

# LIGHT AND SCANNING ELECTRON MICROSCOPIC STUDY OF NUCLEAR, CORTICAL AND SUB-CAPSULAR CATARACT LENSES

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## CONTENTS

Introduction	---	1
Patients & methodology	---	2
Result	---	2
Discussion& conclusion	---	5
References	---	6

**Abstract:** Cataract associated with aging (senile or age-related cataract) most often occurs in both eyes, with each cataract progressing at a different rate. Generally normal aging and cataractous changes in the lens are related to its metabolic activity. Human nuclear, cortical and subcapsular cataract lenses were obtained from patients admitted for cataract extraction in the ophthalmology department of District hospital, Kottayam.

Light microscopic study shows nuclear opacification and lysis, cortical degeneration and thickening, fibre fragmentation with partial dissolutions of the lenticular tissue, subcapsular degeneration, cell separations, dissolution and lens tissues with anteroposterior thickening in the cataractous lens when compared with normal lens. In Scanning electron microscopic study cataractous lenses shows lamellated band of lens fibres of different density, disarranged and degenerated lens fibres with vesicles or globules, cortical rupture, large opacities or lesions, uneven cloudiness in the subcapsular region, necrosis, the swelling of the broken ends (asterisks), the porosity and granulation of the lens fibres and vacuoles or vesicles fused together in the form of spherical bodies or balloon like appearance when compared with the normal lens.

**Keywords:** Nuclear cataractous lens, cortical cataractous lens, subcapsular cataractous lens Histomorphology, Light microscopy, Scanning electron microscopy.

## Introduction

Nuclear cataracts result from excessive nuclear sclerosis and yellowing with consequent formation of a central lenticular opacity. In some instances the nucleus can become very opaque and brown termed a brunescens nuclear cataract. Changes in the ionic composition of the lens cortex and the eventual change in hydration of the lens fibers produce a cortical cataract. Formation of granular and plaque-like opacities in the posterior subcapsular cortex often heralds the formation of posterior subcapsular cataracts. Cataract associated with aging (senile or age-related cataract) most often occurs in both eyes, with each cataract progressing at a different rate. Generally normal aging and cataractous changes in the lens are related to its metabolic activity. Cataract is a public health problem in many developing countries including India. Formation of granular and plaque-like opacities in the posterior subcapsular cortex often heralds the formation of posterior subcapsular cataracts. Posterior Subcapsular (PSC) cataracts is located just beneath the posterior capsule and takes place due to abnormal differentiation and migration of lens epithelial cells (LEC). This type of cataract, which develops between the back of the lens and the lens capsule, is the softest and most rapidly growing type. PSC cataracts tend to scatter light at night and thus interfere with night time driving. People with diabetes, high farsightedness or retinitis pigmentosa or those taking high doses of steroids may develop a sub capsular cataract.

According to Kalariyaet al., (1998) in the lens fibers three main age-related fine structural alterations were found membrane ruptures, water vacuoles and multilamellar bodies. The frequency of these alterations increased with age and they remained restricted to the superficial equatorial cortex. They were absent in the anterior and posterior cortex, supra nuclear equatorial cortex

and nucleus. The membrane ruptures and water vacuoles are in morphological support of the view, based on biochemical evidence, that oxidative stress leads to destabilization and disintegration of membranes and consequently disturbs the water balance of fibers. It is

## 2

postulated that the lamellar bodies are involved in the repair of ruptured membranes and breakdown of affected proteins thus explaining the late onset of senile cataractous changes.

### Methodology

Human nuclear, cortical and subcapsular cataract lenses were obtained from patients admitted for cataract extraction in the ophthalmology department of District hospital, Kottayam. Their clinical findings were recorded. The samples collected in small vials immediately after extra capsular extraction and fixed and embedded for light and scanning electron microscopy.

The samples for scanning electron microscopic study were fixed in 2.5% gluteraldehyde and light microscopic samples fixed in bouin's fluid. The fixed specimens were passed through tissue processing, according to the procedure (Culling,1985). Fixed SEM specimens processed through the following procedures for scanning electron microscopic studies (Glauert, 1974).

### Result

#### 1) Nuclear cataract

Nuclear cataract lens sections show lens tissues with anteroposterior thickening, nuclear opacification, cortical degenerations and lysis (Fig.C1). There is dissolution of the cortical cells (Fig.C3) and fragmentation and separation of the cortical region (Fig.C2). Due to the nuclear swelling the cortical rupture and separation of fibres occurred. Nuclear area is well degenerated in Fig.C4. Swollen disintegrated fibres in the equatorial region can be noticed in Fig.C5 (Plate- 1).

#### 2) Cortical cataract

Cortical cataract lens sections show lens with cortical fragmentations, lysis and marked destruction (Fig.D1). Considerable disruption in the cortical region is clearly visible in cortical cataract lens. The nuclear lens fibres is moderately lysed and thin

## 3

(Fig.D2). Marked destruction, dissolution and lysis of cortical fibrosis seen in the equatorial region in Fig.D3. Degeneration and separation of cortical fibres is also visible in the equatorial region in Fig.D4 (Plate- 2).

#### 3) Subcapsular cataract

Subcapsular cataract lens sections show lens tissue with cortical degeneration, subcapsular degeneration, cell separations and dissolution. The nucleus is lysed partially (Fig.E1). Partially lysed nuclear region and subcapsular degeneration is seen in Fig. E2 & E3. Fragmentation and separation of the subcapsular region due to degeneration can be clearly seen in Fig. E4. Degeneration of cortical fibres is seen in the cataractous lens (Fig.E5) and cortical dissolution is visible in some regions in Fig. E6 (Plate- 3).

#### 4) Normal lens

Normal lens section shows normal configuration. In the normal lens nuclear area appears as a compact mass (Fig.H1). A fibre to fibre arrangement and little inter-fibril space are peculiar to the normal cell morphology that is visible in Fig.H2. Fibril arrangement of the cortical region is visible in the figures (Plate- 4).

### 2. Scanning Electron microscopy

#### 1) Nuclear cataract

Lamellated bands of lens fibers of different density with fine spaces and broken cortical region can be seen through A-P cut surface due to the swelling of the nuclear region (Fig.3a-1). Degenerated and disarranged nuclear region in the Fig. 3a-2. In the degenerated and disarranged nuclear region, edge and groove pattern is visible in high magnification (Fig.3a-3) . Separated and broken layers of cortical lens fibres shows hexagonal shapes with finger like processes and flap like processes (Fig.3a-4) and degenerated subcapsular outer side of the cataractous lens is also seen (Fig.3a-5) (Plate- 1a).

Broken nuclear cataractous whole lens can be observed in Fig.3b-1. Arranged cortical fibres in the upper part and broken and separated lens fibers in the cut end (Fig.3b-2) with large

## 4

vesicles or spherical masses of different shape and size are present on the surface of the lens fibres (Fig.3b-3).(Plate- 1b).

#### 2) Cortical cataract

Lamellated and broken cortical region with fine spaces and less lamellated nuclear region (Fig.4a-1). Membrane ruptures can occur as a result of swelling, its occurrence and the presence of liquid containing vacuoles can be considered as age

related structural alteration of the lens fibres. Less degenerated nuclear region (Fig.4a-2). Ruptured cortical region shows broken and separated lens fibres in low (Fig.4a-3) and high (Fig.4a-4) magnification. Degenerated and disarranged superficial cortical region of the lens(Fig.4a-5). Disarranged and separated lens fibres with large and small vesicles scattered in the cortical region (Fig.4a-6).The spherical bodies escaped from the cytoplasm is penetrating the porous lens cell membrane at several places, this could in particular be observed at the intercellular space between the lens fibres (Plate- 2a).

### 3) Subcapsular cataract

In Plate-3a the antero-posteriorly cut surface of subcapsularcataractous lens (Fig.5a-1) fine lamellated lens fibres of different density with degenerated subcapsular region are seen. Degenerated and broken subcapsular region with granules is clearly visible in high magnification (Fig.5a-2) and even though degeneration started in nuclear lens fiber region tongue and groove pattern is visible (Fig.5a-3). Broken and well degenerated subcapsular region with plaque like opacity is clearly visible in high power (Fig.5a-4) and the degenerated layered lens fibres can observed through the side of the cut surface of the lens (Fig.5a-5).

Degenerated and broken subcapsular region is seen through the dorsal side of the whole lens (Fig.5b-1). Degenerated subcapsular region with small vesicles (Fig.5b-2) and broken capsular region and in the posterior broken region elongated ribbon like lens fibres are present with numerous small vesicles on the surface. Formation of granules and plaque like opacities in subcapsularcataractous lens cortex.Disruption of the lens fibres and a disturbance of the cytoplasm having changed into a mass of globular elements. Fig.5b-3 shows disarranged cortical region with few vacuoles scattered in the fibres. (Plate- 3b).

## 5

### 4) Normal lens

Normal lens viewed through the equatorial region of the whole lens (Fig.8a-1). Arranged cellular architecture in the nuclear region in low power (Fig.8a-2) and fiber arrangement in the nuclear region in high power can be seen in Fig.8a-3. Normal fibre to fiber arrangement in the cortical region can be clearly visible (Fig.8a-4). A fibre to fibre arrangement and little interfibre spaces are peculiar to the normal lens morphology. Normal sub capsular region can be viewed through the whole lens in Fig.8a-5 (Plate- 4a).

### Discussion and conclusion

Tarwadi&Agte (2009), the section of lenses of hypertensive etiology showed homogenous areas and fine lamellated areas dispersed with fine space. According to Dorairaj *et al.*, (2002) lens of diabetic etiology showed lamellated bands of fibres of different density, senile cataract lens of cream colour showed fine lamellations .A sequence of histological changes was identified from the equatorial region to the posterior pole, extracellular granular and fibrillar material were produced (Eshaghian& Streeten.,1980). Nucleus shrinkage (5 microns) was more evident in nuclear cataracts; in subcapsular cataracts most of the nuclei were large (average 9 microns diameter). Variation in morphological changes like vacuolization of cytoplasm and nuclei, pyknotic nuclei, and superimposed cells was more evident in the mixed type of cataracts (Vasavada *et al.*, 1991).

Cortical cataracts usually begin with either sharp limited clear fluid clefts, resulting in opaque spokes, or clear lamellar separations, resulting in cuneiform opacities. In cortical and subcapsular cataracts and lens perforations the main cause of grey opalescence appears to be the result of lens proteins (water-soluble crystalline) coming into direct contact with free fluids (water). In cortical cataracts this happens in the area of sharp limited mechanical cortical ruptures (fluid clefts), and in subcapsular cataracts during passive, external fluid entry, resulting in subcapsular fluid vacuoles.

## 6

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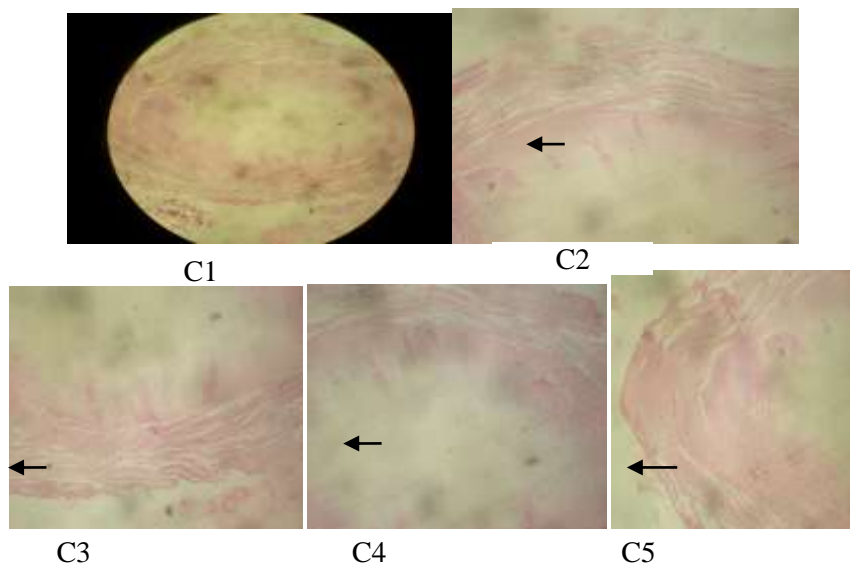
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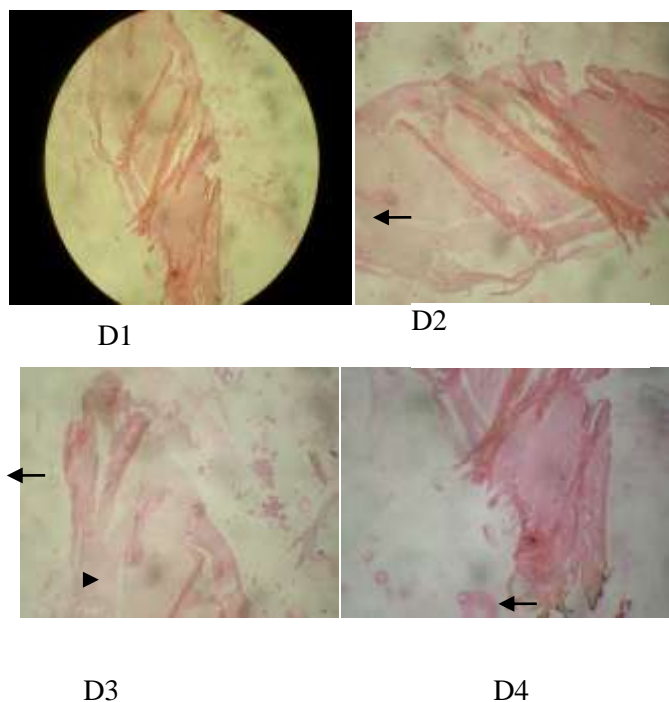
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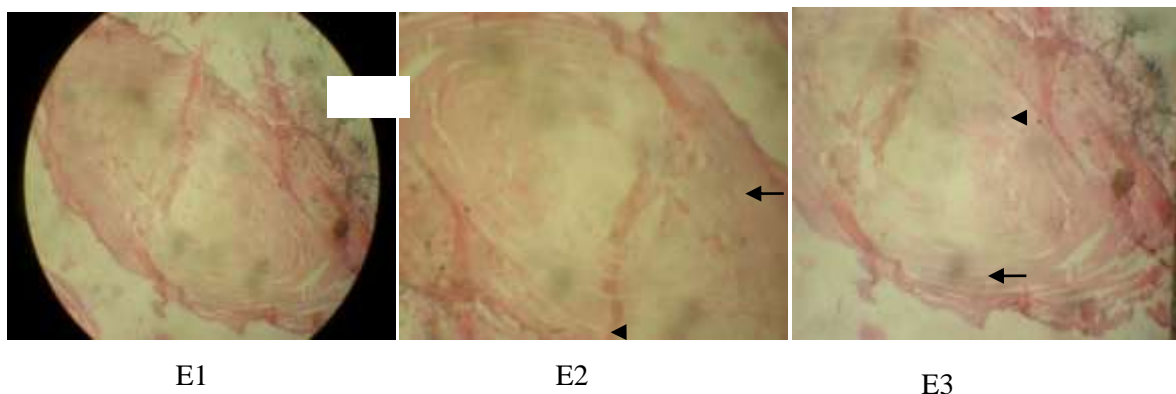
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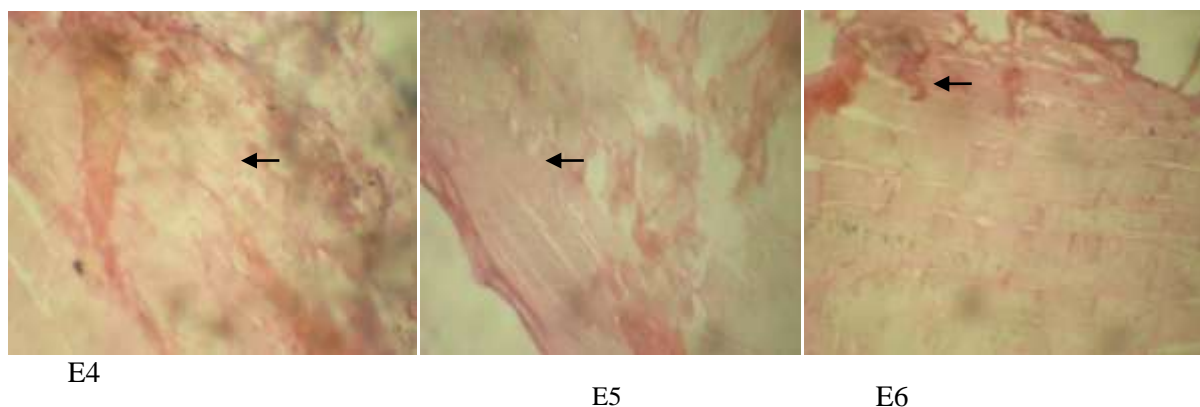
**Plate - 1. Human nuclear cataractous lens section:-**Fig.C1- Nuclear cataract lens section whole view  $\times 400$ . Fig. C2 - Cortical fragmentation and separation (arrow). Fig.C3 - Cortical dissolution (arrow). Fig.C4 - Well degenerated nucleus (arrow). Fig.C5 - Swollen disintegrated fibres in the equatorial region (arrow)  $\times 1000$ .



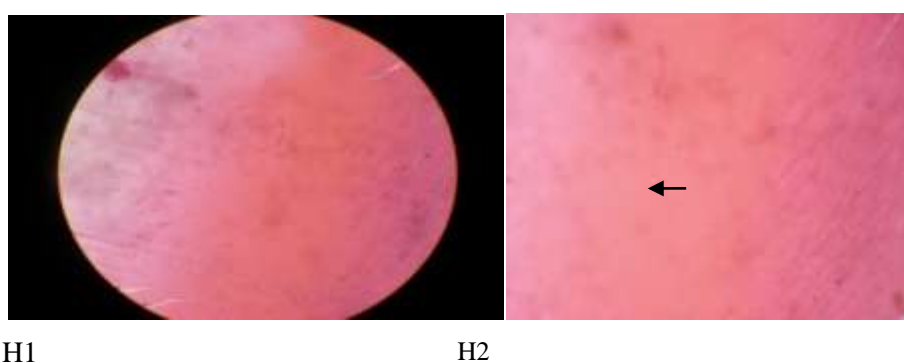
**Plate - 2. Human cortical cataractous lens section:-** Fig.D1- Cortical cataract lens section whole view  $\times 400$ . Fig. D2-Nucleus moderately lysed and thin (arrow). Fig.D3 - Cortical destruction (arrow head), dissolution and lysis in the equatorial region (arrow).Fig.D4 - Equatorial cortical fibre degeneration and separation (arrow)  $\times 1000$ .







**Plate - 3. Humans subcapsular cataractous lens section:-** Fig.E1- Subcapsular cataract lens section whole view  $\times 400$ . Fig.E2 & E3-Partially lysed nuclear region (arrow) and subcapsular degeneration (arrow head). Fig. E4 - Fragmentation and separation of the subcapsular region (arrow). Fig.E5 - Degenerated cortical fibres (arrow). Fig. E6- Dissolution of cortical fibres (arrow)  $\times 1000$ .



**Plate- 4. Human normal lens section:-** Fig.H1:- Normal lens section whole view  $\times 400$ . Fig.H2- Fibril arrangement of the lens fibres (arrow)  $\times 1000$ .

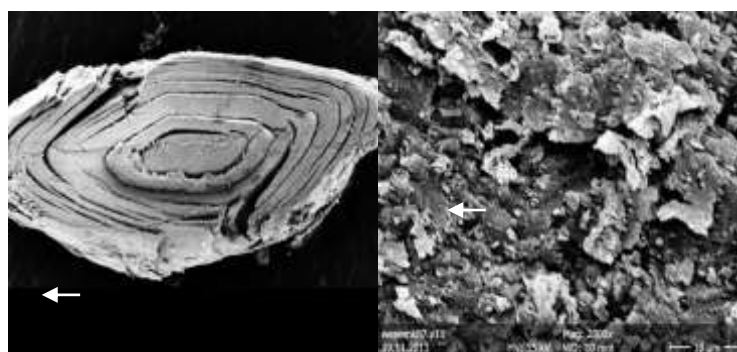


Fig. 3a-1

Fig. 3a-2

H2

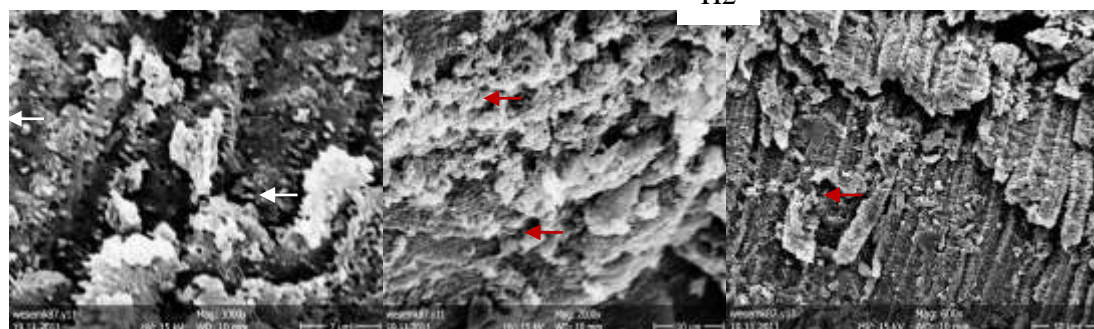


Fig. 3a-3 Fig. 3a-4 Fig. 3a-5

**Plate 1a:** **Human nuclear cataractous lens:-**view through the antero-posterioly cut surface. Fig. 3a-1- Lamellated bands of lens fibers with fine spaces and broken cortical region (arrow)  $\times 30x$ . Fig.3a-3- Degenerated and disarranged nuclear region with edge and groove pattern in high (arrow)  $\times 3000x$  and Fig. 3a-2 in low magnification (arrow)  $\times 2000x$ . Fig. 3a-4- Cortical lens fibres shows hexagonal shape (arrow)  $\times 600x$ . Fig. 3a-5- Degenerated layers of lens fibres of subcapsular region (arrow)  $\times 2000x$ .

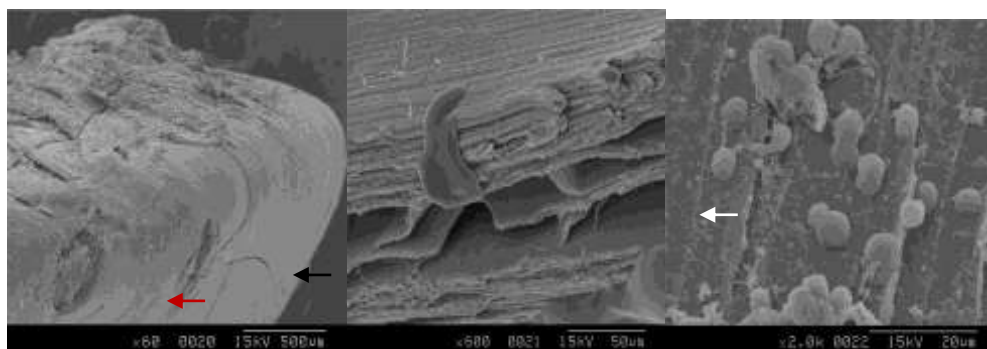


Fig.3b-1 Fig.3b-2

Fig.3b-3

**Plate 1b:** **Human nuclear cataractous lens:-** view through the dorsal side of the whole lens. Fig.3b-1- Broken nuclear cataractous lens can be observed (arrow) $\times 60x$ .Fig.3b-2- Broken and separated lens fibers (arrow)  $\times 600$ . Fig.3b-3- Large vesicles (arrow) in the lens fibres $\times 2.0K$ .

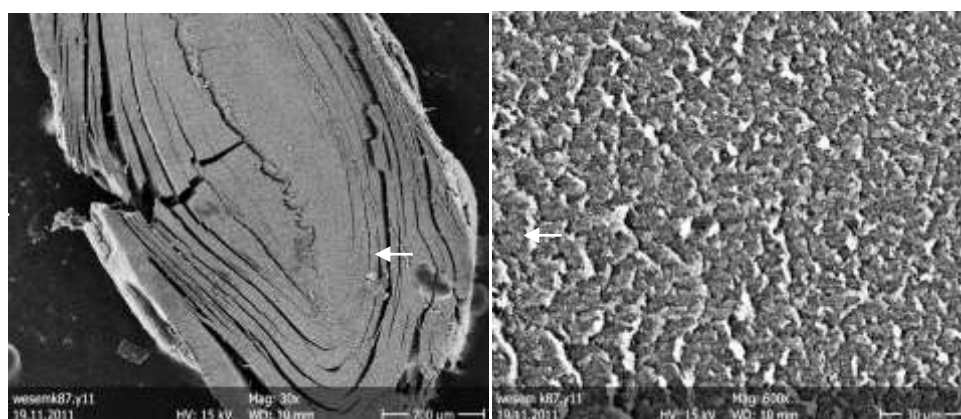


fig.4a-1

fig.4a-2

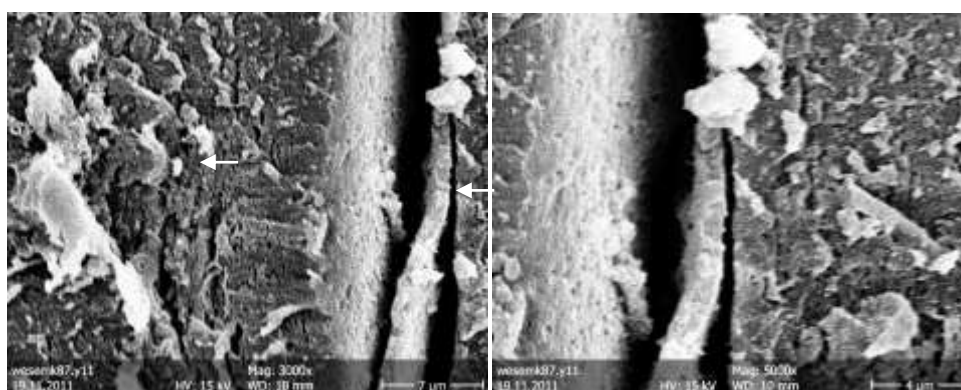


Fig.4a-3

Fig.4a-4



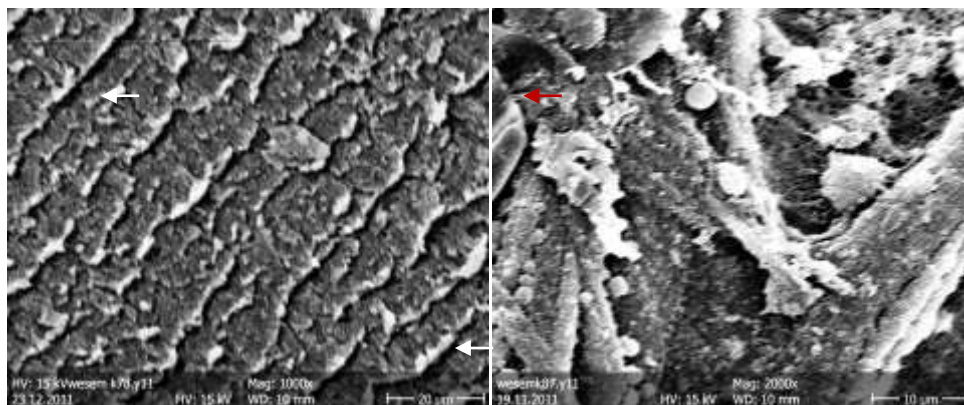


Fig.4a-5

Fig.4a-6

**Plate 2a: Human cortical cataractous lens:-** view through the antero-posterioly cut surface. Fig.4a-1- Well lamellated and broken cortical region with fine spaces and less lamellated nuclear region (arrow)  $\times 30x$ . Fig. 4a-2- Degenerated nuclear region (arrow)  $\times 600x$ . Fig.4a-3- Broken and separated lens fibres in the cortical region in low (arrow)  $\times 3000x$  and in high magnification  $\times 5000x$  (Fig.4a-4). Fig.4a-5- Degenerated superficial cortical region of the lens (arrow)  $\times 1000x$ . Fig.4a-6- Small vesicles scattered in the cortical fibres 2000x.

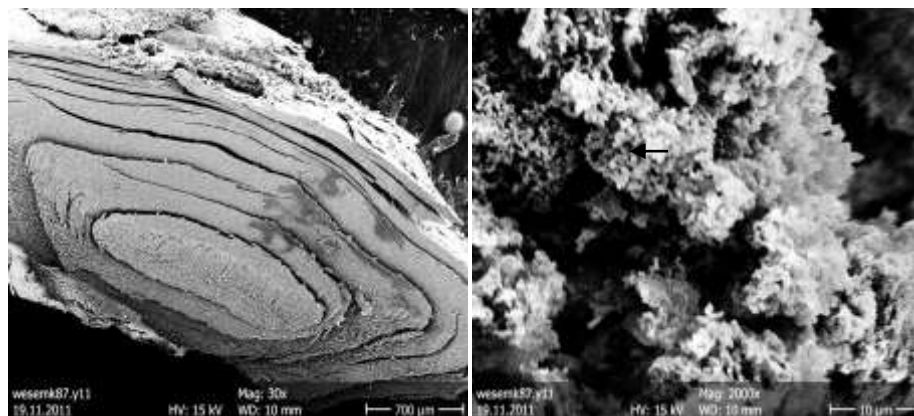


Fig.5a-1

Fig.5a-2

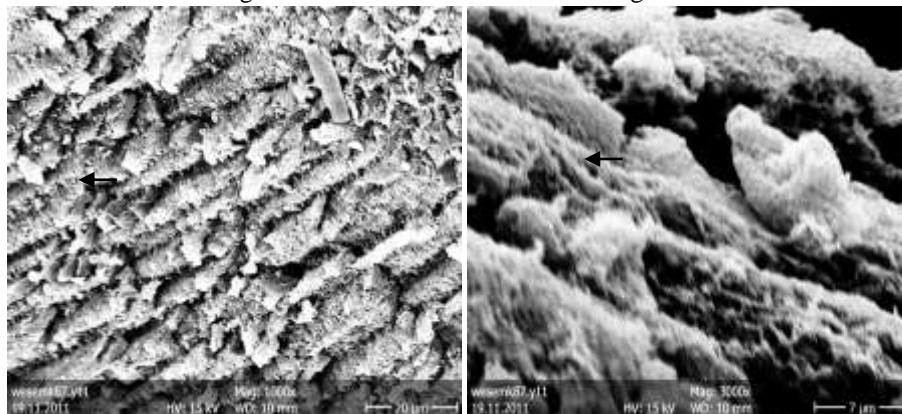


Fig.5a-3

Fig.5a-4

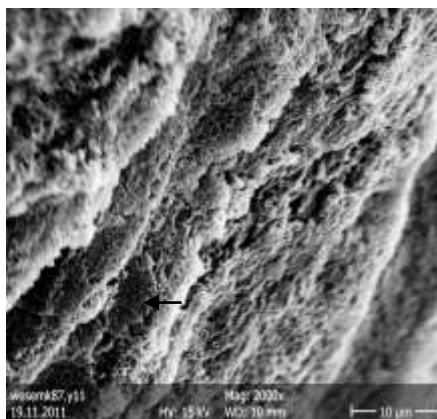


Fig.5a-5

**Plate 3a: Human sub-capsular cataractous lens:-** view through the antero-posterioly cut surface. Fig.5a-1- Fine lamellated lens fibres with degenerated subcapsular region  $\times 30x$ . Fig.5a-2- Degenerated subcapsular region in high magnification (arrow)  $\times 2000x$ . Fig. 5a-3- Degenerated nuclear region (arrow)  $\times 1000x$ . Fig.5a-4- Broken subcapsular region (arrow)  $\times 3000x$ . Fig.5a-5- Degenerated layers of lens fibres of outer side (arrow)  $\times 2000x$ .

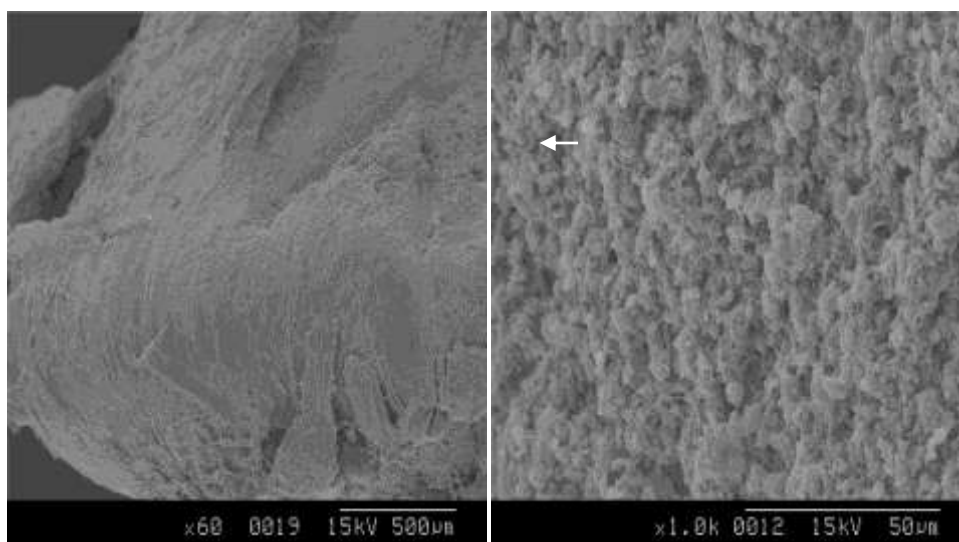


Fig. 5b-1

Fig. 5b-2

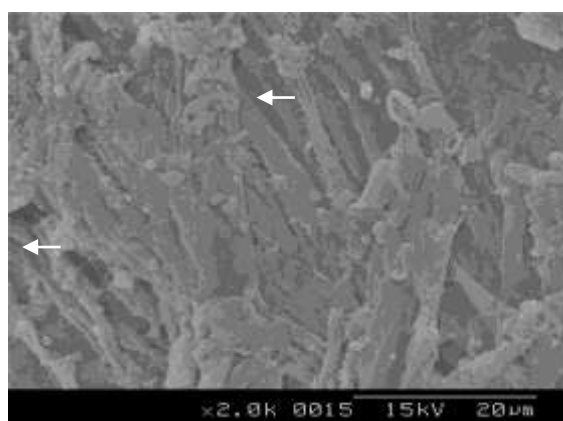


Fig. 5b-3

**Plate 3b: Human subcapsular cataractous lens:-** view through the dorsal side of the whole lens. Fig. 5b-1 - Degenerated and broken subcapsular region through dorsal side (arrow)  $\times 60x$ . Fig. 5b-2- degenerated sub capsular region (arrow)  $\times 1.0K$ . Fig. 5b-3- Disarranged cortical fibres with small vesicles (arrow)  $\times 2.0K$ .



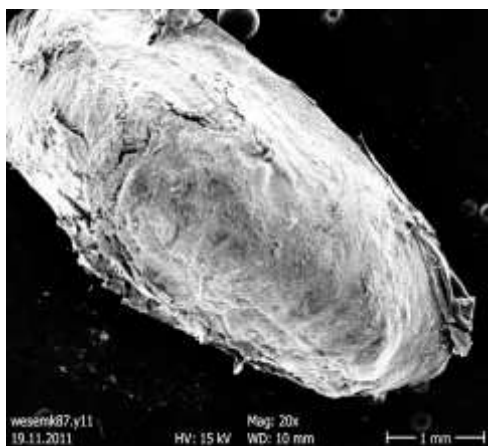


Fig. 8a-1

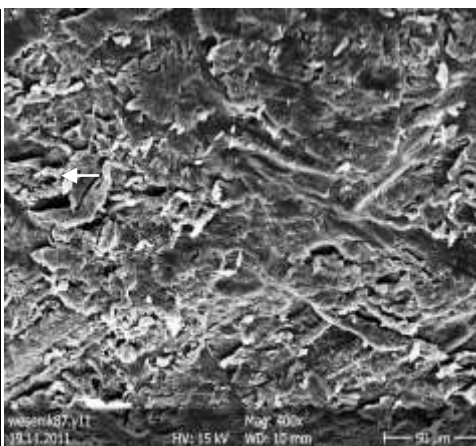


Fig. 8a-2

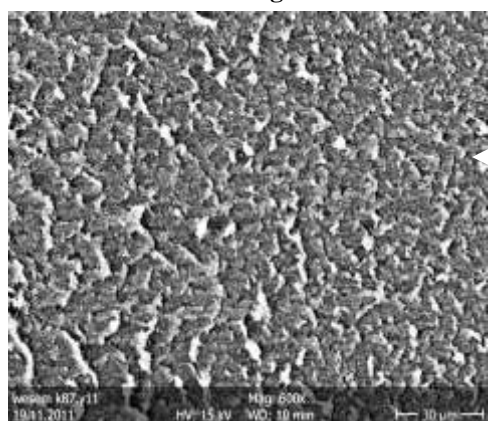


Fig. 8a-3

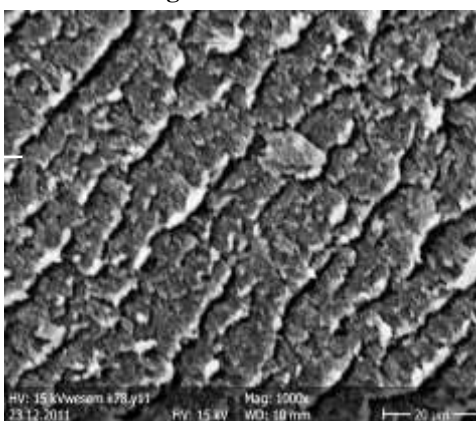


Fig. 8a-4

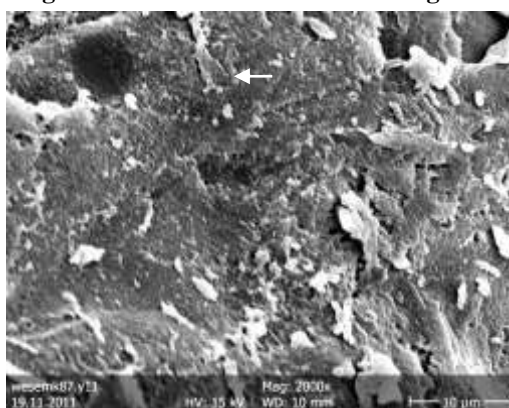


Fig. 8a-5

**Plate 4a:** Human normal lens- Normal lens view through the longitudinal side  $\times 20x$  (Fig.8a-1). Fig.8a-2- Arranged cellular architecture in the nuclear region  $\times 400x$ . Fig.8a-3- Fibre arrangement in the nuclear region  $\times 600x$ . Fig.8a-4- Fibre to fibre arrangement in the cortical region  $\times 1000x$  view through toheanterio- posteriorly cut surface. Fig.8a-5- Normal subcapsular region view through the whole lens  $\times 2000x$ .