Coupling of phaco tip and cataract fragments may cause cell damage, inflammation

William J Fishkind

MOMENTARY couplings of the phaco tip and cataract nucleus fragments during phacoemulsification apparently result in random dispersion of ultrasonic energy inside the eye, new research suggests.

This chaotic energy may be responsible for much of the damage sustained by the corneal endothelium and the iris blood-aqueous barrier during micropulse phaco procedures, particularly those involving harder nuclei, according to William J Fishkind MD, FACS, co-director of Fishkind & Bakewell Eye Care and Surgical Centre, Tucson, US, and clinical professor of ophthalmology, University of Utah, Salt Lake City, US.

"When the fragment moves with the phaco tip it is coupled and becomes an emitter of free energy. The harder the fragment, the greater the coupling, and the greater the transfer of energy," Dr Fishkind told the 2007 American Society of Cataract and Refractive Surgery Symposium on Cataract, IO L and Refractive Surgery, where he presented research based on ultra-high speed video of phaco procedures on cadaver and pig eyes.

Dr Fishkind’s research suggests that mechanically chopping hard nucleus fragments into smaller pieces and holding them against the phaco tip with a second instrument along with use of adequate phaco power to quickly dissolve fragments would reduce coupling. Torsional phaco handpieces appear to eliminate it altogether, he said.

Dr Fishkind believes that minimising phaco tip-fragment coupling may be a key to help control the corneal damage and postoperative inflammation often seen with harder cataracts.

"The operative word is ‘may’. We haven’t proven any of this yet," he said.

Fragment as ultrasonic emitter
Dr Fishkind discovered the phaco tip-fragment coupling effect while researching the microenvironment around the phaco tip during micropulse procedures at American Medical Optics’ high-speed video lab. AMO supported this research, the firm has allowed Dr Fishkind unrestricted use of the findings, he said.

"Micropulse phaco, with its ultra-short on and off periods, is a modifier of both power and flow. I wanted to do some experiments to look at and how it affected emulsification at the phaco tip," Dr Fishkind explained.

So he taped at 3,000 frames per second phaco procedures conducted in vitro on mature cataracts in human and pig eyes. He tested Sovereign with W hitestar and ICE (AMO), Infinity with micropulse and ABS tips (Alcon) and Millennium (Bausch & Lomb) machines.

The tapes he showed at the ASCRS meeting clearly showed coupled cataract fragments moving in unison with the phaco tip at ultrasonic frequencies.

"I started to see this with every fragment on micropulse phaco," said Dr Fishkind, who is also a clinical instructor at the University of Arizona, Tucson, US. The tapes showed that couplings occurred repeatedly during phacoemulsification procedures, and often continued for as long as phaco energy was applied.

Dr Fishkind noted that energy transfer from one solid body in direct contact with another is highly efficient, as seen with steel balls suspended on a frame.

"When you release the ball at one end, the ball on the other end bounces out with the same energy."

To examine and demonstrate the potential for coupled objects to transmit energy in random directions, he attached glue and small stones to a phaco tip. Tapes showed streams of energy radiating off the glue. When immersed in a solution, streams of bubbles could be seen shooting off the tip of the stone, Dr Fishkind said. He speculates that these streams correspond with focused energy emissions, and that similar random energy emanates from irregularly shaped cataract nucleus fragments when they couple with the phaco tip.

"Imagine the energy moving through the phaco tip, and through this material and out the other side. It is chaotic, it is random, it is striking the iris, it is striking the endothelium, and it is striking intracocular structures. This may be the cause of the increased corneal oedema and endothelial cell loss we see as we start to phaco more and more mature cataracts."

Size doesn’t matter
Dr Fishkind noted that coupling occurred with fragments of all sizes. Harder fragments appeared to transmit more energy than softer fragments.

"Size doesn’t matter; consistency does," he said.

Dr Fishkind found that using enough phaco power appears to reduce coupling by speeding emulsification. Pre-chopping fragments and pressing them into the phaco tip with a second instrument also appeared to reduce coupling by speeding up emulsification and possibly by damping energy transfer. The side-to-side motion of torsional phaco appeared to eliminate coupling by making it impossible for fragments to attach to the tip. Dr Fishkind suggests that further research be done on the effect of angled tips and tips using aspiration bypass ports on fragment coupling.

Additional research into the phenomenon of coupling is also indicated. One seminar participant pointed out that tapping at 3,000 frames per second is far too slow to capture everything that is happening at ultrasonic frequencies of about 45,000 cycles per second. In theory, 120,000 frames would be needed to adequately sample motion at that speed, he said. Less than that leaves the actual dynamics in question.

Dr Fishkind acknowledged the issue, but believes that higher-speed observations will only confirm what he has observed.

"You can see from the tapes that the movement appears to start and stop, so it is under-sampled. My assessment is that [coupling] is happening more than what we are seeing. Again, this is speculation, but this issue may be even more significant than we realise."

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