Digital Image Capture and Quantitative Analysis of Posterior Capsular Opacification

Essay
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LIST OF ABBREVIATIONS

AQUA : Automated Quantification of After-cataract.

AMD : Age-related Macular Degeneration.

BCVA : Best Corrected Visual Acuity.

BU : Brightness Unit.

DRCP : Digital Coaxial Retroillumination Photography.

EAS : Anterior Eye Segment Analysis System.

EPCO : Evaluation Of Posterior Capsule Opacification.

FGF : Fibroblast Growth Factor.

HGF : Hepatocyte Growth Factor.

IOL : Intraocular Lens.

LECs : Lens Epithelial Cells.

OCT : Optical Coherence Tomography.

OU : Opacity Unit.

PAS : Periodic Acid Schiff.

PCO : Posterior Capsular Opacification.

PCT : Posterior Capsular Thickness.

PMMA : Polymethylmethacrylate.

POCO : Posterior Capsule Opacification software.

POCOman: manual POCO.

PXF :Pseudoexfoliation Syndrome.

RK : Refractive Keratotomy

ROI : Region of Interest.

RP : Retinitis Pigmentosa.

SD : Standard Deviation.

TGF : Transforming Growth Factor.

VA : Visual Acuity.

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Anatomy of the lens capsule and epithelium

The lens capsule:

The lens capsule is the ensheathing elastic basement membrane that helps to maintain epithelial cells and lens fibers as one unit. The capsule is produced anteriorly by the basal membrane of the epithelial cells while posteriorly it is produced by the basal membrane of elongating fiber cells ***(Forrestre et al, 1996)***.

It begins as a thin structure increasing in thickness until approximately the age of 35 years ***(Olson, 1985).***

The capsule of the lens forms a transparent, homogenous, highly elastic envelope. Normally the capsule is thickest (12-21 microns) anteriorly over the lens epithelial cells. It averages 9 to 17 microns in the equatorial zone, and is thinnest (2 to 9 microns) posteriorly ***(Spencer***, ***1985).***

The capsule of the lens is made up of two layers; the capsule proper, which represents the main portion of the membrane, and the more superficially located, very delicate and attenuated Zonular lamella (***Duke-Elder, 1963).***

In histologic sections, the capsule is non-cellular and homogenous. It stains positively with periodic acid-schiff (PAS) indicating the presence of sulphated mucopolysaccharide component. It is dissolved in collagenase indicating a collagen component ***(Rafferty, 1985).***

Under electron microscope, the capsule appears to have a relatively amorphous appearance in which the lamellar structure is suggested by coarse scattered filamentous elements. There are up to 40 lamellae, each of which is about 40nm in thickness. The lamellae are formed of fine fibrils as seen under higher resolution ***(Fisher and Hayes, 1979).***

The capsule is basically formed of type IV collagen but also contain type I and III collagens in addition to other extracellular matrix components as laminine, fibronectin, heparin sulphate proteoglycan entactin and vitronectin ***(Dische and Zelmenis, 1965; Lisa, 1999***).

Epithelial cells:

The lens epithelium arises as a single layer of cells beneath the anterior capsule and extending to the equator of the lens. There is no corresponding posterior layer since the posterior embryonic epithelium is involved in the formation of the primary lens fibers ***(Anthony et al, 1997).***

The basal surface of the epithelial cells adheres to the capsule. The rest of the cell membrane is relatively complex. The lateral margin shows undulations whereas the apical membrane shows interdigitations with the underlying lens fibers. The cells are attached to each others by desmosomes and to the underlying capsule by hemidesmosomes ***(Bron et al, 1997).***

The cells are polygonal (in surface view) cuboidal (in sagittal section), being approximately 10 microns high and 15 microns wide ***(Anthony et al, 1997).***

By electron microscope the epithelial cells show few organelles as rough endoplasmic reticulum, Golgi apparatus, free ribosomes and small mitochondria lying in coarse granular cytoplasm ***(Yeh et al, 1986; Rafferty and Scholz, 1989).***

The central cells are located near the anterior pole. They are polygonal with rounded nuclei that show no mitotic figures except when stimulated mechanically ***(Bron et el, 1997).***

Pathogenesis of posterior capsule opacification

Capular opacification is a misnomer as it is not really an opacification of the lens capsule but an opaque material that lines the capsule rendering it non transparent ***(Pandy et al,2004).***

Posterior capsule opacification is due to presence of remnants or regenerated lens epithelial cells following cataract surgery that migrate centrally to opacify and reduce visual acuity. Three sources produce visual opacification; (1) cuboidal anterior epithelial cells, (2) remnant epithelial cells from the equatorial lens bow and (3) dislodged cortical fibres.

Anterior epithelial cells that form the equatorial lens bow become germinal centers that have an inclination to grow along the posterior capsule after surgery ***(Legler et al, 1993).***

Cuboidal cells making up the anterior epithelium lining the anterior capsule can transform into fibrocyte-like cells. These cells can proliferate but do not migrate. The germinal epithelial cells of the equatorial lens bow show mitotic activity. When disturbed during surgery, they migrate to form epithelial pearls on the posterior capsule ***(Apple et al, 1992 and Marc Antionio et al, 1999).***

Types of PCO:

When proliferation and posterior migration of epithelial cells occur, the resulting opacity takes one of two morphological forms or a combination

of both: epithelial pearls (cellular element) and fibrous membranes secondary to metaplasia of the epithelial cells (fibrous element)(***Jaffe et al,1997).***The individual subcapsular epithelial cells enlarge and swell to such a degree that they have the appearance of soap bubbles and are referred to as 'Elschnig's pearls'.It has been suggested that these pearls represent the aberrant attempts of the lens epithelial cells (LECs) to differentiate into lens fibres ***(McDonnel et al,1984 and Kappelhof et al,1986).***The fibrous type represents hyperplastic lens epithelium that had apparently undergone fibrous metaplasia. These aggregates of hyperplastic cells always originate at the site of apposition of an anterior capsular flap to the posterior capsule and extend to a variable degree centrally towards the papillary axis. The presence of folds suggests that these cells have contractile power (***McDonnel et al,1984).***

Although the proliferative activity of the epithelium is more intense in younger persons, it is by no means limited to the epilhelia of younger people ***(McDonnell et al, 1984).***

Factors modulating PCO:

Certain chemical substances play a role in the pathogenesis of capsule opacification namely:

- Cytokines: cytokines are peptides secreted from cells after cell injury ***(Duncan et al, 1997).***
- Transforming growth factor-beta [TGF-b]: TGF-b promotes cellular adhesions ***(Hynes, 1987).***
- Fibroblast growth factor [FGF]: FGF was found to increase epithelial mitosis and collagen production ***(Nishi et al, 1996).***

- Hepatocyte growth factor [HGF]: secreted by mesenchymal cells and acts upon epithelial cells influencing their migration and survival ***(Grieson et al,2000).***

Less common factor in the pathogenesis of capsular opacification is the break down of blood ocular barrier with release of inflammatory mediators and cells into the aqueous humour ***(Saxby, 1999).***

Pigmentations arising from the posterior surface of the iris and ciliary body may also play a role in posterior capsular opacification. Iris melanocytes are sometimes found on the posterior capsule ***(Saxby et al, 1998).***