Early Experience with Microphaco

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ABSTRACT

Microphaco is the separation of irrigation from aspiration that allows removal of cataracts through sub-2 mm incisions. While proven intraocular lenses (IOLs) are not available at this time to take advantage of the small wounds, these wounds are advantageous from a separating irrigation standpoint which makes it a useful instrument. It is also well suited to any clinical condition where there is either a minimal anterior chamber or pressure in a swollen capsule. With approval of good IOLs that can be inserted through these small incisions, this technique could become the dominant surgical procedure in the future.

INTRODUCTION

The idea that irrigation can be separated from the ultrasound aspiration needle is not new. Posterior segment surgeons have done this for 30 years, and Dr. Shearing wrote an article about his early experience with this almost twenty years ago.[1] With IOLs at that time requiring at least a 5.5 to 6 mm incision, phacoemulsification equipment was certainly much less safe than it is today. Microphaco as a concept died out. There was also great concern about wound burn without an irrigating sleeve around the ultrasound needle to effect cooling.

In the last six years there has been a resurgence of microphaco interest. In 1998, Dr. Amar Agarwal submitted a film for the American Society of Cataract and Refractive Surgery Film Festival, which was the first recent public presentation on this technique. In order to avoid wound burn, he irrigated continuously around the phaco aspiration needle and claimed good results. In many areas of the world there has recently been a near-explosion of interest in this approach. With only experimental lenses available in the United States and Canada, and with the lenses approved in Europe for these small incisions lacking a long track record, the question one must ask is: does this approach deserve much interest at this time? Interestingly, Market Scope—a United States survey company—reported in December 2003 that approximately 35% of those surveyed in the United States stated that they were going to at least consider this approach in 2004.[2] At the very least, it appears that this approach is getting widespread interest.

As we first approached microphaco prior to working with any patients, it was critical to know if this approach is safe. The two main concerns were obtaining sufficient irrigation to maintain a deep and stable chamber, as well as minimizing the risk of wound burn. Ensuring ample irrigation into the eye was a problem, so our earliest approach used four large oval openings to minimize flow impedance and make sure that there was plenty of irrigation if one or more of the irrigating openings were blocked during any chopping maneuver.

My first microphaco case was a 2+ nuclear sclerosis in which the cataract was chopped and largely aspirated in order to minimize the risk of wound burn. Chamber stability was a major problem. It became obvious that the incisions were too large, exacerbating the chamber stability problem. The instrumentation with four irrigating openings allowed two of the holes to occasionally back out of the eye immediately, resulting in chamber instability (Fig. 1); therefore, this design was abandoned after just two clinical cases. Still, using 19-gauge technology, we did have incisions approximately 1.6 to 1.7 mm in size and successfully removed both cataracts.

This promptly led to temperature experiments to determine the ultrasound usage level where wound burn would become a concern. We experimented with 19-gauge instrumentation that had two openings toward the end of the irrigating chopper. Our incisions were much tighter (as determined from our intraocular pressure measurements), and we found that microphaco was very forgiving with flowing irrigation. As an endpoint, we used up to three minutes of continuous ultrasound and found that we had to go to 100% power for over one minute of continuous ultrasound to create a burn.

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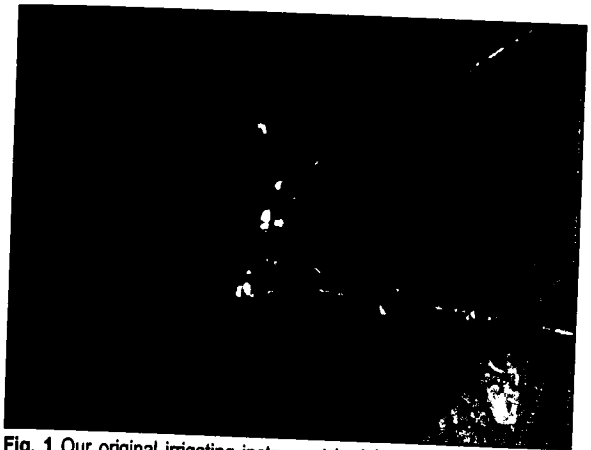

Fig. 1 Our original irrigating instrument had four irrigation holes that proved impractical because the posterior two holes could easily come out of the eye and result in chamber collapse.

Clinically, aspiration must be blocked to create a burn; therefore, our second round of experimentation was clamping the aspiration line. However, there was always some leakage around the ultrasound needle. It was quite clear that a malleable sleeve in regular coaxial phaco is more likely than microphaco to completely seal the wound. We were pleased to discover that even though the threshold for a burn dropped dramatically, it still took 80% power for almost one minute of continuous ultrasound.[3] Although creating a wound burn is possible, microphaco might actually be somewhat more forgiving than coaxial phaco in this aspect, since incision leakage always occurs in microphaco.

At that time WhiteStar (Advanced Medical Optics, Santa Ana, CA), a power modulation that could create extremely short energy cycles, was made available to me for experimentation. Working in moderately hard rabbit nuclei, it became apparent that we could go as short as 6 ms on and 12 ms off with approximately the same efficiency as continuous ultrasound. Holding the needle between my fingers resulted in little temperature increase, so this technology appeared to be tailor-made for microphaco. In duplicating our previous experiments with WhiteStar at 6 ms on and 12 ms off—even with aspiration blocked—we were pleased to find that our maximum temperature at the end of three minutes was 32.4°C.[4] As a "divide and conquer surgeon", Dr. Eric Donnenfeld measured his microphaco wound temperature using WhiteStar and never had them go above 37C.[5] Combined, both of our studies indicated that ultrapulse technology renders this approach safe, especially with duty cycles of no more than one-third on and two-thirds off.

The inflow problem was particularly acute with early irrigating instruments. It was apparent the openings and tubing were often restrictive of flow. When flow was measured at the usual bottle height it became apparent that inflow did not equal outflow at times, which clearly would not allow chamber stability when aspiration was on. Any curtailing of inflow is therefore a problem, and it is apparent that there should be no constriction in the tubing at any point. The greatest constriction occurred with the final metal cannula going into the eye; it should be as thin-walled as possible and have two holes (preferably oval) as large as possible. A single opening at the end resulted in the least flow restriction; however, attaching something on the end of the cannula with an open end was a problem. In response, Microsurgical Technology (Redmond, WA) has pioneered such instrumentation. Many tip styles can be screwed into the cannula handle, affording many possible approaches to cataract removal.

Appropriate sizing of the wound is critical in maintaining chamber stability. If the wound is too tight, then the wound can easily tear and not easily seal at the end of the case; conversely, if it is too loose, then the leakage will be increased and chamber stability will diminish. Furthermore, lens particles will flow into the wound rather than going into the phaco needle. Experimentation with keratomes has shown that appropriately-sized wounds must be based upon the gauge of the instrumentation that is used. My own work indicates that 21-gauge technology requires a 0.8- to 0.9-mm keratome, 20-gauge requires a 1.1- to 1.2-mm keratome, and 19-gauge requires a 1.4- to 1.5-mm keratome. Although many keratomes are larger than this, the accompanying leakage is unacceptable and nuclear particles in the wound are an annoyance; therefore, it is recommended to avoid oversized incisions.

Dr. Agarwal has used a fish pump to pressurize the infusion line, tremendously increasing the amount of inflow.[6] As this is an uncontrolled maneuver, the amount of pressure could potentially be dangerous and this is a possible means of fluid contamination. To my knowledge, however, Dr. Agarwal has not had trouble with his pressurized infusion system. As we raise the bottle as high as possible, this could also theoretically result in some very high pressures. However, as long as aspiration is always on, the chamber is stable without dangerously high pressure; I have not heard of difficulty with this approach—incidentally, it is the most widespread approach today. Another approach is a commercial pressurized line such as the Alcon Accurus (Fort Worth, TX) that controls the infusion to create a predetermined intraocular pressure (IOP) in the eye without chamber stability concerns.

Outflow parameters should also be moderated, so I have not tried aspiration above 26 mL/min in microphaco.

Fig. 2 Capsulorhexis is easily performed through a side-port incision using the 23-gauge Kawai forceps (ASICO, Westmont, IL).

It was apparent, however, that things were moving faster than I expected at such a flow rate; at least a partial reason must be that in coaxial phaco, some of the irrigate comes to the phaco needle and is immediately aspirated (shunted), achieving no productive work. Grossly trying to assess the speed of how things happen, I feel that 25 to 30% of the fluid in coaxial phaco is shunted, which does not happen in microphaco; therefore, 26 mL/min of flow seems more like 34 to 35 mL/min of flow in coaxial phaco. To maintain chamber stability I have held vacuum levels at 250 to 300 mm Hg. However, Dr. David Chang has been able to duplicate the vacuum levels and efficiency of his regular phaco using the Staar Cruise Control device. The Staar Cruise Control is a constriction that obviates surge and also filters out nuclear particles so they cannot block the constriction. Today with this combination of factors, flow and chamber stability (as well as efficiency of the procedure) are not dramatically impacted.

We were also concerned about whether the procedure was safe and efficient for very hard cataracts and therefore undertook a study looking at Grade 4 through 6 nuclei on a 6 point scale and entered 18 such cases in a study. Using all of the technology available we were able to successfully remove all of those cataracts without breaking the capsule and had 13 of 18 judged as completely edema-free on the first post-operative day, with excellent long-term results.[7] It is apparent that microphaco will work in any condition in which regular coaxial phaco is used.

For those newly interested in microphaco the question often asked is, "How is the procedure different and does it feel different?" Moving to microphaco is immensely easier for anyone who routinely uses their second hand throughout the cataract surgical procedure, as the second hand is always actively engaged in microphaco. Here are the steps:

1. Incisions

The keratome must be sized appropriately for the gauge of instrumentation, and a trapezoidal incision is superior because it decreases instrument "oar-locking". Two such incisions are made and to further minimize oar-locking, make them parallel to the iris so that they are about 50% longer than their width. Incisions perpendicular to the surface are likely to leak. Those that are twice as long as their width will often tear and oar-locking as well as the wrinkling of the corneal surface can be a substantial problem.

2. Capsulorrhexis

After the first incision is made, fill the anterior chamber with viscoelastic, being careful not to over-deepen the chamber, and then make the second incision. Those who are comfortable using a needle find it a simple maneuver to create capsulorrhexis through a stab incision. Now there are 23-gauge capsulorrhexis forceps (Fig. 2) that can easily be used through these small incisions. Once one becomes accustomed to the constriction of the stab incision, then the capsulorrhexis approach is no different than in regular coaxial phaco.

3. Hydrodissection/Hydrodelineation

This approach is very similar; however, the bolus of fluid must be smaller in that fluid egress should be minimal. Irrigate on the way in to make sure that there is a fluid track out of the wound and carefully watch for deepening of the chamber that should be minimized. I also "burp out" a small amount of viscoelastic to allow more room for the fluid. Frequently decompress the nucleus after fluid is trapped in the capsule. With a little experience, both hydrodissection and hydrodelineation can be easily carried out.

4. Insertion of the Instruments

The irrigating instrument usually has an appendage, which first must be brought into the wound, and then the instrumentation must be rotated so that the irrigating instrument is inside the eye. At this point, I prefer to have irrigation on to open the wound for insertion of the phaco needle. Almost any phaco needle can be used; however, those that have a bell on the front edge will result in a wound way too large as you move beyond the bell. Therefore the outside diameter must be the same throughout and there must be some angulation of the tip, as getting a zero-degree needle through these small incisions is extremely difficult.

5. Lens Removal

With appropriate instrumentation and attention to detail, any approach is possible (Fig. 3). One must be careful about using continuous ultrasound; a short duty cycle is a much safer way to go. Wound burns have been reported to

Fig. 3 The nucleus is chopped using 21-gauge microphaco instrumentation.

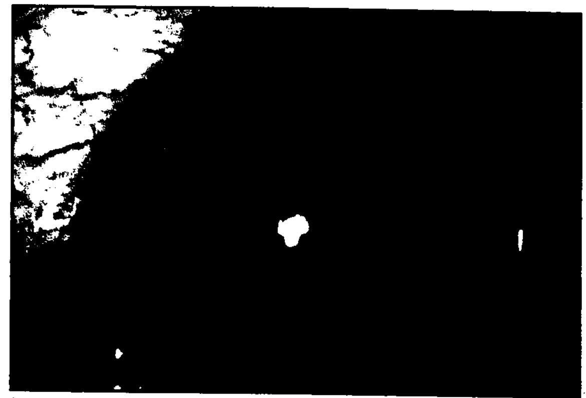

Fig. 4 The irrigating chopper is left in the eye so that there is no chamber collapse while the phaco needle is switched for an aspiration needle.

me in microphaco, however, I don't have any idea at this time whether that is more or less likely to occur than with coaxial surgery.

6. Irrigation/Aspiration (I/A)

This is where microphaco may have an advantage. I don't remove my irrigating instrument, but simply remove the phaco needle and am then given an aspirating instrument to place in the eye to remove any cortex (Fig. 4). This maintains anterior chamber depth. The small aspirating needle easily goes into the capsular fornix and the irrigating instrument can be used to fluff up cortex and open up the capsule. Also, if there is sticky cortex just under the incision, switching the two instruments obviates this problem and is one reason why bimanual I/A has been popular in many parts of the world. The ability to switch the instrument is a potential advantage throughout the procedure. Prior to removing irrigation you can fill the chamber with viscoelastic so there is never any chamber collapse.

7. Insertion of the IOL

Many open up one of the incisions, however, I have found them to be a bit too short for easy closure and sometimes a little stretched. Therefore, my preference is to make a new, clean incision with a diamond blade between the two original small incisions, with the lens placed in the usual fashion.

8. Viscoelastic Removal and Sealing of the Wounds

I stromally hydrate all of the wounds and then use the bimanual I/A setup to remove the viscoelastic. If this is not done, then the IOL incision will leak, and you will not have good chamber stability. Also, all the wounds are well hydrated so as you come out of the eye there is good chamber depth. If any wound will leak at this time, it will be one of the original micro-incisions and, if this is persistent, it means that you torqued the instruments too much or the wound was too tight. I have had to put a suture in one of these small incisions that I removed the next day; however, with experience this should not be a problem.

Freeing up irrigation and having the option of being able to switch from one wound to the other are advantages, especially in difficult situations. Using irrigation alone to manipulate lens particles so that the phaco needle never approaches the capsule, iris, or the cornea may improve safety. These advantages are theoretical because, to my knowledge, no clinical study has yet been able to prove these contentions; however, I do feel that they are important and will be proven eventually.

In my opinion, microphaco is safer in the following two clinical situations: where there is a very tight anterior chamber or very tense capsule. In an intumescent cataract or phacomorphic glaucoma (where the lens is substantially swollen) or in the case of nanophthalmos (where there is very little room to maneuver), iris prolapse is often a problem. If the capsule is tense, simply starting the capsulorrhexis can result in extension out to the equator of the lens. The capsule pressure can be maintained by doing the capsulorrhexis through a stab incision with a forceps (a needle does not occlude the wound as well) and using a very viscous viscoelastic such as Healon 5 (Pfizer, New York, NY), so that tear extension is simply not a concern. There is such great chamber stability that even milky cortex does not become an issue (Fig. 5). Iris prolapse is also avoided. In nanophthalmos where a choroidal effusion is always a concern, maintaining a deep chamber and positive pressure throughout the procedure is simple and assured.

Another theoretical advantage is there is never a particular deepening of the chamber due to the lowered

Fig. 5 Capsulorhexis is performed with complete chamber stability in a case of intumescent cataract.

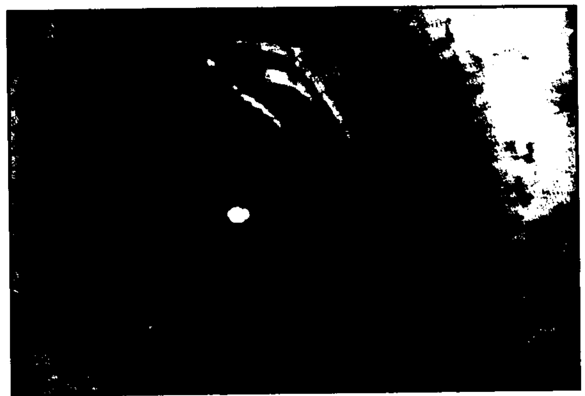

Fig. 6 ThinOptX IOL upon insertion through a sub-2 mm incision. Note the Fresnel lines on the optic, which renders this IOL very thin.

infusion forces and there never need be a chamber collapse. The assumption has been that retinal detachment risk after cataract surgery is associated with over-deepening of the chamber combined with chamber collapse, resulting in premature symptomatic vitreous detachment that can lead to tears with traction and, later, retinal detachment. A stable anterior chamber without any collapse is possible with microphaco, which might prove to be advantageous in decreasing retinal detachment risk especially in young, male myopes.

9. IOLs

Dr. Tsuneoka has placed the 5.5 mm SA-30 Alcon AcrySof lens through 2.2 mm incisions by inserting the lens without a sleeve through the wound using a special insertion device.[8] There also are two lenses (AcriTec and ThinOptX) that can go through sub-2 mm incisions. The AcriTec is a hydrophilic acrylic IOL, which can be rolled into a very thin profile and is being used in Europe and elsewhere in the world.[9] The ThinOptX lens is also made of hydrophilic acrylic but uses the Fresnel lens principle to make the optic extremely thin (Fig. 6). It can be wrapped tightly (now facilitated with a special device) and this can go through an incision as small as 1.5 mm.[10] Clinical studies have begun with this lens in the United States.

For microphaco incision IOLs to be successful it is not enough for them to go through small incisions. They must also be as effective as the lenses we accept as the standard today. This would include obviating issues such as after-cataract formation with minimal dysphotopsia and long-term stability. In particular, the ThinOptX IOL appears to me to be susceptible to wrinkling as the capsule tightens, however, this potential problem has not been reported at this time. Also, both lenses would appear to have a significant after-cataract problem. What is apparent is that IOLs that can successfully be inserted through sub-2 mm incisions will eventually be available and will dramatically impact the acceptance of microphaco.

Summary

Microphaco is an approach that is in its infancy. Although it has been talked about for a long time, as with all emergent technologies it is important to look at the advantages and disadvantages, which I have tried to lay out as objectively as possible. Even without having micro-incision IOLs available, there may be reasons to consider microphaco. The utility of the instrumentation and potential safety advantages are interesting considerations. With refractive lens exchange and maintaining a stable chamber throughout the case, if chamber stability can then be shown to decrease the risk of retinal detachment, this could speed acceptance of microphaco. With appropriate ultra-small incision IOLs that are as good as or better than what we have now, then microphaco could very well become our standard approach. ❑

References

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