MRI of the Capsular Bag in Pseudophakic Human Donor Eyes

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Purpose: To use MRI to investigate the effect of cataract surgery and IOL type on the capsular diameter in multiple imaging planes.

Introduction: MRI is not impeded by the iris or optical distortions and has the unique ability to visualize the entire crystalline or intraocular lens (IOL) and its relationship to the surrounding tissue, including the lens capsule, in any desired plane. The capsule is an accommodative structure affected by life-long lens growth (Fig 1). Its post-operative condition and its dimensions have implications for both standard and accommodating IOL design.

Complications of new IOL designs are often not discovered until years after their introduction. Many complications can be directly or indirectly linked to Soemmering's ring (SR), which forms within the capsular bag and is believed to develop to some extent after most cataract surgeries. SR may also play a role in glaucoma either by direct uveal displacement or iris pigmentary dispersion. A SR is a doughnut-shaped growth composed of retained/regenerated cortex material and lens epithelial cells that may form following any type of disruption of the anterior lens capsule. It is a precursor to posterior capsule opacification and, if abundant, can result in IOL tilt and displacement, iris contact with pigmentary dispersion, and possibly angle closure and glaucoma. Its abundance is inversely related to the age of patient at the time of surgery and the care taken in cortical clean-up. IOL design is also known to play a significant role.

Methods: Donor eyes (N=200, ages 50-99) were imaged 1.5T (General Electric) using a custom RF coil (MRI Research) and T1 weighting. The capsule is very thin, but can be visualized with MRI both in the aphakic donor eye and in the pseudophakic eye in the absence of SR. Additionally, its diameter can be reasonably assumed to be given by the lens equatorial diameter for the phakic eye. The diameters of the capsular bag were measured from the MRI images in multiple planes including those that were parallel and perpendicular to the haptic axis (Fig 2,3,4). A subset of donor eyes underwent gross and histopathological evaluation in order to validate the MRI findings as well as to further characterize the capsule.

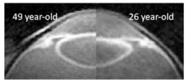

Figure 1a: In vivo composite, life-long lens growth increases lens capsule of a 49 year-old male and a 26 year-old female.

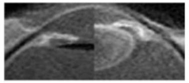

Figure 1b: In vivo composite before and after cataract surgery of an 85 year-old with AcrySof single-piece. The lens capsule shrinks around IOL.

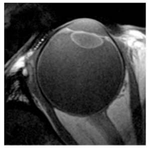

Figure 1c: An in vivo MR Image of a 45 year-old male in the accommodative state.

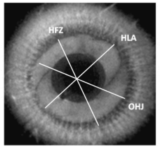

Figure 2: Coronal image of a donor eye showing the orientation of the images: Haptic Long Axis (HLA), Optic Haptic Junction (OHJ) and Haptic Free Zone (HFZ).

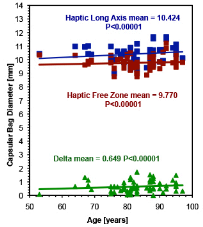

Figure 5: Graph of capsular bag diameter versus age. Note the asymmetry between the HLA and HFZ.

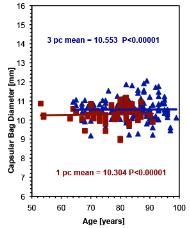

Figure 6: Graph of the Capsular Diameter versus Age for single piece and 3 piece IOL along HLA.

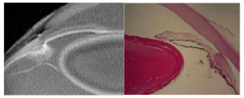

Figure 7: Composite image of a 90 year-old male with Glaucoma showing the relationship between anterior chamber structures using MRI and histopathology.

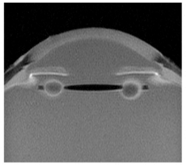

Figure 3a: Single piece IOL oriented along HLA. Soemmering's ring forms between haptic and optic.

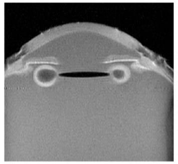

Figure 3b: Single piece IOL oriented along HFZ.

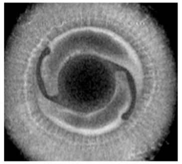

Figure 3c: Coronal image of single piece IOL.

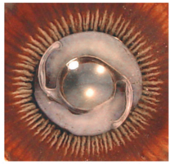

Figure 3d: Gross anatomy using Miyake-Apple technique.

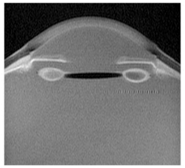

Figure 4a: 3 piece IOL oriented along HLA.

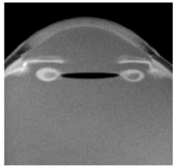

Figure 4b: 3 piece IOL oriented along HFZ.

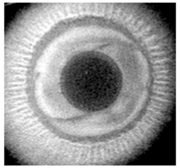

Figure 4c: 3 piece IOL in the coronal orientation.

Figure 4d: Gross anatomy using Miyake-Apple technique.

Results: MRI revealed that the capsule is asymmetric after cataract surgery, with the most pronounced difference occurring between the plane of the haptic long axis and the haptic free plane (mean difference = 0.649 mm, P < 0.0001 Fig 5). Differences in capsular dimensions (HLA) were also observed for different lens types; with those of silicone 3-piece lenses (N=143) exceeding those of single-piece hydrophobic acrylic (N=57), (mean difference = 0.248 mm, P < 0.0006 Fig 6). Gross and histopathological analysis revealed the capsulorhexis shape, amount of optic covered by the capsulorhexis, the presence of anterior or posterior capsular opacification, and verified that the IOL was within the capsular bag (Fig 3d, 4d, 7).

Conclusion: MRI allows imaging in any desired plane providing complete characterization of the IOL and capsular dimensions and their geometric relationship to the intraocular structures. This study of adult pseudophakic donor eyes reveals differences in capsular dimensions with IOL type that are similar to those observed in a smaller gross analysis study of postmortem pediatric eyes undergoing experimental implantation. Additionally, combining MRI data with gross and histopathological data allows a more detailed view of the effects of cataract surgery on the capsule and the possibility of more completely characterizing the effects of recently introduced laser-created capsulorhexis. It also validates the MRI technique allowing it to be extended in vivo to cataract patients. Our MRI findings have implications for IOL design, selection, and surgical technique.

References:

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