Clinical & Surgical Ophthalmology is pleased to present this interview with Dr. David Yan (Toronto) about the advances of hydrophilic acrylic IOLs. CSO met with Dr. Yan immediately after his presentation of the same name at the 15th Annual Scientific Meeting of the Canadian Society of Cataract & Refractive Surgery, which was held on May 3rd in Vancouver, British Columbia.

An Interview with David Yan, MD about the Advances of Hydrophilic Acrylic IOLs

David Yan, MD

CSO: Recently, you delivered a presentation at the CSCRS Meeting in Vancouver, entitled "The Advances of Hydrophilic Acrylic IOLs," and if I may, I would like to discuss some of the points that you raised in your presentation. To begin with, what led you to present this paper?

Dr. Yan: For quite some time I have been implanting IOLs in three different hospitals in the Toronto area. For the most part, I have used the lenses that were made available to me because they were either on contract or on consignment at each of these hospitals. This means that, over time, I have implanted just about every type of IOL from virtually every major manufacturer. Between all the different places I run around to, all of which use different phaco machines and IOLs, I think I implant 10 different IOLs right now on a regular basis. In fact, it's gotten to the point where I actually need to color code my patient files in order to help distinguish between the different lens types I plan to use, and my files have started to resemble a bowl of Fruit Loops. However, the interesting thing about all this is that it has given me more than sufficient experience to be able to make some educated observations about the different types of IOLs in use today, and more specifically about the advantages that are offered with the new class of hydrophilic acrylic IOLs.

David Yan, MD — Staff Ophthalmologist, Mount Sinai Hospital and St. Joseph's Health Centre Director, Toronto Ophthalmology Residency Course, Assistant Professor, Department of Ophthalmology, University of Toronto, Ontario

CSO: Well, let's start off with your thoughts about silicone IOLs.

Dr. Yan: As you know, the silicones were the first foldable IOLs and they are still widely available today at a fairly low cost, especially in third-world countries. However, their major disadvantage is the high degree of capsular fibrosis (Fig. 1) and/or decentration associated with them. The lens material is inherently highly elastic, so they unfold a little too quickly, and often with a little less control than desired inside the eye. These lenses also tend to pit quite easily when a YAG capsulotomy is being performed. All in all, I think it's a lens type that still has its place, but I wouldn't consider it to be my first choice for an IOL.

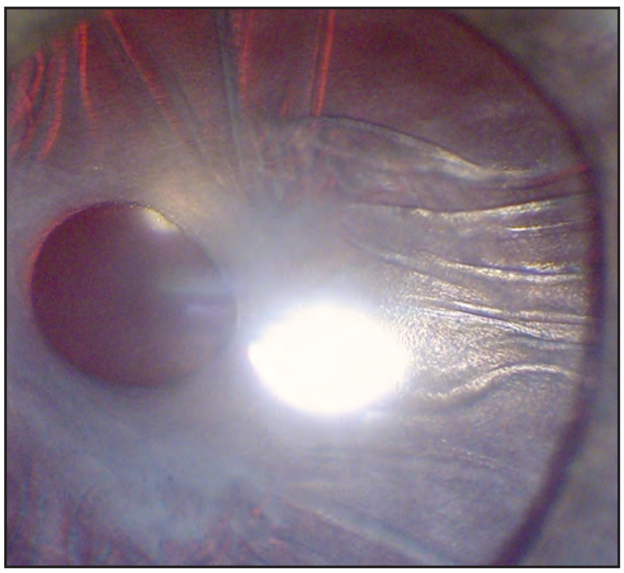

Fig. 1 Capsular fibrosis associated with a silicone IOL.

CSO: Moving on, what are your observations about hydrophobic IOLs?

Dr. Yan: There are several advantages associated with the hydrophobic acrylic IOLs. First off, I believe their biocompatibility is better than that of the silicone IOLs. In addition, they remain very stable in position inside the eye. I've actually implanted a significant number of these lenses into broken capsular bags over the past 7 years, both with an anterior capsular run-out or a posterior capsular tear. I follow all of these patients longer-term, for at least 2 years post-op, and I have not seen a single case of significant IOL migration. But then there are the disadvantages, such as a high refractive index which can lead to dysphotopsias and edge glare. I've also encountered problems with impurities, glistenings, and thermolability. The capsular bag rapidly develops a fibronectin adhesion to the IOL, which is good for maintaining IOL stability.

CSO: With this in mind, what are your experiences with the new class of hydrophilic acrylic IOLs?

Dr. Yan: From my experience, I feel that the current hydrophilic acrylic IOLs may be even more biocompatible than the hydrophobic lenses. They have remarkable stretch strength, and resist tearing. Scratching of the lens also seems to be less common than with the hydrophobic IOLs. They handle well, and offer excellent shape recovery with a reasonably good degree of control during unfolding; what's more, they are not thermolabile. In addition, they are compatible with VR surgery with relatively low fibrotic proliferation. This lens material also has a very low rate of decentration or capsular phimosis like the hydrophobic acrylics.

CSO: Was this always your impression of hydrophilic lenses?

Dr. Yan: No it wasn't. My own earlier experience with hydrophilic acrylic lenses was far from positive, and led me to take a very cautious approach when newer generations of IOLs made from this class of material became available. When I finished my training over a decade ago, the first hospital at which I was granted operating privileges used the Hydroview lens as its standard foldable IOL. Before long, it was the only lens that I was implanting when foldable IOLs became the standard of care. Not long after that, reports of unusual calcification began to surface at meetings and later in the literature. As it turned out, a small but significant number of my own patients eventually exhibited very bad IOL calcification, and you can imagine the impact this had on me when I was a young surgeon only recently out of residency. This had a tremendous effect on me and at the time I swore off using any more hydrophilic acrylic lenses. Obviously, though, I've gradually changed my mind over the years as newer generations of hydrophilic IOLs were developed, or I wouldn't be speaking with you today about the advantages.

CSO: What changed your mind?

Dr. Yan: When the data on the calcification deposits began to emerge, it became clear that the problems were caused by the silicone in the packaging material rather than the IOL itself. In fact, the adverse effects were isolated to that particular lens, and, as far as I know, there have not been any new reports in recent literature with any of the newer generation hydrophilic acrylic IOLs, none of which had similar packaging issues. Since then, hydrophilic acrylic lenses have gone on to become one of the most widely implanted IOL biomaterials worldwide with a long and extensive track record of safety in Europe.

CSO: How does the biomaterial make-up of an IOL affect its performance?

Dr. Yan: I have a mechanical engineering background, and tend to be overly technical since my days at M.I.T., so I will try to keep my answer relatively free of techie jargon. Foldable IOLs store energy when they are deformed from their natural shape (i.e. folded) and it is the release of this stored energy that allows them to return to their original shape once injected inside the eye. If an IOL has mostly elastic material properties, it will convert more of this stored energy into kinetic energy as it is unfolding. If an IOL has mostly plastic material properties, it will convert more of this stored energy into thermal energy as it is unfolding. Silicone IOLs are more elastic than plastic, so they will unfold rapidly. Too rapid unfolding is not desirable, especially in many of the more difficult cases we commonly see, such as pseudoexfoliation with weak zonules, small pupils, anterior or posterior capsule tears, or floppy irises. In such cases, a precise and well-controlled unfolding is highly desirable to ensure the IOL ends up in the right place without any damage to the eye from the movement of the haptics. On the other hand, hydrophobic lenses tend to be more plastic than elastic. They unfold very slowly, but the elastic forces generated by restitution of the material to its original shape are sometimes not enough to overcome the "stickiness" of the lens material onto itself. That is why hydrophobic acrylic IOLs occasionally get stuck in the folded position after being delivered into the eye. Hydrophilic acrylics have a nice balance of both elastic and plastic properties. They unfold in a relatively well-controlled manner without being so stiff to the point of being difficult to fold or unfold.

CSO: What other advantages do hydrophilic IOLs have to offer?

Dr. Yan: An interesting thing about hydrophilic acrylic materials is that they exist in two states, either dehydrated or hydrated. In their hydrated state, hydrophilic IOLs are very pliable and remarkably easy to manipulate when implanting inside the eye. However, in their dehydrated state, hydrophilic lenses are extremely rigid. Consequently, they can be very finely micro-lathed. This is why you will find that their lens designs are much more complex than those of their hydrophobic acrylic or silicone counterparts. Those materials could easily fracture if micro-lathed, and could also tear easily if haptics made of the same material were too thin. That is why many of the hydrophobic acrylic and silicone IOLs still rely on a conventional three-piece design with PMMA haptics. An example of the unique and highly complex designs possible with hydrophilic acrylics are the Rayner C-Flex or SuperFlex IOLs.

CSO: What is the reason for the unique haptic design of the Rayner IOLs?

Dr. Yan: The older silicone and hydrophobic lenses with three-piece PMMA haptic designs rely on only two points of fixation between the optic and the haptics. When these lenses are implanted, they can rotate or tilt around the long axis of the optic-haptic plane. This is best illustrated in Fig. 2. In contrast, the closed loop haptic design of the Rayner lenses offers two fixation points per haptic, or more precisely, four fixation points for the entire optic (Fig. 3). This virtually eliminates any tendency for these lenses to unintentionally tilt in the eye, which can induce astigmatism, much like eyeglasses when they are improperly fitted.

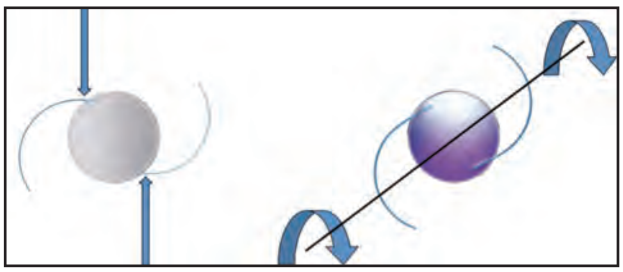

Fig. 2 Tilt and rotation of older lens designs.

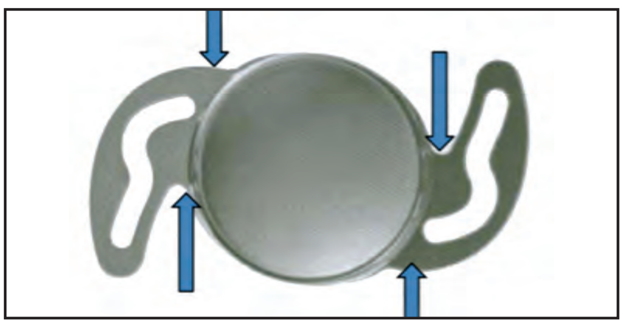

Fig. 3 Two-point fixation per haptic of the Rayner lens.

CSO: A lot has been said about spherical aberration. In your opinion, should IOLs be negatively or positively aberrated, or should they be aspheric instead?

Dr. Yan: The human eye has a positive spherical aberration, which means that the peripheral part of the lens has more power than the central part (Fig. 4). In terms of the IOLs that we have available today, the older and more classic lens designs, for the most part, have positive spherical aberration. We all start life with mild positive spherical aberration at the cornea that is partly offset by a bit of negative spherical aberration in the lens. The net result is a slight bit of positive sphericity, which seems to be good for optimizing visual acuity and depth of focus in the young, healthy eye. But as we get older, our lenses change from negative to positive spherical aberration with the onset of cataracts, all the while our corneas are becoming more positive. We end up with a strongly positive total spherical aberration in the aging eye, and this contributes to the degradation of acuity and contrast sensitivity commonly associated with cataracts. If a cataract is replaced with an IOL that has positive aberration, we are still left with an optical system that is far too positively aberrated for optimal image quality. The first IOLs to address this issue, such as the Tecnis from AMO, were designed with a negative spherical aberration. In theory, these negatively aberrated lenses offset the positive corneal aberration to give the patient a net zero spherical aberration. However, the newer hydrophilic acrylic lenses like the Rayner C-Flex and SuperFlex IOLs are available in aspheric designs. In contrast, aspheric IOLs have no associated spherical aberration, and the net outcome will be just a little bit of residual positive aberration in the pseudophakic eye. This may be good for preserving depth of field.

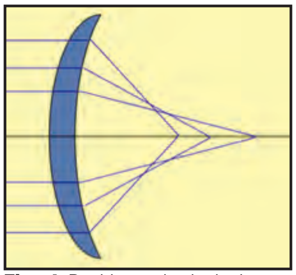

Fig. 4 Positive spherical aberration of the human eye.

CSO: Are there any other advantages to aspheric IOLs?

Dr. Yan: An aspheric lens is far less sensitive to image degradation from decentration than an IOL with significant positive or negative spherical aberration. In a perfect world, if you had an IOL that was always perfectly centered and perfectly emmetropic in the eye, having some spherical aberration in the IOL would

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probably not matter much. However, that's not the real world. Most studies have found the average IOL decentration to be about 0.3 mm to 0.4 mm, and the standard deviation is also quite high, generally in the 0.2 mm range. That means that a large proportion of our patients may end up with IOL decentration of 0.5 mm or more, and this may result in significant image quality degradation compounded by spherical aberration. In scenarios where there is a higher likelihood of decentration, such as pseudoexfoliation, high myopes, irregular capsulorrhexis shape or capsular tears, it may be more suitable to implant an aspheric IOL to minimize this issue. So, perhaps the question should more correctly be, "What should you be aiming for, an aspheric eye or an aspheric IOL?" If the cornea is not itself aspheric, then obviously you can't have both. I think that this is a good question that merits further investigation in order to be answered properly. As well, we have to debate the merits of correcting the entire population with the same degree of negative IOL aberration when the population average is not well established.

CSO: But hasn't this already been addressed in the literature?

Dr. Yan: Regarding the published data about aspheric eyes, my comment is, "Does your own cornea actually have 0.27 microns of spherical aberration (Zernike coefficient Z(4,0)?" I belive that 0.27 microns is a population average taken from a meta-analysis of a number of studies that came up with pretty widely divergent results. Clearly, there isn't one single numerical value that applies for everyone; this single value for the entire population also does not take into account potential factors such as age, axial length, and race. We don't know if these factors play a role, though intuitively one is inclined to believe so. For example, corneal thickness is correlated to the risk for developing glaucoma, and race is a also factor, with African Americans tending to have thinner corneas and a higher risk for glaucoma. My own feeling is that spherical aberration is highly variable amongst different patients, so a single spherical aberration correction cannot be applied to the entire population.

CSO: What are your thoughts and observations about the Rayner hydrophilic acrylic IOLs?

Dr. Yan: Regarding the Rayner lens material, it's a rather unique co-polymer (Fig. 5). There is a hydrophobic methylmethacrylate (MMA) component that gives it its plasticity for controlled unfolding, while the hydrophilic 2-hydroxy ethyl methacrylate (HEMA) component gives it its elasticity for shape recovery and good bio-compatibility. Its optical design is also quite interesting. It is aspheric, biconvex and planar with no vaulting, which means that it can theoretically be implanted upside down simply because there is no right side up for this lens. In addition, it has a 360-degree square edge uninterrupted at the optic-haptic junction, and this is a key design element to prevent epithelial cell migration and capsular opacification (Fig. 6A, B).

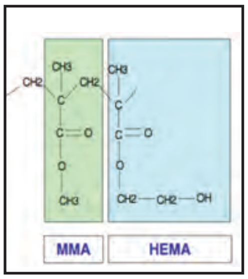

Fig. 5 Comparison of hydrophobic vs hydrophillic molecular structure.

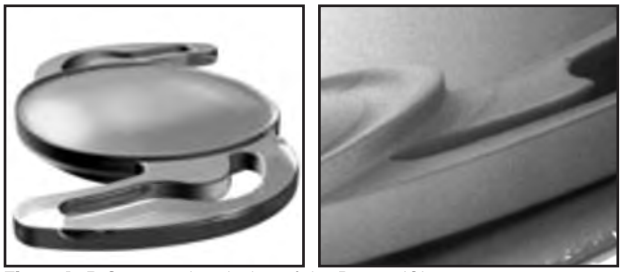

Fig. 6 A, B Square edge design of the Rayner IOL.

CSO: The haptics are certainly a little different in shape than what we are used to seeing in North America. What do you think of their design?

Dr. Yan: The haptic design is quite interesting as well, because it offers very broad fixation at the equator of the capsular bag. This is important for maintaining long-term fixation, as well as eliminating any tilting, rotating and/or squeezing of the IOL from side to side. Moreover, the haptics can compress quite easily from 10.5 mm to 9.5 mm, to better conform to the individual shape and size of the capsular bag, which, again, is important for achieving and maintaining good IOL centration (Fig. 7).

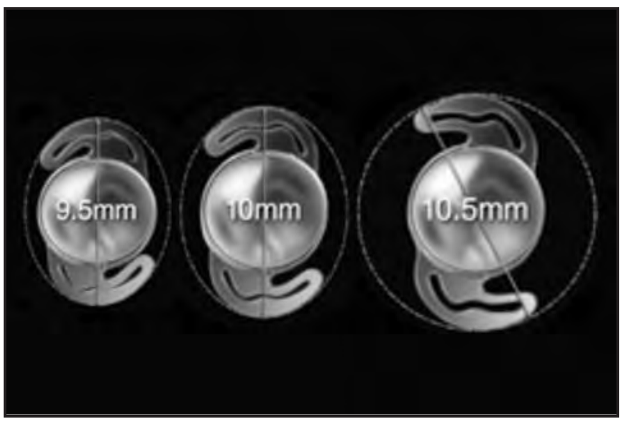

Fig. 7 Haptic compression of the Rayner IOL.

This cannot be said for all hydrophilic acrylic IOLs with the open loop haptic design; many of these act much like plate IOLs because their haptic loops cannot expand to conform to the capsular bag over a wide diameter range. And as we know, plate IOLs are known to decentrate more than other IOL designs with haptics that unfold.

CSO: Do you think this haptic design performs well in the eye?

Dr. Yan: My own impression is that these lenses center very well, and this has been supported in the literature. The mean decentration of the Rayner lens is really quite good at 0.3 mm for high myopes, and 0.1 mm for normal eyes. This compares very favorably to the 0.3 mm and 0.4 mm that is described in the literature for normal eyes in most studies.

CSO: You talked earlier about controlled unfolding as one of the key characteristics in good IOL design. What do you think about the unfolding characteristics of the Rayner lens?

Dr. Yan: This lens delivers quite slowly into the eye and that's one of the particularly nice things about them. The delivery is also quite planar in trajectory, with very little anterior/posterior tilting as it leaves the cartridge. As well, I have not noticed any significant twisting of the IOL during the entire delivery into the eye. In fact, of all the lenses I have had experience with, I would rate the Rayner lens among the easiest to learn to implant. Ironically enough, the second Rayner C-Flex lens I ever implanted was on a pseudoexfoliation patient whose anterior capsule tore during the phacoemulsification. I was careful to refill the anterior chamber with viscoelastic before removing the phaco tip from the eye, as anterior chamber deflation can increase the risk of having the tear run through the equator and across the posterior capsule. After removing the cortex by I&A, I again refilled the eye with visco-elastic before turning off the irrigation. I think that is the best advice in dealing with anterior capsular tear. Don't worry about how many vials of viscoelastic you burn through; just make sure the eye never deflates in order to avoid making things worse. I remember I was more than a little nervous to inject a Rayner lens into the eye under these circumstances as it was the second one I had ever done! But the lens entered the capsular bag in a highly controlled manner and centered perfectly, although it looked like I had had more than a few espressos in my video of this case that I showed at the CSCRS. This case gave me a lot of confidence in the sheer ease of use of this lens. I do a lot of resident teaching, and I would have no problem using it if it were in teaching hospitals, as I think it goes into the eye with far less drama than some of the other IOLs I currently use.

CSO: What would you like to say to sum up this interview?

Dr. Yan: Given the quality of the patient results, I feel confident that the hydrophilic acrylic IOLs will become increasingly popular in North America, just as they already are in the rest of the world. And even though I was a naysayer for many years when it came to hydrophilic acrylics, I have come back to the fold (no pun intended) because, in terms of what these lenses have to offer our patients, they represent some significant advances worth considering.