.2–1.4 mm) width indicator.

![Fig. 2.2 Alio’s MICS metal knife (Katena Inc)](image1)

![Fig. 2.3 Alio’s MICS diamond knife (Katena Inc)](image2)
This knife can make the intended shape of the incision (Cat. No. 75-1214, Angiotech, Reading, PA) (Fig. 2.4).

Oasis Medical PremierEdge knife (Cat. No. PE3915, Oasis Medical, Glendora, CA) is a blade with incremental widths of 1.0, 1.5, and 3.0 mm. The new Oasis MICS knife is angled with a single bevel up blade and has incremental widths of 1.0, 1.3, and 1.5 mm (Fig. 2.5).

A Microcut is a trapezoidal knife with widths 1.2 and 1.4 mm, and satisfies the conditions of MICS incision (PhysIOL, Toulouse, France).

Laseredge® Clear Corneal Knife with trapezoidal shape can be also adapted to MICS surgery. It has 1.7 mm width with the 1.5 mm marker (Cat. No. E7599, Bausch & Lomb Inc, Rochester, NY) (Fig. 2.6).

3D Bi-Manual Phaco Blade, made by Rhien, is a knife with progressive width from 1.2 to 1.4 mm (Cat. No. 03-3011, Rhein Medical Inc, CA) (Fig. 2.7).

Phaco Slit Angled 1.3 mm and Phaco Slit Angled Trapezoid 1.4 × 1.6 mm knife are for MICS incisions. The smaller version 1.1 mm is for the 0.7 mm MICS incisions (Fig. 2.8) (Cat. No. 901361, 971416 Surgistar, Inc. Knoxville, TN).

### 2.3 MICS Capsulorhexis

The MICS incision is too tight for standard capsulorhexis forceps. The capsulorhexis can be made by cystotome or by MICS capsulorhexis forceps. The use of special forceps is thought to be much more adequate. The MICS capsulorhexis forceps allows for more flexible and precise surgery, with better control of the capsular bag and it should be the preferred technique in MICS. We use Alio’s MICS Capsulorhexis Forceps (Cat. No. K5-7651, Katena Inc). This 23 guage diameter tool can easily be inserted in the wound of the cornea without stretching it. At the end of the forces, a pointed catch is found. It enables a controlled puncturing of the anterior bag of the lens. Pressure is applied on the bag and then with a little movement, the slice is made in the anterior bag. The forceps enables a free manipulation of the torn capsular bag. The size of the surgical wound and the diameter of the forceps prevent the possibility of OVD leakage and flattening of the anterior chamber, stabilize the cataract lens and the bag and reduce the probability of bad tearing (Fig. 2.9).
The forceps can be helpful to manipulate and release small adhesions with ease.

The other type of capsulorhexis forceps is the Giannetti MICS Capsulorhexis Forceps (Cat. No. K5-5090, Katena Inc). The construction of this forceps is based on the standard forceps structure. The 1 mm shanks allows for manipulation in the wound with minimal stretch of the corneal tissue (Fig. 2.10).

The Kelman Capsulorhexis Forceps has a very thin and curved shaft and facilitates maneuvers with the capsule. The forceps has a diameter of 23 guage (Cat. No. D100.23 Synergetics Inc. O’Fallon, MO) (Fig. 2.11).

Fine–Hoffman Capsulorhexis Forceps 23G was also designed for MICS surgery (Cat. No. DFH-0020, MST Redmond, Washington). The construction of this instrument is based on the structure of the micro forceps. This type of construction is ideal for wound protection and for maneuvering into the anterior chamber (Fig. 2.12).

Capsulorhexis Tip is designed to perform capsulorhexis through a 1.4 mm phaco incision. A nonrotating squeeze handle is used for control during MICS procedures (Cat. No. ET8190 H Storz, Bausch & Lomb, CA) (Fig. 2.13).

Fine Ikeda Super Micro Capsulororhexis Forceps 23G has a tip length of 0.95 mm. Tapered tips allow for easy maneuverability through the paracentesis incision. The 13 mm shaft from tip to handle, gives adequate access within the anterior chamber. It features a 90° tip that can be used as a cystotome. Proximity of the tip allows for easy working in the subincisional area without snagging the Descemet membrane. Compressible handle allows for maximum tactile feedback (Cat. No. AE-4389S ASICO LLC, IL) (Fig. 2.14).

Rhein Tubular 23g capsulorhexis forceps is adapted to 1.0 mm incision (Cat. No. 05-2362, Rhein Medical Inc) (Fig. 2.15).
2.4 MICS Prechopping

The ultrasound energy delivered into the eye during surgery is always too high. Prechopping is one of the saving elements here. This maneuver will diminish ultrasound time surgery, ultrasound energy and thermal energy. This type of activity is much better and does not cause any adverse effect when performed in accordance with the rules. This is an upcoming trend now and more surgeons have started to perform this procedure.

The idea of prechopping led to development bimanual and monomanual techniques. Frequently used choppers like Fukasaku and Akahoshi choppers are monomanual choppers. However, two equal incisions can be used to separate masses in MICS. The idea of bimanual prechopping seems to be more effective and safe.

The advantages of manual prechopping are:

1. Reduction of phaco time
2. Lower amount of liberated ultrasound energy
3. Diminished damage to endothelium and trabecular meshwork
4. Diminished zonullar stress

Prechoppers are needed to attain these advantages. One-hand chopper maneuvers are not recommended because of the lesser efficacy of this action and huge zonullar stress. For small incision surgery bimanual prechopping is more safe and correct.

To perform prechopping, two Alio-Rosen MICS prechoppers (Katena Inc) or Alio-Scimitar MICS Prechoppers (Cat. No. K3-2324, Katena Inc) are used (Figs. 2.16 and 2.17).

Two prechoppers should be inserted into the bag under the anterior capsular rim opposite to each other.

![Fig. 2.16 Alio-Rosen phaco prechopper for micro incision cataract surgery (Katena Inc)](image)

![Fig. 2.17 Alio Scimitar prechopper for micro incision cataract surgery (Katena Inc)](image)

The hooks of the choppers should be parallel to the anterior capsule bag. Next, the choppers should be gently rotated along the axis of the tool. The choppers should now be situated behind the masses of the lens under the bag on the perimeter. Both the hands should symmetrically carry out this activity. The choppers are crossed by symmetrically situating them opposite oneself. Now, cutting movements are made by gently crossing the prechoppers (Fig. 2.18).

The cut will be made from the perimeter to the center of the nuclei. Internal edge prechoppers have sharp edges that facilitate the incisions of the lens masses. This ambidextrous activity is important to prevent zonular stress. It can also be carried out in the case of subluxated cataracts. When the cut is made, two dividing hemispheres are formed. The nucleus is then rotated about 90° and then for the second time, prechopping is repeated as described. After carrying out prechopping, we have four lens quadrants in the bag. Fast and effective division of the nuclei reduce the duration of operation. The new Alio Scimitar Prechoppers are made for the same type of maneuvers, but they have different endings. Scimitar Prechopper has a curved tip with a blunt end and a sharp inferior edge. This makes the cortical and the nuclear cut easier and can diminish zonular stress at all stages of prechopping. The shape of the Scimitar Prechopper is prepared to perform and facilitate the 0.7 mm MICS surgery.

Nichamin triple choppers are ambidextrous choppers and can be used in MICS (Cat. No. 8-14506V, Rhein Medical Inc) (Fig. 2.19).
Akahoshi Super Micro Combo prechopper can also be useful to make MICS nucleotomy. This 20 gauge combo prechopper is able to fit through a 1.2 mm incision (Cat. No. AE-4287 Asico LLC). The cataract lens can divide before phacoemulsification and without nuclear grooving (Fig. 2.20).

The Fukasaku hydrochop canula (Cat. No. K7-5462, Katena Inc) is also useful in dividing the nucleus. Thin cannula with liquid irrigation can divide the nucleus into parts (Fig. 2.21).

### 2.5 MICS Irrigation/Aspiration Instruments

Other ideas of fluidics management and ultrasound power management have led to the development of newer types of irrigating choppers. The most important factor was to connect the irrigating performance of the cannula with the mechanical properties of the chopper. The small diameter of the instrument was a challenge. Olson, Fine, Nagahara, and Tsuneoka made the first infusion cannulas with a high flow. Their cannulas had liquid flow up to 60mL/min. Nevertheless, the first MICS cannula with a liquid flow of more than 70mL/min was the Allo’s MICS Irrigating Stinger. This chopper has a high liquid infusion efficiency. All these infusion cannulas satisfy the requirements of MICS fluidics.

#### 2.5.1 19G Instruments

**Irrigation Cannulas.** The phacoemulsification can start when the quadrants are divided. In bimanual surgery, both incisions are involved in fluid transport. Use of irrigation cannula is obligatory. Infusion cannula has an additional application in MICS. It functions as both, chopper and manipulator. The end of the instrument, which is provided with a special hook, facilitates tearing and crumbling large fragments of the masses. It is very useful in the first part of nuclei phacoemulsification. The plane end is very practical to manipulate the masses and translocate them to the phaco tip or the aspiration cannula, when small fragments or soft cortical masses circulate in the anterior chamber.

The irrigation hole of the MICS irrigation tool should be on the bottom of the lower side. The diameter of the hole is 1 mm. Very thin walls and increased internal diameter of the instrument allows achieving irrigation in borders 72 cm³/min. The stability of the anterior chamber is the result of irrigation, and direction of the liquid to the lens masses at the bag back (Fig. 2.22).
The strength of the stream permits the bag to be held at a safe distance from the phacoemulsification tip and at the same time, enables convenient manipulations of the tools and lens masses. Additionally, this stream can clean the back bag from remaining cortical cells. A stream to the back bag is provided for the preservation of corneal endothelial cells before mechanical and thermal damage, instead of the cannulas with lateral holes. The posterior-directed stream gives the masses from the posterior chamber, the opportunity to circulate directly to the phaco tip. This helps the surgeon to avoid putting the phaco tip inside the capsular bag.

While starting phacoemulsification, vacuum levels should be set at 500–550 mmHg as the process involves pressured infusion. In most cases, when the cataract is not very hard, Alío’s MICS hydromanipulator irrigating fingernail can be used. This makes it possible to divide and aspirate fragment masses of the lens without using ultrasound or torsional energy or to use them in the minimum way. In the case of hard cataracts, when total occlusion of the tip makes aspiration impossible, the Stinger Alío’s MICS Irrigating Chopper would be more useful. This tool has a narrow edge at the end, which divides the masses and allows easy aspiration of the phacoemulsification tip. The fragmented elements of the hard cataracts are now easily aspirated, using the high under pressure and, at times, using ultrasound energy.

The Alío’s MICS hydromanipulator irrigating fingernail (Cat. No. K7-5860 Katena Inc) is the first tool inserted in the anterior chamber during this stage of operation (Fig. 2.23).

This tool’s end is shaped like a fingernail. It helps to remove rather soft cataracts. The tool that allows the removal of harder cataracts is Alío’s MICS Irrigating Stinger (Cat. No. K7-5861, Katena Inc) (Fig. 2.24).

Fine Olson 19ga irrigating chopper is a bimanual irrigating chopping instrument with an angled chopping tip. The irrigating hole is on the lateral side of the instrument (Cat. No. MVS1099 Storz, Bausch & Lomb) (Fig. 2.25).

Nagahara 20G irrigating chopper is for bimanual irrigation chopping. The irrigating hole is on the lateral side of the instrument (Cat. No. MVS1095 Storz, Bausch & Lomb) (Fig. 2.26).

Duo Max Tsuneoka irrigating chopper tip 20 guage has large dual oval ports at the distal end for maximum irrigation. The side port configuration avoids pushing away the nucleus being chopped (Cat. No. AE7-3028 ASICO LLC) (Fig. 2.27).

Olson 20g Irrigating Chopper is the instrument with open-end irrigation. It can be used in 1.4 mm incision surgery (Cat. No. 8-14548, Rhein Medical Inc) (Fig. 2.28).

Aspiration cannula. The aspiration cannula has a smaller internal diameter than the irrigation cannula.
This will cause disproportion in the resistance of flow between infusion and aspiration and will guarantee the anterior chamber stability. The increase in the depth of the anterior chamber causes the movement of the lens diaphragm. This can cause the lens masses movement into the space behind the iris. Masses can be placed between the iris and the anterior bag in the space surrounding the sulcus which does not allow the masses to be seen. However, the masses can be seen in the anterior chamber after few hours of the operation. Rinsing out and cleaning this space is extremely important.

The stability of the anterior chamber, in case of MICS, is definitely higher than in coaxial phacoemulsification. MICS does not cause frequent and considerable changes in the proportion anatomy of the eyeball and there is no traction during the operation. It is possible to maintain the anterior chamber stable from the capsulorhexis to the OVD injection before lens implantation during the MICS surgery [11].

Alio’s MICS Aspiration Handpiece (Cat. No. K7-5820, Katena Inc) also serves to remove the remains of cortical masses. It has a port diameter of 0.3 mm (Fig. 2.29).

Oasis bimanual kit for 19 and 21 guage surgeries have instruments with open or closed ended curved textured tips. This is the single use tip. The blue irrigation handpiece has dual oval port with a diameter of 0.5 mm. The purple aspiration handpiece has one round port of 0.3 mm (Cat. No. 1719, Oasis Medical) (Fig. 2.30).

2.5.2 21 G Instruments

The minimization of MICS tools surgery allows us to carry out phaco through 0.7 mm. Part of the standard MICS tools can be adapted to 0.7 mm MICS, but irrigation and aspiration cannulas are not fitted. The 22G Alio Stinger irrigating chopper Duet System (MST, Redmond, WA) allows to perform the 0.7 mm MICS through 1 mm incision (Fig. 2.31).

The decreased thickness of the walls and the appropriate internal profile gives an opportunity to achieve the required inflow of the fluid into the anterior chamber. Stinger irrigating chopper 22G also has a narrow edge at the end, this allows to divide and conduct the masses into the aspiration cannula.

Fine/Olsen irrigating chopper is an open-ended 20 guage instrument, especially designed for MICS. This instrument has external diameter of 0.89 mm. It allows easy insertion into MICS incision (Fig. 2.32) (Cat. No. MVS2000 20 Storz, Bausch & Lomb).

Olson Cannula irrigating chopper 21G is the instrument with horizontal infusion holes (Cat. No. 91-7146-L, Rhein Medical Inc) (Fig. 2.33).

The oasis set for 21 and 23 guage cataract surgery is composed of two I/A handpieces. The instruments have
close-ended curved textured tips. The blue irrigation handpiece has dual oval port with a diameter of 0.5 mm. The gold aspiration handpiece has one round port of 0.3 mm (Fig. 2.34) (Cat. No. 1621, Oasis Medical).

BiManual Max Irrigating Tip is the 23 guage curved bimanual micro irrigating handpiece with dual oval ports of 0.4 mm, with a capsule polisher. Bimanual Micro Aspirating handpiece has an oval 0.3 mm port (Cat. No. AE7-0208 ASICO LLC) (Fig. 2.35).

2.6 MICS Auxiliary Instrument

2.6.1 Scissors

Scissors are useful in complicated cataracts, which may require a cutting within the anterior chamber of the eye. A scissors can, cut delicate membranes, cut adhesions, make iridotomy, and cut fibrosis of the bags. In these cases, Alio’s MICS scissors are useful (Cat. No. K4-5351, Katena Inc). This tool has 23 gauge curved shaft with horizontal micro blades (Fig. 2.36).

The 0.6 mm breadth allows for access into the anterior chamber without the need to widen the incision.

In modern cataract surgery, fluidics management becomes a very important element of the surgery. Small diameters of the irrigation and aspiration tools, and the efficacy of the pumps present a huge challenge for maintaining the fluidics. The 20 guage diameter and even the 19 guage inflow diameters can cause problems in delivering the proper amount of the liquid into the eye. However, the problem arises only when the 0.9 or 0.7 mm phaco tip starts to aspirate.

The main problems are:
1. Stability of the anterior chamber
2. Stability and control of intraocular pressure (IOP)
3. Stable incision with no leakage
4. High vacuum

To maintain the fluidics, the inflow of the fluid to the anterior chamber should be superior to the outflow. The first step to achieve this balance is to differ the internal diameter of the I/A tools. The aspiration diameter should be smaller than the irrigation one. The efficacy of the Venturi pump is very high and therefore, the danger of the IOP drop and anterior chamber collapse may exist. To solve this problem, gas-forced infusion (VGFI by Alcon) is used. This system controls the IOP and increases the infusion over the gravitation efficiency of the traditional infusion. However, the problem of anterior chamber collapse can still exist. During the tip occlusion, the vacuum rises to a maximum value. After the occlusion brake, the flow is very high without compensation of inflow. This moment is dangerous for anterior chamber stability. There are some post-occlusion surge prevention strategies. Lifting the bottle is insufficient in MICS surgery and hence we need to force infusion with an additional air pump. Phacoemulsification systems such as Accurus (Alcon)
2.6.3 Surge Prevention

To prevent the surge during occlusion breaks at higher vacuum level the flow restrictor can be installed between the phacoemulsification handpiece and the aspiration tubing. Stable Chamber System® and Cruise Control™ are the devices that are specially designed for making cataracts in the bimanual microincisional phacoemulsification mode at the high vacuum settings. They have a disposable flow restrictor and a mesh filter against blocking. The lens masses stay on the filter. Restrictor limit the flow. At a vacuum level of 500 mmHg, the anterior chamber does not become shallow, especially if you are working with pressured infusion (Figs. 2.37 and 2.38).

2.7 New MICS Instruments

2.7.1 Flat Instruments

The new concept is the idea of plane instruments. Incision with a diameter of 1.5 mm is very susceptible to stretching. The plane instrument idea is to fit the instrument into a natural-shaped wound. The flattened oval profile is better adapted to a linear incision (Fig. 2.39). This type of instrument does not affect the wound border and improves the self-sealing propriety of the incision. Wound integrity is one of the most important factors as it may influence the outcome of the surgery. The tools are adapted to the wound, but the wound is not stressed by the tools. The tissue of the wound is practically untouched. Self-sealing capability of the corneal incision is mainly dependent on wound construction: the angle, the width-to-depth ratio, and multiple-plane construction of incision. Any disturbance in these conditions can affect postoperative healing. The flat instruments do not affect the edges of the tissues of the incision and therefore, the natural process of healing is not disturbed.

Assurance of the proper amount of fluidics in MICS requires a large dimension of the tools. This is the reason for the corneal tissue stress during the operation. Mechanical tissue stress can evoke leakage, astigmatism, and problems with stability of the anterior chamber [13, 14]. Improved tools are required to solve these problems. New Alio’s MICS Flat Instruments are made by Katena. The irrigation and aspiration tools have a rectangular cross-section. The change of shape does not influence the fluidics parameters. The fluidic flow of these tools is proper for MICS. The leakage around the tool is absent. Manipulation of the tools is easy and cause only minimal corneal tissue stress. Vertical manipulation does not stretch the wound and the horizontal movements do not press the angle of the wound.
because of the trapezoidal shape. This concept of irrigation-aspiration flat tool is a new way of conserving the wound (Fig. 2.40).

**Take Home Pearls**

- The right choice of instruments will help the surgeon in the transition.
- Watertight incisions, especially during phacoemulsification and proper I/A instruments should be used.
- Fluidics should be improved by increasing the inflow and reducing outflow by use of other specific devices such as cruise control, which now is useful to improve MICS surgery at a high vacuum level.

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