FEA of Prosthetic Lens Insertion During Cataract Surgery

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Abstract: Cataract surgery is the most common surgery in America today. Modern surgeries require the opacified crystalline lens to be removed and for a prosthetic lens to be inserted through a suture-less incision during a 5-10 minute outpatient procedure. The industry is driving for smaller incisions by redesigning the lens and insertion device geometry in addition to new materials. Typical lens dimensions are 6mm diameter with a center thickness of 1mm which is inserted through a 2.8mm incision. For the insertion the lens is folded and elongates while advancing down a tapering tube. Abaqus Explicit was chosen for this analysis because of its capability to solve large deformations and difficult self contact. During the insertion the lens can experience strains in excess of 60%. The purpose of this model is to increase our understanding of the mechanical response of existing products to aide in the design of our future products.

Keywords: Biomechanics, Biomedical, Contact, Self Contact, Abaqus/Explicit, Hyperelasticity, Implantable Medical Device, Large Deformation, Optics, Visualization, quasi-static.

1. Introduction

Cataracts develop as part of the natural aging process. The crystalline lens which is located behind the iris and is responsible for the focusing of light becomes hardened and opaque. If left untreated blindness would inevitably result. Insertion of a prosthetic lens following cataract removal began with a rigid PMMA intraocular lens (IOL) which required an incision roughly half way around the cornea. The medical community has made significant strides in the improvement of this procedure by improving outcomes, reducing recovery time and simplifying surgical techniques.

Current surgeries employ a highly deformable silicone or acrylic lens utilizing an inserter instead of forceps. The lens is loaded into the inserter and pushed with a plunger down a tapering tube. Internal areas of the inserter are filled with viscoelastic (viscous aqueous substance) to lubricate the surface and to prevent the introduction of air bubbles into the eye. The end of the tube is placed through an incision in the eye and the lens is allowed to bloom inside of the eye behind the iris. The driving factors in reducing the incision size to 3mm and below removes the need for sutures to seal the wound and reduces surgically induced astigmatism. Now the driving factor is to further improve visual outcomes. The size of the incision is directly related to optical aberrations that will remain after healing. Incisions less than 1mm have been proposed which is currently the limit of the additional surgical instruments used in the procedure.