Many of the retinal cell types in both vertebrate and invertebrate eyes have already been investigated using these techniques. As is well known, this has resulted in the positive identification of the physiologic response of vertebrate photoreceptors and certain other retinal neurons.

These results are among the most important in recent visual physiology. As interest in intracellular staining increases we can expect to see its greater use in the central pathways of vision and a more detailed anatomic use of the method as practical methods of electron microscopy are combined with intracellular staining.

What just a few years ago seemed a utopian dream of linking structure and function in the visual system is now being realized in an intracellular staining epoch of visual research.

REFERENCES

Phaco emulsification: trials and tribulations*

Research eventually will provide a means of preventing most cataracts; until then, an explosive search for the ideal mode of cataract surgery will continue. That search has many complexities, both technical and human.

Ophthalmologists face an alternative to continuing their generally satisfactory method of cataract extraction which keeps a patient in the hospital for four to six days and on limited activities for weeks or months. The alternative would require tooling up with expensive instrumentation for a new procedure known as phaco emulsification which is hazardous to perform until well-tutored skill has been developed. Instead of the usual large 15 mm. incision in the eye, only a 2.5 mm. incision is required for the introduction of an ultrasound-fortified, irrigation-aspiration "needle" used to suck out the cataract contents. Having firsthand familiarity with the method but being neither an expert in its performance nor having any personal responsibility for its development, I was asked to comment on this topic.

The idealized advantage of phaco emulsification is a 24-hour hospital admission for the patient, who can return to work in a day or two. With some 400,000 cataract extractions performed each year in the United States alone, there are immense socioeconomic implications of phaco emulsification, should it prove to be as successful as its advocates assert. Small wonder that news of this surgery has already caused a vibrant stir within ophthalmology—and a premature optimism in the public mind!

Some major advances in the technology of cataract surgery have been made in recent years. Ophthalmologists trained before the 1960's used modified forceps or an ersysiphake to grasp a cataract and pull it through the surgical wound, aided by spectacle-type loupes with 2x to 4x magnification. Since then, cryoextraction, generally viewed with skepticism less than a decade ago, has virtually replaced traditional techniques of grasping the cataract at the time of its removal. Many "cryoextractors" were condemned before the safer models in current use reached development. Next in the changing trends of cataract surgery was the advent of microsurgery with its delicate hand in-
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The cost of the commercially-available phaco emulsification instrument exceeds $30,000. A second-generation model will be about two-thirds that cost and will not require a technician in constant attendance. Disposable materials for the cataract instrument alone amount to $85 per patient.

Expense is not the only problem. The technique of phaco emulsification includes many small but vitally important details that necessitate a special training course, animal surgery, and a very cautious adaptation to clinical usage. By removing the cataract within its capsule (intracapsular cataract extraction through a large incision), no residual lens material remains in the eye. This is a distinct advantage, for such material has the potential for causing recurrence of impaired vision by growth of an opaque membrane across the pupil and the necessity of a second operation. It is difficult for any other method to compete with the success rate and definitive results characteristic of intracapsular extraction (although I suspect that nationwide there is a somewhat higher rate of complications associated with that operation than most published series indicate). The surgeon performing phaco emulsification must remove all remnants of the cataract with the exception of the posterior portion of its capsule, and he must accomplish this goal without damage to the cornea, the iris, or the vitreous. The use of a microscope is *sine qua non*. Eyes with corneal dystrophy, shallow anterior chamber, or a pupil that dilates poorly are definitely inappropriate for phaco emulsification.

The idea of removing a cataract by aspiration is not new. Even in the ninth and tenth centuries, A.D., Arabian ophthalmologists suggested drainage of cataracts through a needle inserted within the eye. Aspiration-irrigation of cataracts through hollow needles has become routine in pediatric cases over the past fifteen years, for these lenses are soft, readily aspirated, and risky to remove by extraction due to a high risk of vitreous loss. The harder cataracts in adult eyes cannot be extracted through a simple needle-syringe system, for their substance must be "broken up"—and this is accomplished by the phaco emulsifier's ultrasonic vibrations at the tip of the handpiece introduced into the cataract by way of a small incision at the limbus.

There are now 35 phaco emulsifiers in the United States, six of which are located within teaching institutions. Some 200 American ophthalmologists have been trained in phaco emulsification in one of numerous five-day courses conducted in New York and more recently in Los Angeles. To date, about 3,500 phaco emulsification procedures have been performed. Only a few ophthalmologists have done 50 cases or more. Some doctors have used the instrument a few times and then decided to return to traditional cataract surgery owing to unsatisfactory experience with the new method. The extent of training with model eyes, animal eyes, and with the microscope undoubtedly influences a doctor's facility in learning the new surgical skill.

The reading public is clamoring to have "the easy way" of cataract surgery, while many outstanding ophthalmologists who themselves perform technically excellent cataract extractions consider phaco emulsification to be risky and the instrumentation to be prohibitively expensive. Because of this important issue, and in the interest of delineating the facts, I have undertaken a nationwide review of the records of 500 cataract operations performed by residents and staff surgeons at various teaching institutions.
of optimal patient care, the Council of the American Academy of Ophthalmology and Otalaryngology at its annual meeting in Dallas, Sept. 1972, issued a statement pointing out that scientific evidence has not been published in the medical literature to prove that phaco emulsification is as safe or as effective as the methods of cataract extraction now used. The Council proceeded to appoint an ad hoc committee to collect data on safety, effectiveness, and value of this technique; a final report should not be expected for a year or more.

Meanwhile, some four or five ophthalmologists, working in collaboration with engineers or directly with industry, are producing similar instruments with minor and even major variations on the basic principle of phaco emulsification—to accomplish the same goal with less expensive machines. These instruments are prototypes, and it remains to be shown if they are competitive in safety and performance. As with other forms of surgery, a real problem exists in determining how clinical research of this nature can be safely conducted. There must be progress and there must be safety for the patient.

At this point one fact is certain: ophthalmic surgeons with genuine interest in the basic and clinical research on aspiration-irrigation of adults' cataracts would be well advised to avoid lay publicity concerning their devices and to evaluate them cautiously before exhorting the features of their modifications. It is important to recognize the serious lessons taught from information given to the press regarding operations or devices whose true significance remains undetermined. Even some of our leading professional societies are responsible for encouraging press releases. In the public interest, it behooves the individual doctor to be discrete and conservative in what he states or implies.

Phaco emulsification is not an inevitable resolution to the quest for ideal cataract surgery. Much work is being done to close the traditional incision of cataract extraction by "watertight" suturing. If that could be attained it would negate the unique value of phaco emulsification's tiny incision. Some day there may be a glue-like, absorbable substance that can be painted over the cataract extraction's incision to seal it as tightly as though no incision had been made. Then the patient would have the advantages of intracapsular cataract extraction and yet could return to full activity just as promptly as the patient having phaco emulsification. I mention that as one hypothetical alternative which would take a great deal of pressure off the practicing, instrument-poor ophthalmologist who feels compelled to "emulsify" because his patients migrate toward other doctors who use that method.

In conclusion, I believe that phaco emulsification of cataracts—sooner or later—will probably be shown to be a real contribution to ophthalmic surgery and to the comfort, convenience, and economy of our patients. That view is based on the experience of some surgeons now experiencing no more complications than with routine cataract extraction. At this point it is easier to state which patients should not have phaco emulsification than it is to select those who should. As of today, phaco emulsification is a highly specialized skill requiring expensive instrumentation and a new microsurgical finesse. Future instruments will surely be less expensive, safer, and easier to operate. It will be of great interest to review the facts as more scientific publications appear.

If I had a cataract, would I have it managed by phaco emulsification? Only when I can answer that question with no reservation will I feel that I can give adequate advice to my patients.

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