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A Morphometric, patho-anatomical and histological study of human lens after cataract extraction surgery

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Abstract: *Cataract seems to be an ageing process. The aim of this study to find out the various morphometric and histopathologcial changes present in human cataractous lenses. There are many precipitating factors such as diabetes,hypertension,exposure to sunlight etc The observational prospective interventional cross-sectional type of study was carried out in 200 extracted cataractous lenses in the Department of Ophthalmology, Maharani Laxmi Bai Medical College Jhansi, during the period of 22 month duration (Feb 2018 to Nov. 2019). Detailed history, statistical data, morphometric study and histological picture of the selected cases were carried out. Of the cases observed, 49 were males and 51 were females. The age group ranged from 40 to 84 years. Nuclear, cortical and posterior subcapsular cataract was seen in 120, 55 and 54 respectivelyIn some cases more than one type of cataract was present. The etiology of cataract in 154 was due to senility; in 16 it was due to diabetes; in 14 it was due to hypertension; in 2 it was due to diabetes and hypertension and in 10 of them it was due to prolonged exposure to sunlight,and in 4 it was prolong systemic drugs administration. The size of the extracted cataractous lens ranged from 5 to 9 mm in diameter and 3 to 5 mm in thickness and the colour ranged from pale grey present in 36, yellow grey in 50, yellow in 62, amber yellow in 48 and dark brown in 4 cases. These lenses of differnt etiology were processed for H & E stain and they showed different histological pictures. Most of the extracted cataractous lens showed homogenous appearance with loss of concentric lamination in 120 cases (60%).*

Key words*: Human cataract lens, Morphometry, Diabetes, Senility, Hypertension, Histology.*

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I. Introduction

Visual impairment is a global public health problem. The prevalence of blindness in developing countries is 10-40 times higher than that in developed countries. The majority of blinds live in the developing nations of Africa, Asia and latin America [1]. Cataract is a major cause of visual impairment and blindness. It is likely to become an increasing problems in the world as age advances. It is estimated that there are about 12 million blind people due to cataract in India alone. In the eye the lens plays a crucial role in focusing unimpeded light on the retina. Human lens is a biconvex, transparent, elastic, avascular structure that is located just behind the iris and the pupil, and suspended in place by the zonular fibres, which connect the lens to the ciliary body. Structurally, the lens has three main components; capsule, epithelium and lens fibers. The capsule is the transparent, elastic, acellular basement membrane that completely encloses the lens . It's main function is in the process of accommodation by molding the shape of the lens in response to tension from zonules [2]. The lens epithelium is a single sheet of cuboidal cells just beneath the capsule at the anterior surface of the lens. It regulate most of the homeostatic functions of the lens and maintain the transparency of the lens. The fibers are long, thin, transparent cells form the bulk of the lens.The epithelial cells elongate, divide and differentiate to form the regularly arranged lens fibres and are formed throughout the life. Lens fibers arranged in zones, the cytoplasm of the cells of superficial bow region and the newly formed lens fibres contain organelles and later on, all the light scattering organelles undergo an inbuilt suicide process that minimizes light scatter and favour transparency[3].

Cataract is defined as visual impairment as a result of disturbances in the transparency of the lens i.e, clouding of the eye lens that reduces the amount of incoming light and results in deteriorating vision The progressive sclerosing process within the lens is manifested at the end of fifth decade (Bertner, et al 1996) [4]. The human lens changes in density and thickness correlating with aging (Kashima et al 1993) [5]. The degenerative process of lens fibres in a cataractous lens is described as the biochemical changes of a part of the lens protein (Kalicharan, et al 1993) [6]. When diabetes is not well-controlled, changes in blood glucose levels cause changes in sugar alcohols of the lens that in turn results in blurred vision (Vaughan, et al 1994).[7]

Types of cataracts:

I. **Cortical cataract** white, wedge-like opacities that start in the periphery of the lens and progress toward the center in a spoke-like fashion. This type occurs in the lens cortex.
II. **Nuclear cataract** forms deep in the central zone (nucleus) of the lens. It usually associated with aging.
III. **Posterior subcapsular cataract** occurs at the back of the lens. More common in diabetics or those taking high doses of steroid medications.

On the basis of maturity cataract:

1. **Immuture cataract**: In which the lens is partially opaque.
2. **Mature cataract:** Cataract in which lens is completely opaque.

3. **Hyper mature:** Cataract which has a shrunken and wrinkled anterior capsule due to leakage of water out of the lens.
4. **Morgagnian cataract:** Is a hypermature cataract in which total liquefaction of the cortex occur and it allow the nucleus to sink inferiorly.

Etiological classification:

a. Congenital and developmental cataract

b. Acquired cataract - Senile cataract, Traumatic cataract, Complicated cataract, Metabolic cataract, Electric cataract, Radiational cataract, Toxic cataract e.g.,Corticosteroid-induced cataract, Miotics-induced cataract, Copper (chalcosis) and iron (siderosis) induced cataract, Cataract associated with skin diseases, Cataract associated with osseous disease, Cataract with miscellaneous syndrome e.g., Dystrophic myotonica, Down's syndrome, Lowe's syndrome, Treacher–Collin's syndrome

Risk factors:

Congenital cataracts: Genetic -In developed industrialised countries almost always have genetic causes (mutations in genes for the crystallins, membrane molecules, enzymes for galactose metabolism and iron metabolism). Co-natal cataracts (following exposure to the measles, mumps or rubella virus before or during birth) are very rare [Gra 03].

Acquired cataracts (age-related cataracts): Generally occur without any obvious identifiable etiology. It is probable that poorer supply of the lens cells due to "ageing" of the cell junctions, as well as prolonged increased concentration of reactive oxygen species (ROS) which can be observed in smokers, various medical conditions, play a role. The spectrum of risk factors for these cataracts is broad. Known risk factors include [Abr 06, Con 03]:Gender (women face a higher risk than men), Genetic predisposition (family history of cataract) Medical conditions (diabetes mellitus, hypertension, hypercholesterolaemia), Smoking (nicotine), Medication (steroid hormones and analogs), Mechanical effects ("tennis ball" trauma), Injuries to the lens capsule (foreign bodies, surgery), Chronic choroiditis, Infrared, UV radiation (occupational exposure, leisure activities) Ionising radiation.

Mechanism of Cataract Formation:

Cataract is accompanied by a series of pathways that associated with imbalance in oxidant-antioxidant status[8], membrane lipid peroxidation[9] defected cellular communication[10], ion imbalance[11], modification, aggregation and accumulation of proteins [12,13], lenticular cell death [14,15] and inflammation [16,17] etc.

II. Method and Material

This observational prospective interventional cross-sectional type of study was conducted at Department of Ophthalmology, MLB Medical College Jhansi, U.P, India, over a period of 22 month duration (Feb 2018 to Nov. 2019). Total 200 patients of age > 40 years with cataract who were attending OPD in Ophthalmology department and satisfied the eligibility criteria,were included in this study. The procedures followed were in accordance with the ethical standarded committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000. The necessary permission from the Ethical and Research Committee was obtained for the study.

Inclusion criteria:

- Patients with age $\geq$ 40 years with informed written consent
- Who agreed to participate in the study
- Patients diagnosed with unilateral or bilateral cataract and having impaired visual acquity in Snellen Chart 6/12 or worse
- Patients operated for cataract using the SICS procedure

Exclusion criteria:

- Patients of age < 40 years Patients with congenital cataract or pre-senile cataract, subluxated lens, zonular instability and posterior capsular dehiscence.
- Patients who have been operated for complicated cataract, traumatic cataract, combined procedures (SICS with glaucoma filtrations surgeries etc.), operated with secondary IOL implantation.
- Other ocular co-morbidities which may affect the visual outcome.

A detailed history was taken including history of any ocular complaints, diminution of vision, duration of diminution, use of glasses, history of floaters, pain, redness, trauma to the eye, past ocular surgery, previous ocular and any systemic medication, history of any systemic complaints/diseases like Diabetes Mellitus (DM), Hypertension (HTN). Patients satisfying the inclusion criteria were selected and a detailed ocular examination was performed in the following sequence, unaided visual acquity, visual acquity with pin hole and glasses in each eye using snellen's charts. Local examination of eyelids, lacrimal system, conjunctiva, cornea, anterior chamber, iris, pupil were done. Slit lamp biomicroscopy with diffuse illumination, focal illumination & retro-illumination were used for any evidence of uveitis, the type of cataract & capsule. Grading of cataract was done by the use of LOCS III [18]. Surgical technique used were manual-small incision cataract surgery (MSICS). After the cataract extraction surgery the extracted cataractous lens of the patients were collected in the Operation Theatre in small biopsy containers with 10% formal saline. The morphological features of the lenses was observed. The colour of the lenses was observed. The diameter of the lenses was measured in horizontal and vertical directions with the help of castroviejo calipers and the values were read from a scale and the average was taken. In the same way the thickness (width/anteroposterior) of the lenses was also measured. The lenses of different etiology were selected and were processed for histological study by paraffin wax section and **stained** with following stains:

- **Haematoxylin & Eosin (H& E)** – for general histological changes
- **Masson's Trichome** for collagen.
- **PAS (Periodic Acid Schiff)** Stain- for glycogen.
- **Sudan black-B** for lipids.

The observation of slides were done under microscope (40X and 100X magnification) after that photography of slides were done by NIDEK DSLR camera. Data will be analysed by the Statistical Package for the Social Sciences (SPSS for windows, version 25.0).

III. Result

Table 1: Distribution of patients on the basis of gender

Sex	No. of patients	Percentage
Male	98	49%
Female	102	51%
Total	200	100%

In this study 98 were male and 102 were female

Table 2: Distribution of patients on the basis of age

Age Group	No. of patients	Percentage
40-49	20	10%
50-59	65	35%
60-69	89	47%
70-84	26	13%
Total	200	100%

In our study, maximum number of patients 89(47%) in the age group of 60-69 years, 20(10%) number of patients in age group 40-49 years, 65(35) in the age group of 50-59 years, 26(13%) in the age group of 70-84 years.

Table 3: Types of cataract

Type of Catract	No. of patients	Percentage
Posterior Subcapsular	40	20%
Cortical	36	18%
Cortical + Nuclear	13	6.5%
PSC + Cortical	4	2%
PSC + Nuclear	8	4%
Mixed	2	1%
Nuclear	97	48.5%
Total	200	100%

Nuclear cataract was maximally present in our study 120(60%) both pure 97(48.5%) and in combined form 23 (11.5%). Cortical cataract was seen in 55(27.5%) patients, 36(18%) was in pure form and 19(9.5%) in combined form. Posterior subcapsular cataract was present in 54(27%) patients, 40(20%) in pure and 14(7%) in combination.

Table 4: Etiology of catract

Etiology	No. of cases	Percentage %
Senile	154	77%
Diabetes	16	8%
Hypertension	14	7%
Diabetes+Hypertension	2	1%
Prolong sunlight exposure	10	5%
Systemic drugs	4	2%
Total	200	100%

Out of 200 patients, 154 (77%) were having senile cataract, 16 (8%) patients with Diabetic etiology, 14 (7%) patients with Hypertensive etiology, 2 (1%) patients with Diabetes and Hypertention, 10 (5%) patients with prolonged sun exposure and 4 (2%) patients with prolonged systemic drug intake.

Table 5: Comparison of age with diameter and thickness of extracted lens

Age Group (years)	Mean Minimum Diameter (mm)	Mean Maximum Diameter (mm)	Mean Minimum Thickness (mm)	Mean Maximum Thickness (mm)
40-49	5.0	9.0	3.5	3.5
50-59	7.0	9.0	3.0	5.0
60-69	7.0	9.0	3.5	5.0
70-84	8.0	9.0	4.0	5.0

Patients of 40-49 yrs age group had minimum and maximum diameter and thickness of extracted lens- 5.0mm, 9.0mm and 3.5, 3.5mm respectively. Patients of 50-59 yrs age group have minimum and maximum diameter and thickness of extracted lens - 7.0mm, 9.0mm and 3.0mm, 5.0mm respectively. Patients of 60-69 yrs age group have minimum and maximum diameter and thickness of extracted lens 7.0 mm, 9.0mm and 3.5, 5.0mm respectively. Patients of 70-84 yrs age group have minimum and maximum diameter and thickness of extracted cataractous lens 8.0mm, 9.0mm and 4.0, 5.0mm respectively. The minimum and maximum values of diameter and thickness in different age groups showed a definite increase in diameter and thickness as age advanced.

Table 6: Different types of colour of cataractus lens

Colour of lens	No. of cases	Percentage
Pale Grey	36	18%
Yellowish Grey	50	25%

Yellow	62	31%
Amber Yellow	48	24%
Brown/Dark Brown	4	2%
Total	200	100

Extracted cataractous lens of pale grey present in 18% of patients, Yellow grey in 25% of patients, Yellow in 31% of patients, Amber Yellow in 24% of patients, Dark brown in 2 % of patients

Table 7: Colour of lens with age incidence

Colour of lens (Age Incidence)	No. of cases
Pale Grey (40-62)	36
Yellow Grey (41-68)	50
Yellow (49-72)	62
Amber Yellow (57-78)	48
Brown/Dark brown (73-84)	4

Pale Grey colour of lens present in 36 patients of 40-62 age group, Yellow Grey colour of lens present in 50 patients of 41-68 age group. Yellow colour of lens present in 62 patients of 49-72 age group. Amber Yellow colour of lens present in 48 patients of 57-78 age group. Brown/Dark Brown colour of lens present in 4 patients of 73-84 age group.

Table 8: histological changes in 200 human cataractous lenses

Changes	No. of cases	Percentage
Bladder / Wedl cell	32	16%
Posterior migration of epithelial cells	22	11%
Homogenous appearance with loss of concentric lamination	120	60%
Morgagnian globules	35	17.5%
Accumulation of eosinophilic fluid b/w lenticular fiber	20	10%
Glycogen granules	8	4%
Collagen	10	5%
Lipid granules	4	2%

In this study most of the extracted cataractous lens were present with homogenous appearance with loss of concentric lamination, present in 120 cases (60%). Morgagnian globules were present in 35 cases (17.5%). Bladder / Wedl cell were present in 32 cases (16%). Posterior migration of epithelial cells were showed by 22 cases (11%). Accumulation of eosinophilic fluid b/w lenticular fiber were present in 20 cases (10%).8 cases (4%) showed glycogen granules deposition and presence of collagen were showed by 10 cases (5%).4 cases (2%) showed lipid deposition. Lens of diabetic etiology showed lamellated bands of lens fibres of different density. Lens of hypertensive etiology showed homogenous areas and certain areas of fine lamellations scattered with fine spaces. Lens with prolonged exposure to sunlight showed homogenous area. Senile cataract lens of cream colour showed fine lamellations, Yellow colour showed well defined lamellations, Honey colour showed very well defined lamellations, Brown colour showe–dense & homogenous areas and because of the difficulty in cutting showed lot of serration.

IV. Discussion

In our study cataract was proportionately higher in female (51%) compared to males (49%), Our results were consistent with the finding of other studies; 61.2% in males and 68.5% in females, **(**Boyle et al.,2008), [19] 49.1% in males and 54.8% in females (Murthy GV et al.,2007)**.**[20] In the present study maximum number of 57.5% cases belonged to age group ≥60 yrs. Other study also show more prevalence of cataract in people aged ≥60 ranged from 72% Athanasiov P.A.et al [22] to 87% in Seah S.K et al, Husain R et al [21,23]. Nuclear cataract was maximally present in our study (60%), both pure and mixed. Cortical cataract was present in (27.5%) of the patients, posterior subcapsular was present in (27%) which was found consistent with the study which suggested that higher incidence of nuclear cataract has been reported in tropical and subtropical areas, (Sasaki H et al 2002)[24] and Vashist P et al[25] (NC-48%,PSC-21%,CC-7.6% in north india; NC-38%,PSC-17%,CC-10.2% in south india). Of these cataractous cases, 16(8%) were having diabetes mellitus, 14(7%) were hypertensive, 2(1%) had both diabetes and hypertension, 10(5%) had prolong sunlight exposure, 4(2%) gave history of prolonged systemic drug intake and maximum cases were of senile cataract 154(77%). Our study was found consistent with study of Dorairaj, S.J;et al[26] that suggested that the no. of diabetes cases(8), hypertension(7), diabetes and hypertension(1) prolong sunlight exposure, senile cataract (79). In the present study with increasing age the diameter and thickness of extracted cataractous lens increases and showed a mean value of 7.76 ± 0.86 mm for minimum diameter, mean value of 8.29 ± 0.78 mm for maximum diameter and a mean value of 3.8 ±0.50mm for thickness, which were close to that of the observations made by (Klein BEK et al.,1998)[27], (Assia & Apple 1992)[28] (thickness 4.5 mm and diameter 9.5 mm). As per the present study it was observed that the deepening of the colour took place with increasing age. The lens colour changes to pale grey, yellow grey, yellow then amber yellow to brown and dark brown. There was a progressive hardening of the lens, which was manifested after the age of 40. Hardening of the lens nucleus parallels decreased transparency and the lamellations became prominent as age advances.

In the present study histological examination of cataractous lenses revealed that in many cases the lens fibers were showing Bladder cell/ swollen cell, a degenerative change, Uga et al[29] observed similar change in their study. Morgagnian Globular formation have resulted by fragments of swollen cell wall. Gorthy[30] observed similar changes in cataractous rat lens, in a cataractous patient with retinitis pigmentosa[31] .In our study nuclear fiber cells give homogenous appearance with loss of their concentric lamination. Same change occurred in the philly mouse lens (congenital cataract).[32] Posterior migration of epithelial cells beneath posterior capsule is stimulated by prior equatorial and posterior cortical degeneration. Similar changes had been recorded in a hereditary cataract of philly mouse[32]. In many cases the lens fibers cytoplasm is full

of glycogen granules with PAS stain, lipid granules in cytoplasm of nuclear region with Sudan black B. More than one changes were observed in many cataracts.

V. Conclusion

Cataract are responsible for 65.2 million cases globally[33]. In India cataract is the leading cause of blindness in people above 50 years, according to the National Blindness and Visual Impairment Survey India 2015-19. The condition is behind 66.2 % blindness cases, 80.7 % severe visual impairment cases and 70.2 % moderate visual impairment cases. And around 93 % of blindness cases and 96.2 % of visual impairment cases in this age group were avoidable[34]. In the South East Asia region Cataract is the most common cause of blindness and is responsible for 50-80% of all blindness.[35] Accordingly, control of blindness and visual impairment due to cataract is a priority in the World Health Organization's (WHO) current "Universal Eye Health: a global action plan 2014–2019" which was endorsed at the 66th World Health Assembly"[36,37]. All lens parameters increase as a function of age, consistent with continuous lens growth. The information obtained from morphometric analysis of large number of extracted cataractous human lens over a wide age range will be valuable in the understanding of biomechanical changes and optical alteration of natural and artificial crystalline lens that changes to cataract. For clinical ophthalmologists it would be interesting to learn, what histological changes correspond to the clinical features of cataract as it is useful for clinicians to exchange information and it would lead to a better insight into cataracts and help them to make use of most of the latest knowledge in clinical practice.

References

[1]. Hashemi H, Fotouth A, and Mohammad K. The Tehran eye study. research design and eye examination protocol. BMC ophthalmol 2003;3:8.
[2]. Streeten BW. The nature of the ocular zonule. Trans Am Ophthalmol Soc. 1982; 80: 823-854
[3]. Hogan MJ, Alvarado JA, Weddell JE. Histology of the human eye. Philadelphia: WB Saunders. 1971
[4]. Hales, A.M., Chamberlain, C.G., Murphy, C.R. Mc Avoy, J.W. (1997) : Estrogen protects lenses against cataract induced by transforming growth factor – beta (TGF beta) Journal of Experimental Medicine. Jan 20; 185(2) : 273-80.
[5]. Kashima, K., Trus, B.L., Unser, M., Edwards, P.A., & Datiles, M.B. (1993) : Aging studies on normal lens using the Schermipflug Slit – lamp camera. Investive Ophthalmology Visual Sciences Jan : 34(1) : 262 - 99.
[6]. Kalicharan. D., Jongebloed, E.L. : & Worst, J.G. (1993) : Lens fibre degeneration at Cataract lenses. ALM, SEM and TEM investigation Doc Ophthalmology, 85(1): 77 - 85. 9.
[7]. Vaughan, D & Asbury, T. General Ophthalmology 10th End. : Lamage Medical publication, Los Atlas, California, p 247 (1994).
[8]. Adedapo KS, Kareem ST, Bekibele CO, Nwobi NL. Increased oxidative stress and non enzymatic antioxidant levels in senile cataract. Arch ApplSci Res. 2012; 4: 2461-2466.
[9]. Kisic B, Miric D, Zoric L, Dragojevic I, Stolic A. Role of lipid peroxidation in pathogenesis of senile cataract. Vojnosanit Pregl. 2009; 66: 371-375.
[10]. Gao J, Sun X, Martinez-Wittinghan FJ, Gong X, White TW, Mathias RT. Connections between connexins, calcium, and cataracts in the lens. J Gen Physiol. 2004; 124: 289-300.
[11]. Duncan G, Bushell AR. Ion analyses of human cataractous lenses. Exp Eye Res. 1975; 20: 223-230.
[12]. Takemoto LJ. Oxidation of cysteine residues from alpha-A crystallin during cataractogenesis of the human lens. Biochem Biophys Res Commun. 1996; 223: 216-220.
[13]. Boros S, Wilmarth PA, Kamps B, De Jong WW, Bloemendal H, Lampi K, et al. Tissue transglutaminase catalyzes the deamidation of glutamines in lens ßB2 and ßB3 crystallins. Exp Eye Res. 2008; 86: 383-393.
[14]. Harocopos GJ, Alvares KM, Kolker AE, Beebe DC. Human age-related cataract and lens epithelial cell death. Invest Ophthalmol Vis Sci. 1998; 39: 2696-2706.
[15]. Li WC, Kuszak JR, Dunn K, Wang RR, Ma W, Wang GM, et al. Lens epithelial cell apoptosis appears to be a common cellular basis for non congenital cataract development in humans and animals. J Cell Biol. 1995; 130: 169-181.
[16]. Descamps FJ, Martens E, Proost P, Starckx S, Van den Steen PE, Damme JV, et al. Gelatinase B/matrix metalloproteinase-9 provokes cataract by cleaving lens ßB1 crystallin. FASEB J. 2005; 19: 29-35.
[17]. Klein BE, Klein R, Lee KE, Knudtson MD, Tsai MY. Markers of inflammation, vascular endothelial dysfunction, and age-related cataract. Am J Ophthalmol. 2006; 141: 116-122
[18]. Ch ylack LT Jr, Wolfe JK, Singer DM, Leske MC, Bullimore MA, Bailey IL, et al. The lens opacities classification system III. The lens opacities classification system III. The longitudinal study of cataract study group. Arch Ophthalmol 1993;111:831‑6.
[19]. Boyle E, Katrina Altersitz. High Prevalence of Cataract Continues. Ocular Surgery News India edition. September 1, 2008.
[20]. Murthy GV, Gupta SK, Maraini G, Camparini M, Price GM, Dherani M, et al. Prevalence of lens opacities in North India: The INDEYE feasibility study. Invest Ophthalmol Vis Sci 2007;48:88-95
[21]. Seah S.K., Wong T.Y., Foster P.J. Prevalence of lens opacity in Chinese residents of Singapore: the Tanjong Pagar survey. Ophthalmology. 2002;109:2058–2064. [PubMed] [Google Scholar]
[22]. Athanasiov P.A., Casson R.J., Sullivan T. Cataract in rural Myanmar: prevalence and risk factors from the Meiktila Eye Study. Br J Ophthalmol. 2008;92:1169–1174. [PubMed] [Google Scholar]
[23]. Husain R., Tong L., Fong A. Prevalence of cataract in rural Indonesia. Ophthalmology. 2005;112:1255–1262. [PubMed] [Google Scholar])
[24]. Sasaki H, Jonasson F, Shui YB, Kojima M, Ono M, Katoh N, Cheng HM, Takahashi N, Sasaki K. High prevalence of nuclear cataract in the population of tropical and subtropical areas.DevOphthalmol.2002 ;35:60-9. Years
[25]. Vashist P[1], Talwar B, Gogoi M, Maraini G, Camparini M, Ravindran RD, Murthy GV, Fitzpatrick KE, John N, Chakravarthy U, Ravilla TD, Fletcher AE. Prevalence of cataract in an older population in India: the India study of age-related eye disease. Ophthalmology2011 Feb;118(2):272-8.e1-2. doi: 10.1016/j.ophtha.2010.05.020.
[26]. Dorairaj, S.J; Vatsala, V; Vijaya Kumar, J; Kesavai R; Sucheethra, D.S; Vidyasree, S. J Anat. Soc. India 51(1) 14-17 (2002)
[27]. Klein BEK, Klein R, Moss SE. Correlates of lens thickness:the beaver dam eye study. Invest Ophthalmol Vis Sci 1998; 39:1507-1510
[28]. Assia, E.I. & Apple, D.J. (1992) : Side – View analysis of the lens I the cystalline lens and the evacuated bag. Archives of Ophthalmology Jan 110 (1) : 89 - 93.
[29]. Uga. S. Kohara. M. and Ishikawa, S. Morphological study of age related changes inmouse lens. Jpn. J. Ophthalmol., 1983;27:157-65.
[30]. Gorthy, W.C. Cataracts in the aging rat lens. Exp. Eye Res., I 978;27:301 -22.
[31]. Dilley, K.J., Bron, A.J. and Habgood, JO. Anterior polar and posterior subcapsular cataracts in a patient with retinitispigmentose: A light microscopic and ultrastructure study. Exp. Eye Res., 1976;22: 155-67.
[32]. Uga, S. Kador, P.F. and Kuwabara, T. Cytological study of philly mouse cataract. Exp. Eye Res., 1980;30:79-92.
[33]. First World Vision Report ,World Health Organization (WHO) on October 8, 2019
[34]. National Blindness and Visual Impairment Survey India 2015-19
[35]. GVS Murthy,Sumit Malhotra,Praveen Vashist. Status of eye care in south east asia region.Delhi J Ophthalmol 2013;24(2):114-118.
[36]. World Health Organization. Universal Eye Health: A global action plan 2014–2019. Geneva: World Health Organization, 2013.
[37]. World Health Assembly. Towards universal eye health: A global action plan 2014–2019. Resolution 66.4, 24 May 2013. Geneva: World Health Assembly, 2013.