New Ways to Quantify Cataract Procedures, Tools, and Techniques
Pig Lenses and a Modified Egg Slicer Result in Pioneering Research to Evaluate the Tools of Cataract Surgery

“All lies and jest; still, a man hears what he wants to hear and disregards the rest.”
— The Boxer, Simon and Garfunkel

Much of the information we receive does at times seem like “all lies and jest.” Yet, we must resist the natural instinct to “hear what we want to hear and disregard the rest.” As physicians, until we look at something objectively, we can’t accept it or be sure our surgical techniques and patient outcomes will improve.

Historically, when it comes to cataract surgery, there have been all kinds of biases. I always think, Is this really better? What price are we paying for using this tool? Are there any great studies on that? The problem has been that typically we have not had a method for objectively determining which cataract surgical procedure, tool, or technique is optimal and most efficient, with fewer complications—until now!

In this newsletter, we’re thrilled to highlight excerpts from pioneering studies designed and carried out by University of Utah medical students and Moran Eye Center’s Department of Ophthalmology and Visual Sciences residents, fellows, and faculty as they tackle big challenges and questions such as, How to Build a Better Research Cataract? How to Determine Optimal Phaco Power Settings? How to Determine which Phaco Tip is the Most Efficient? And How to Improve Efficiency and Decrease Chatter?

I hope you’ll find the information valuable as you make decisions about products and procedures in your practice.

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How to Build a Better Research Cataract
Validating Porcine (Pig) Lens Nuclei Comparable to Human Models

Problem: Human lens nuclei have been utilized for phacoemulsification performance in vitro; however, those studies have been limited in range and scope due to the limited supply of human tissue. Given the inadequate supply of fresh human lens nuclei to facilitate comparative testing, it is largely unknown exactly which phacoemulsification settings improve performance and safety.

Solution: We designed an experimental study to validate a porcine lens model by comparing density and ultrasound with known human standards. We soaked porcine lens nuclei in formalin in hour-based intervals to increase their density. We then developed a device and method to slice this material into uniform pieces using the "cubinator" (described next page). Density was characterized by crushing experiments and compared with human lenses. This is a landmark contribution to the study of phacoemulsification because high-volume comparative research at this scale was previously not possible.
Behold the Cubinator
Modified Egg Slicer Transforms Cataract Surgery Research

The “cubinator” is a device developed by Griffin Jardine, MD, while he was a medical student at the University of Utah. It looks and functions much like an egg slicer. The cubinator divides formalin soaked porcine nuclei into uniform 1 or 2 mm cubes with densities similar to 3-4+ human nuclei. The published and validated model creates thousands of cataract tissue samples which can be hardened or softened as a given study design requires.

This simple device and processed tissue allow new technologies and surgical techniques to be objectively evaluated for safety and efficiency, as the treated lenses are an exact approximation of human lenses at various levels of hardness.

Our group has published an unprecedented number of truly objective studies covering a myriad of technologies available for ophthalmic surgeons—studies such as Determining Optimal Phaco Power Settings, Determining Which Phaco Tip Is the Most Efficient, and How to Improve Efficiency and Decrease Chatter.

Any new phacoemulsification handpiece, tip, fluidics, or power settings can be tested in vitro. The study designs call for changing single variables and performing hundreds of experimental runs at different settings. Now, this limitless availability of cataract tissue allows researchers to detect significant differences in efficiency. The faster the cube is emulsified, the more efficient the setting.

The cubinator also allows for improved patient safety due to the ability to detect chatter events. Chatter occurs when a piece of cataract bounces from the phaco tip. The more chatter events, the less efficient, also the greater chance for unintended contact with the iris or capsular bag. Determining optimum chatter events for different parameters improves efficiency and safety.

Goal: Safer, More Efficient Surgery Results

Formalin-soaked pig lenses are most comparable to human lenses—a landmark study equivalent to performing 1000 cataract surgeries.

The “cubinator” is developed—an egg-slicer device that divides formalin soaked pig lenses into uniform 1 or 2 mm cubes, simulating human cataract material.

An extensive supply of comparable human cataract material is used to test the safest, most efficient phaco tip and optimal power settings and to test variables to improve efficiency and decrease chatter events.

The cubinator and processed pig lenses make it possible to objectively test new technologies and cataract surgical techniques for safety and efficiency.

MORAN RESEARCH GROUP

Moran’s Intermountain Ocular Research Center is the premier laboratory for the evaluation of new IOL technologies—practically every lens on the market today has been tested by this lab—it also functions as a national registry for removed IOLs and tissue with lens-induced disease.

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How to Determine Optimal Phaco Power Settings

Determining the optimal longitudinal power setting for torsional ultrasound using a pig lens model

Phacoemulsification has become the standard method for removing cataracts in the developed world. Phaco works by using high-frequency ultrasound to create energy, which is transferred from the machine through the handpiece to an attached needle. The needle is placed into the eye and interacts with the cataract to break it into pieces. Aspiration and vacuum remove these pieces from the eye.

Newer advances in technology focus on efficiently removing the cataract to decrease the amount of energy expelled within the eye, resulting in more rapid recovery for the patient. There are many different settings, tips, handpieces, and machines to use for cataract surgery. The combinations of these variables make it difficult to isolate one single setting to compare outcomes. Our studies seek objective evidence for phaco efficiency. They are designed to isolate single variables to detect the differences in efficiency.

One such study aimed to determine the optimal longitudinal power setting for Ozil-IP at set torsional phaco levels. Longitudinal phaco works by a jackhammer effect—moving forward and backwards on the lens to break it into pieces. Longitudinal phaco creates cavitational forces that are important in emulsifying the lens particle. The level of phaco required to create cavitation is relatively unknown. Torsional ultrasound works by side-to-side shaving-type motions which break up the lens. We hypothesized that adding longitudinal power to torsional power would increase efficiency by creating different types of energy at the interface between the needle and the lens particle. We tested longitudinal settings of 60, 80, and 100 percent under multiple torsional levels from 0 to 100 percent power. Our results were interesting. At low levels of torsional ultrasound, increasing longitudinal power improves efficiency as we hypothesized. A result that we didn’t anticipate is what occurred at maximum torsional power: if we set the machine at 100 percent torsional power, adding longitudinal power did not increase efficiency.

How to Determine the Best Phaco Tip

Now we have all these variations, but very little objectivity about which tip best reduces complications and increases efficiency.

One of the more common major complications in cataract surgery is a posterior capsule rupture. This complication occurs in approximately 1-3 percent of cataract surgical cases. Recent efforts have been made to enhance the design of the tip that is used to remove the cataract. Classically, the tip has a sharp edge, and this has been associated with the cause of capsule break in approximately 60 percent of the cases where a capsule violation occurred. A recent design adjustment with a rounded edge tip, called the “Dewey Tip,” has been introduced to potentially reduce this complication; however, adopting this tip has been slow due to concerns about decreased surgical efficiency and questions about how much improvement this tip provides in terms of safety with the capsule.

Our group has tackled these concerns with objective experimental designs. Using cadaveric and non-biological tissue models, we have shown that this rounded tip design is significantly safer with regard to capsule breakage rates. However, the question regarding efficiency continued to deter surgeons to adopt this tip. With the rounded edge tip, we have shown surprising results suggesting that efficiency is equivalent and potentially improved rather than impaired, as had been hypothesized by many surgeons. This would suggest that a move toward enhancing safety does not compromise efficiency. Discoveries such as this are crucial to driving improvements that translate to patient care and that allow us to deliver higher quality care, even in the setting of a very successful procedure.

In clinical practice, there are two primary methods of generating vacuum during phacoemulsification: peristaltic and Venturi. Peristaltic pumps create flow using rollers to compress the outflow tubing, which results in flow-based vacuum that builds as the phaco tip is occluded. Venturi pumps use vacuum to create flow. They employ the “Venturi effect,” which refers to the phenomenon of “air flowing over an opening generates vacuum.” The vacuum in Venturi pumps is generated independently of tip occlusion. Proponents of using Venturi vacuum for phacoemulsification predict improved efficiency and decreased chatter because the vacuum is not dependent on tip occlusion. However, because there are many variables, this hypothesis has been impossible to test in a clinical setting.

To test this hypothesis, we employed our novel in vitro cubed pig lenses technique. Pig lenses were hardened to a density similar to human cataracts and then cut into uniform 2mm by 2mm cubes. We conducted phaco experiments with an Abbott Medical Optics (AMO, Santa Ana, CA, USA) Signature machine, as this machine has the ability to switch between peristaltic and vacuum based outflow systems. We compared peristaltic to Venturi vacuum with both transversal and longitudinal phaco. Vacuum levels were set to 300, 400 or 500mmHg. We conducted 20 runs for each setting and measured efficiency (the total time until fragment removal, not including any chatter time) and chatter (one event equals where the fragment was seen to bounce off the tip).

Venturi was significantly more efficient than peristaltic vacuum in the transversal arm at all vacuum levels tested and had decreased chatter events at the higher vacuum levels. In the micropulsed longitudinal ultrasound arm, Venturi was significantly more effective than peristaltic in terms of both efficiency at 300mmHg and 400mmHg and chatter at 300mmHg, with the results at 500mmHg not significant for either efficiency or chatter.

Our study provides objective evidence that Venturi vacuum improves efficiency and decreases chatter in both longitudinal and transversal phacoemulsification. This answers a question that had previously only been theoretically debated. The primary limitation of this study is its in vitro nature. However, our technique using cubed pig lenses provides valuable information because a clinical study controlling for all parameters that we studied would be impossible.

The Mamalis/Werner Laboratories

The Moran Eye Center’s commitment to improving cataract outcomes goes beyond our research into better tools and techniques. When it comes to understanding IOL and cataract technology, no group is doing more work than the researchers at Moran’s Intermountain Ocular Research Center, the premier center for the study of IOL-related complications. Co-directors Nick Mamalis, MD, and Liliana Werner, MD, PhD, have become the go-to experts for the evaluation of new IOL technologies. Practically every lens on the market today has been tested by their lab, and they often consult on the design process as well. “We usually work with a company from the very beginning, until it actually gets to the point where I can use it in my own patients,” says Mamalis. “That’s what motivates me.”

Ophthalmologists worldwide have sent more than 16,000 specimens to the center for analysis, as it also functions as a national registry for removed IOLs and tissue with lens-induced disease. “If we can change one surgeon’s thinking about an IOL, we have helped all of his patients,” says Werner.