

ADVANCES IN INTRAOCULAR LENSES

**Protocol for essay submitted in partial
fulfillment of Master Degree in Ophthalmology**

BY

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Supervised by

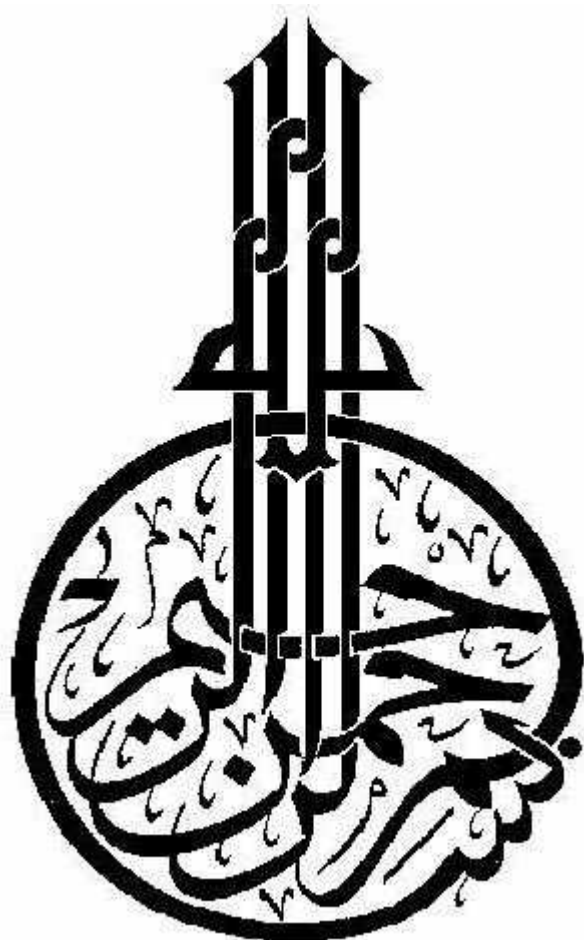
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I thank God for all blisses I have got

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List of abbreviations

AC	Anterior Chamber
ACO	Anterior Capsule Opacification
AMD	Age Related Macular Degeneration
AMO	Allergan Medical Optic
BCVA	Best Corrected Visual Acuity
BSS	Balanced Salt Solution
CB	Ciliary Body
CCC	Continuous Curvilinear Capsulorhexis
CCS	Color Contrast Sensitivity
CP	Ciliary Processes
CRI	Corneal Relaxing Incision
D	Dioptre
DLDD	Digital Light Delivery Device
ECCE	Ectracapsular Cataract Extraction
FDA	Food And Drug Administration
I/A	Irrigation Aspiration
ICCE	Intracapsular Cataract Extraction
IOL	Intraocular Lens
IR	Iris
LACS	Laser Assisted Cataract Surgery
LAL	Light Adjustable Lens
LRI	Lateral Relaxing Incision
OR	Operation Room
PCO	Posterior Capsule Opacification
PMMA	Polymethylmethacrylate
RI	Refractive Index
UCVA	Uncorrected Visual Acuity
UV	Ultraviolet
VF	Vitreous Face
ZA	Anterior Zonule
ZP	Posterior Zonule

INTRODUCTION

Dr. Kelman's work, which forever changed cataract surgery, was not widely adopted until the early 1980s, when a foldable IOL was introduced. In other words, the success of phacoemulsification was closely allied with implant technology. With the advent and increasing popularity of small-incision cataract surgery, surgeons now have numerous choices of soft foldable implants and insertion methods. These implants and insertion tools can be described as lens systems, and they all have advantages and disadvantages (**Horn, 1994**).

With the explosion of new technologies and techniques, microincisions and high-tech IOLs provide the simplest and most reproducible route to full visual correction with cataract surgery. This approach also holds promise for the correction of presbyopia. Because today's cataract procedures use small (< 2-mm) incisions, they are safer, more consistent, and more predictable than ever. Due to the development of laser phaco, phakonit, and other advanced technologies, the size of cataract incisions is rapidly approaching 1 mm or smaller. These microincisions are positioned on the clear cornea, which precludes the need for conjunctival dissection, cautery, sutures, injection of anesthetics, bandaging, and the postoperative restriction of patients' activities. In addition, microincisional cataract surgery has eliminated the complications of wound leak, uveal prolapse, and surgically induced astigmatism. These advances have paved the way for faster, more efficient surgery with less instrumentation, less intervention, and better uncorrected visual recovery for the patient. In turn, the superior visual results patients have achieved through IOL correction of their preexisting myopia, hyperopia, and astigmatism (with or without arcuate keratotomy incisions) have translated into fewer complications and less worry for the surgeon (**KERSHNER, 1994**).

Globally, contemporary cataract surgery has experienced a dramatic change in wound structure and size, as well as in intraocular lens (IOL) materials and folding techniques. However, the goals of cataract surgery have remained the same: to achieve smaller incisions and to employ safer techniques and shorter learning curves for surgeons. With the popularization of clear cornea phacoemulsification and foldable IOLs, cataract surgery and IOL implantation are now accomplished through 2.5 mm to 3.5 mm incisions. With the introduction of phaco laser systems, surgeons now have the ability to perform phacoemulsification through a sub-3.5 mm incision (**Kanellopoulos, 2000**).

Cataract/IOL technology has reinvented itself many times. The first was the progression from the scleral tunnel to the clear corneal incision. Second, the folding technology now employed by the majority of implants has delivered a huge benefit to patients in the form of shortened postoperative recovery. The concept of cataract surgery's eliminating astigmatism as a postoperative goal gave birth to the "refractive" cataract surgeon. IOL injection systems, from folding forceps to injectors, have produced an entirely new field of discovery, experimentation, and triumph. Finally, phacoemulsification instrumentation in development may, shrink the size of a main surgical incision to less than 2 mm for the majority of operations (IOLs and injectors for this size incision are already available) (**Doane, 2000**).

Correcting preexisting astigmatism with cataract surgery using toric IOLs decreases surgical invasiveness, and preserve corneal integrity, which may be needed if further astigmatic techniques are required to enhance the postoperative result (**Gills et al, 2000C**).

Presbyopic correction with cataract surgery or refractive lens exchange is becoming more feasible with advances in IOL design (**Weikert, □□□□**).

In the quest to provide pseudophakic accommodation, one idea has always been to refill the capsular bag with a compressible, clear material. The goal would be to utilize the eye's natural accommodative mechanism according to the Helmholtz theory. Of course, there are many obvious obstacles to overcome (**Chang, □□□□**).

Offering a blue light filtering intraocular lens (IOL) to patients undergoing cataract surgery is a significant advance in the quality of patient care. (**Braunstein et al, □□□□**).

With the Light Adjustable Lens (LAL), surgeons will be able to achieve much more accurate outcomes, because they will be able to modify the IOL's power postoperatively (**SCHWARTZ, □□□□**).

Computer-generated calculations help to create customized lens implants. A new software platform, called Okulix (Ingenieurbüro der Leu, Hillerse, Germany), enables the clinician to integrate corneal topography into IOL calculations and evaluate the retinal image quality based on the individual's IOL parameters. These capabilities set the stage for producing truly customized IOLs (**Preussner, □□□□**).

The development of new lens designs, wavefront analysis, and even better surgical instruments and techniques has brought the science of vision correction and neutralization of refractive error during the cataract procedure to a new level (**Kershner et al, □□□□**).

THE CRYSTALLINE LENS

The lens is a transparent, biconvex structure situated behind the iris, and the pupil and in front of the vitreous body (fig. □□□)

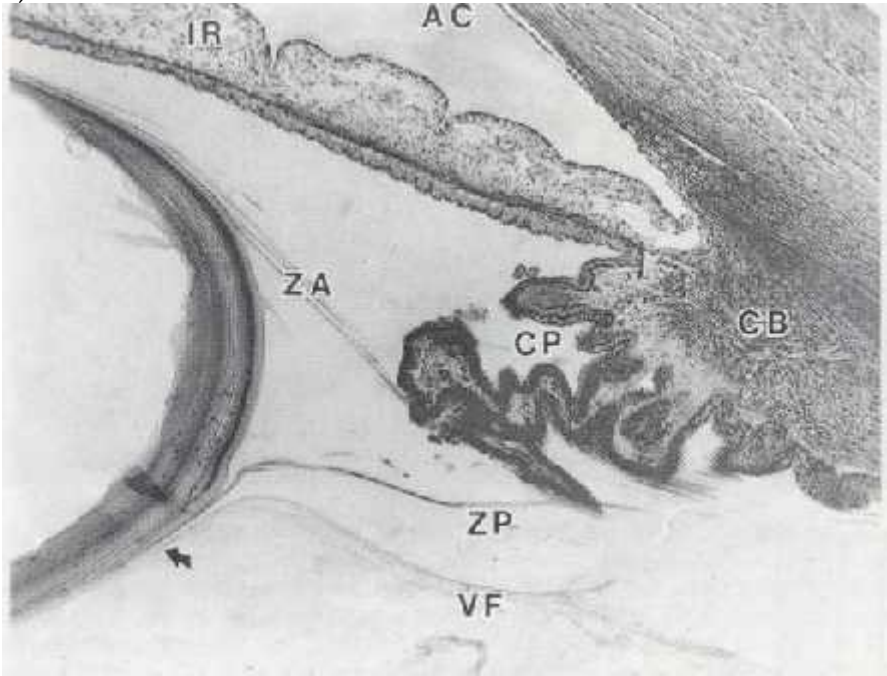


Fig. □□□ The lens in position, AC= anterior chamber, IR= iris, CB= ciliary body, CP= ciliary processes, ZA= anterior zonule, ZP= posterior zonule, VF= vitreous face (**Bron et al, □□□**).

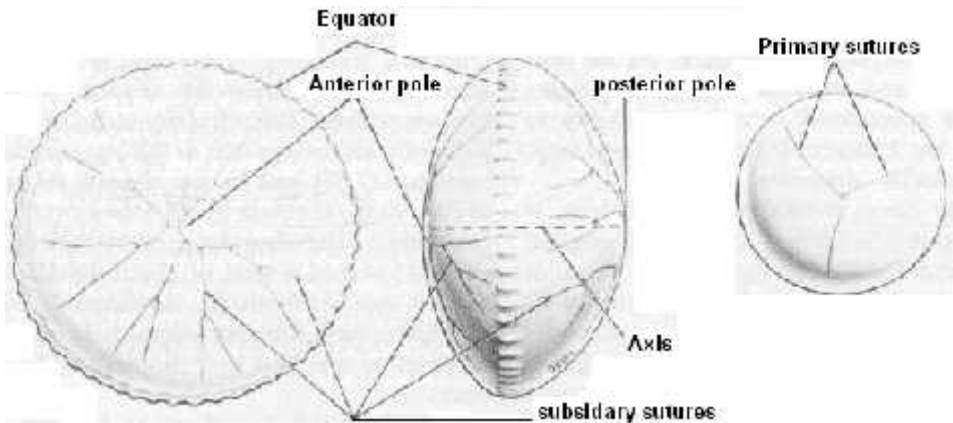


Fig. □□□ The Lens. Lt adult. Rt fetal. (**Bron et al, □□□**).

The convexity of its anterior surface is less than that of its posterior surface. The central points on its anterior and posterior surfaces are referred to as the anterior and posterior poles, a line joining the poles forms the axis of the lens; the marginal circumference of the lens is called the equator. In the adults the lens measures approximately 10 mm in diameter and 4 mm thick (Fig. 10.1). The equator of the lens is encircled by the ciliary processes of the ciliary body and lies 1 mm from them. The lens, which has considerable flexibility, is kept in position by the suspensory ligaments (**Snell et al, 1994**).

The lens continues to grow throughout life. At birth, it measures about 16 mm equatorially and 10 mm antero-posteriorly and weighs approximately 100 mg. The adult lens measures 24 mm equatorial and 25 mm anteroposteriorly and weighs approximately 200 mg. (Fig. 10.2) (**Albert et al, 1994**)

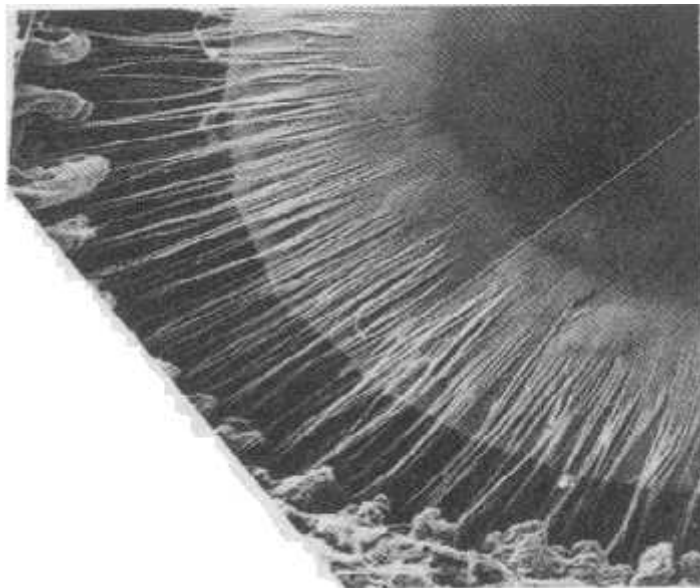
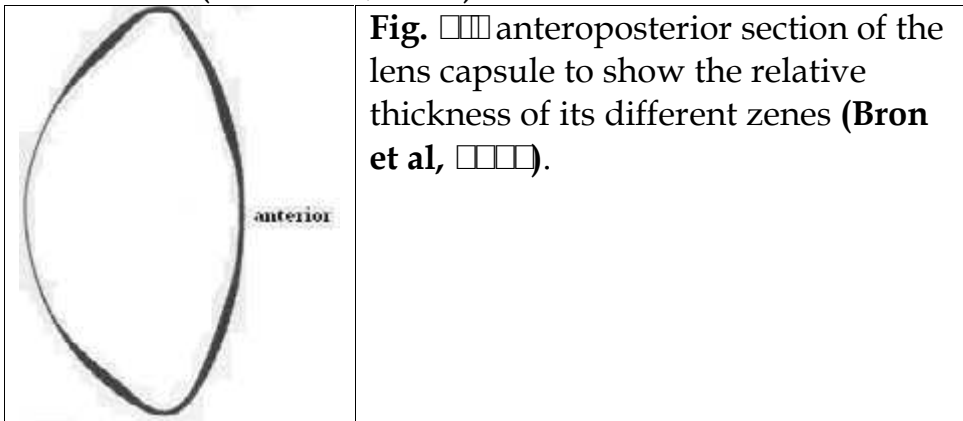


Fig. 10.1 Microphotograph of The crystalline lens suspended to ciliary processes by zonules (**Bron et al, 1994**).

The dioptric power of the entire eye is about 20 diopters, with the cornea responsible for most of this refractive ability. The lens contributes only about 10 diopters of the total

power. The importance of the lens is that it can change its range of dioptric power by changing its shape, allowing distant and near objects to be focused on the retina. The range of dioptric power is reduced with age. The lens has a refractive index of about 1.38 in the periphery and 1.40 in the inner zone. (Snell et al, 2004)



The increases in thickness with age and at the same time; it adopts an increasingly curved shape, so that older lenses have more refractive power. However, the index of refraction decreases with age, probably as a result of the increasing presence of insoluble protein particles. Thus, the aging eye may become either more hyperopic or myopic with age, depending on the balance of these opposing changes. (Albert et al, 2004)

The lens is made up of three parts:

. *An elastic capsule:* (Fig. 1.11)

It is an elastic, transparent basement membrane that envelops the entire lens, it is composed of type IV collagen (Albert et al, 2004). This collagen is laid down by the epithelial cells which are in direct contact with the capsule anteriorly and by the superficial lens fibers posteriorly. (Snell et al, 2004). It serves as the point of attachment for the zonular fibers. The lens capsule is thickest in the anterior and posterior pre-equatorial zones, about 10µm and thinnest in the region of the central posterior pole, where it may be as thin as 2µm.

The anterior lens capsule is considerably thicker than the posterior capsule at birth, the former increases in thickness throughout life. (Albert et al, □□□)

The chief function of the capsule is to mould the shape of the lens in response to the pull of the zonular fibers during accommodation and also serves as a diffusion barrier (Snell et al, □□□)

. *A lens epithelium:*

It is confined to the anterior surface of the lens. It is a single layer of cuboidal epithelial cells, which are metabolically active and are able to carry out all normal cell activities. The epithelial cells are mitotic, and the highest activity occurs in a ring around the anterior lens known as the germinative zone. These newly formed cells migrate toward the equator, where they differentiate into fibers (Fig. □□□). (Snell et al, □□□)

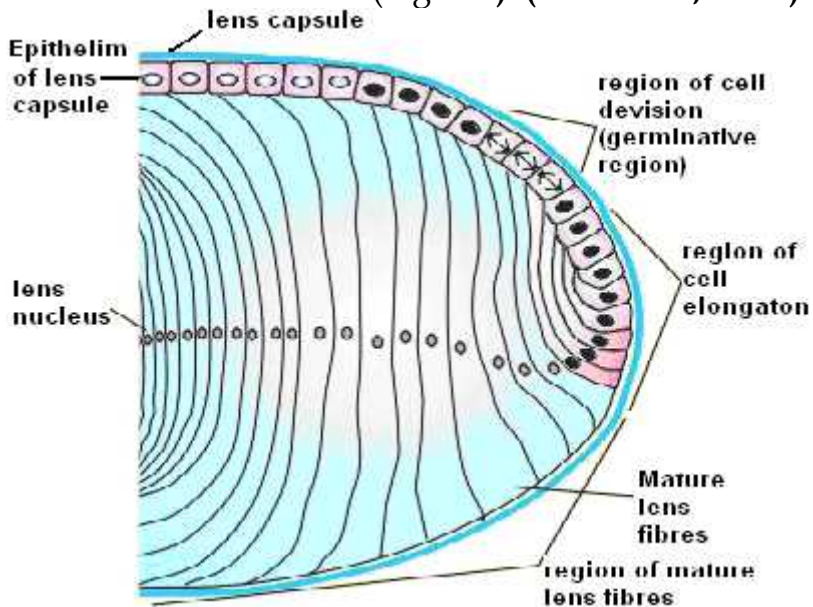


Fig. □□□ Structure of the human lens (Pandey et al, □□□)

. *The lens fibers:*

Constitute the main mass of the lens. The lens cell elongates and turns meridionally forming a U shape. As the apical part of the cell elongates, it slips beneath the internal surface of

adjacent lens cells. This anterior movement of the nuclei as the fiber passes deeper produces the nuclear pattern known as the lens bow. The nucleus later fragments and disappears. Each elongated lens cell is now called a lens fiber. No cells are lost from the lens; new fibers are laid down, crowding and compacting previously formed fibers, with the oldest layers being the most central known as the embryonic and fetal lens nucleus. The outermost fibers are most recently formed fibers and make up the cortex of the lens. (Snell et al, 2004)

The lens fibers produce lens proteins, known as crystallins which constitute up to 90 percent of the lens fiber mass. The high refractive index of the lens is due to the crystallins. The differing concentration of the crystallins in different part of the lens, produce regional differences in the refractive index. This probably compensates for the spherical and chromatic aberration that might exist if the concentration of the crystallins were uniform throughout the lens. (Snell et al, 2004)

Spherical Aberration in Human Eye

In the young human eye, the average positive spherical aberration introduced by the cornea is partially offset by the negative spherical aberration induced by the crystalline lens. As the lens ages and structurally changes, this compensating internal negative spherical aberration is gradually lost, an effect that degrades optical and visual quality and contrast sensitivity (Wang et al, 2004) and people begin to see halos around lights. Someone with 20/20 vision may be unable to drive at night because of this halo effect. (Holladay, 2004)

Light Filtration by Crystalline Lens

Throughout life, the crystalline lens protects the retina from hazardous UV light. (Wang et al, 2004) In childhood, the human crystalline lens filters a great deal of light in the blue wavelength spectrum. As we age, our crystalline lens