Simple Mathematical Description of Age-Related Changes in Human Crystalline Lens Geometry in the Indian Population

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KEYWORDS
Age-Related Changes, Geometry, Human Crystalline Lens, Indian Population

ABSTRACT
The human eye undergoes significant physiological changes with age, particularly in the crystalline lens, which is responsible for focusing light onto the retina. These changes impact visual acuity and are critical to understanding the aging process and associated ocular diseases. Traditional imaging modalities such as Ultrasound Biomicroscopy (UBM) and Optical Coherence Tomography (OCT) have limitations in terms of resolution and penetration depth. UBM suffers from low resolution (~500 µm), while OCT struggles with penetration through opaque tissues like the iris. This study introduces a simplified mathematical approach to describe age-related changes in the crystalline lens geometry, aiming to overcome these limitations. The method involves using key variables—Lens Diameter (LD), Lens Thickness (LT), Lens Volume (V), Radius of Curvature of the Anterior Portion (RAL), and Posterior Portion (RPL)—to construct a comprehensive profile of the lens. Data from the Indian population, characterized by Mohamed et al., is utilized to demonstrate this approach. Results show that LD, LT, and V increase with age, while RAL and RPL also show age-related increments. These findings provide insights into the lens's age-related changes, with potential applications in enhancing optical models and improving clinical practices. Further research is necessary to refine this model and validate the findings with larger datasets, paving the way for more accurate descriptions of the crystalline lens geometry and its changes over time.

1. Introduction

The human eye is an intricate and dynamic organ, playing a pivotal role in visual perception, which is considered the most significant of the five basic senses. The eye's complexity is reflected in its various anatomical structures, including the cornea, lens, retina, and optic nerve, all of which work in unison to process visual information.

Age-related changes in eye physiology are a subject of extensive research, as they provide insights into the biological, physical, and chemical processes underlying aging and disease progression. These changes are not only significant for understanding normal aging but also for diagnosing and managing age-related ocular conditions such as presbyopia, cataracts, and glaucoma.

The study of the human crystalline lens, which is responsible for focusing light onto the retina, is of particular interest. With age, the lens undergoes several morphological and functional changes, affecting its optical properties. Investigating these changes is crucial for developing effective treatments and improving the quality of life for aging individuals.

Various imaging modalities, including Ultrasound Biomicroscopy (UBM) and Optical Coherence Tomography (OCT), have been employed to study the lens's age-related changes. However, these techniques have limitations in terms of resolution and penetration depth. UBM, an ultrasound-based imaging technique, provides valuable insights but suffers from low resolution (~500 µm). On the other hand, OCT, a light-based imaging modality, offers high resolution but is limited in its ability to penetrate opaque tissues such as the iris.

This study proposes a simplified mathematical approach to reconstruct the complete profile of the human crystalline lens, addressing the limitations of UBM and OCT. By leveraging data from the Indian population, we aim to provide a comprehensive understanding of age-related changes in lens geometry.

2. Methods

The human crystalline lens geometry is defined by several key variables, including Lens Diameter (LD), Lens Thickness (LT), Lens Volume (V), Radius of Curvature of the Anterior Portion (RAL), and Posterior Portion (RPL). Understanding the age-related variability in these parameters is essential for characterizing the lens's geometric profile.

Data Collection: Data for this study was obtained from previous research conducted by Mohamed et al. [1], which characterized the age-dependent variability in lens parameters among the Indian population. The study involved both in vivo and in vitro measurements using UBM and OCT imaging modalities.

Mathematical Model: In geometric optics, the optical surfaces of the lens are commonly described using conic sections. The volume of the crystalline lens can be approximated using the following equation:

$$V = \frac{\pi}{6} \times LD \times (LTA + LTP) \times (RAL + RPL)$$

where LD is the lens diameter, LTA and LTP are the thicknesses of the anterior and posterior portions of the lens, respectively, and RAL and RPL are the radii of curvature of the anterior and posterior portions of the lens.

The thickness of the anterior portion (LTA) and posterior portion (LTP) can be determined using the following equations:

$$LTA = \frac{2 \times RAL}{1 + \sqrt{1 - \left(\frac{LD}{2 \times RAL}\right)^2}}$$

$$LTP = \frac{2 \times RPL}{1 + \sqrt{1 - \left(\frac{LD}{2 \times RPL}\right)^2}}$$

These equations define the geometric profile of the lens using two different conic sections with major diameter LD and minor diameters LTA and LTP for the anterior and posterior segments, respectively.

The crystalline lens diameter (LD), lens thickness (LT) lens volume (V), radius of curvature of the anterior portion of the lens RAL, and posterior portion of the lens RPL are the key variables necessary that are used to describe the geometric profile of the human crystalline lens. Mohamed [1] et al. characterized the age dependent variability in such parameters among Indian population given in Table 1. LD, LT, V and RAL were identified to be correlated with age and higher statistical significance. In geometric optics [3], it is common to describe the optical surfaces using conic sections. Accordingly, the volume of the crystalline lens can be approximated using:

Equation 1: Volume of the Crystalline Lens

$$V = 2\pi/3 * (LD^2/4) * (LTA + LTP) \quad (1)$$

Equation 2: Anterior Thickness of the Lens (LTA)

$$LTA = LD^2/ 4RAL \quad (2)$$

Equation 3: Posterior Thickness of the Lens (LTP)

$$LTP = LT – LTA \quad (3)$$

Equation 4: Posterior Radius of Curvature of the Lens (RPL)

$$RPL = LD^2/ 4LTP \quad (4)$$

where the anterior and posterior portions of the crystalline lens geometric profile are defined using two different conic sections with major diameter LD and minor diameters LTA and LTP for the anterior and posterior segments, respectively.

Expanding the Equations

We can substitute the expression for LTA (from Equation 2) into the other equations for further expansion:

Expanding Equation 1 (Volume of the Crystalline Lens):

Substitute LTA = LD^2/ 4RAL from Equation 2 into Equation 1:

$V= 2\pi/3 * (LD^2/4) * (LD^2/4. RAL + LTP)$

Now, using the expression for LTP = LT – LTA (Equation 3), substitute LTA again

$V= 2\pi/3 * (LD^2/4) * (LD^2/4. RAL + LT- LD^2/4. RAL)$

Simplify:

$V= 2\pi/3 * (LD^2/4) * LT$

This is the expanded form for the volume V.

Expanding Equation 4 (Posterior Radius of Curvature):

We can substitute LTP= LT- LTA into equation 4:

So, RPL = LD^2/ 4LTP can be written as:

$RPL = LD^2/ 4. (LT - LD^2/ 4. RAL)$

This is the expanded form for the posterior radius of curvature RPL.

Final Expanded Forms:

i. Volume (V):

$V= 2\pi/3 * (LD^2/4) * LT$

ii. Posterior Radius of Curvature (RPL)

$RPL = LD^2/ 4. (LT - LD^2/ 4. RAL)$

These expansions provide a more detailed expression for the variables involved in the geometry of the crystalline lens.

Measurement Accuracy: OCT imaging is more accurate in measuring key variables LT and RAL compared to UBM. Therefore, the mathematical model relies on OCT data for these measurements, while other variables are deduced using the equations provided.

As illustrated in the Fig. 1, key variables LT and RAL can be measured more effectively from OCT compared to LD and RPL. While the geometric profile of the crystalline lens expected to vary in the accommodated, disaccommodated and cycloplegic states, the total volume V is expected to remain constant in vivo and in vitro situations. Higher statistical significance was also observed in linear regression fit with age for the key variable V [1] and [2]. Therefore, it is possible to deduce LD, LTA, LTP and RPL using equations 1-4 while it is significantly more accurate to measure key variables LT and RAL from OCT imaging.

3. Results and Discussion

The proposed mathematical approach was applied to previously published data on the Indian population to reconstruct the complete geometric profile of the human crystalline lens. Tables 2 and 3 present the key variables for different age groups, highlighting the changes that occur with aging.

Age-Related Changes in Lens Geometry: The analysis shows that lens diameter (LD), lens thickness (LT), and lens volume (V) increase with age. The radius of curvature of the anterior portion (RAL) and posterior portion (RPL) also increase with age. However, the anterior lens thickness (LTA) decreases, while the posterior lens thickness (LTP) increases. These changes are schematically illustrated in Figure 3.

The findings suggest that age-related changes in the lens geometry are characterized by an overall increase in size and curvature, while the distribution of thickness shifts from the anterior to the posterior portion of the lens. This shift may be related to changes in the lens's biomechanical properties and its ability to accommodate.

Implications for Optical Models: The study's findings have significant implications for the development of optical models of the human eye. Accurate geometric descriptions of the lens are crucial for simulating the eye's optical performance and understanding the impact of age-related changes on vision.

Limitations and Future Research: While the proposed approach provides a comprehensive understanding of age-related changes in lens geometry, there are limitations to consider. The study relies on previously published data, which may not fully represent the variability in the broader population. Future research should focus on larger and more diverse datasets to validate the findings.

Additionally, further refinement of the mathematical model is needed to account for the dynamic nature of the lens during accommodation. Advanced imaging techniques and computational models could provide more accurate and detailed insights into the lens's behaviour.

4. Conclusions and Future Scope

The study presents a simplified mathematical approach to describe age-related changes in the human crystalline lens geometry. By addressing the limitations of UBM and OCT imaging modalities, the proposed method provides a more accurate and comprehensive understanding of lens geometry changes with age.

The findings highlight the increase in lens diameter, thickness, volume, and curvature with age, along with a shift in thickness distribution from the anterior to the posterior portion of the lens. These changes have significant implications for optical models of the eye and the development of treatments for age-related ocular conditions.

Future research should focus on refining the mathematical model, validating the findings with larger datasets, and exploring the dynamic nature of the lens during accommodation. Advanced imaging and computational techniques hold promise for further enhancing our understanding of the crystalline lens and its age-related changes.

Figures and Tables:

- **Table 6**: Posterior (Age/ X)
- **Table 7**: Posterior (Age/ Y)
- **Table 8:** Age-Related Variations in Human Crystalline Lens Parameters Based on OCT Measurements- X Axis
- **Table 9:** Age-Related Variations in Human Crystalline Lens Parameters Based on OCT Measurements- Y Axis
- **Table 10**: Comprehensive Listof Age-Related Changes In Lens Geometry

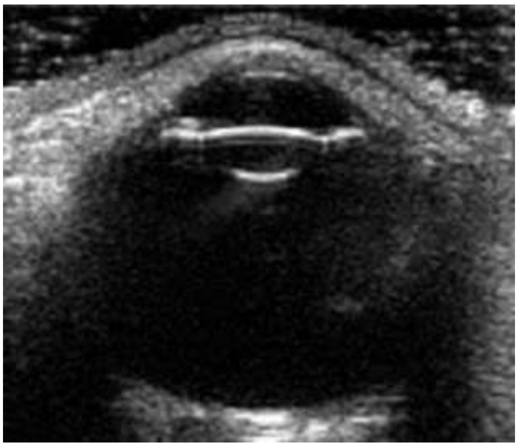

Figure 1. UBM Image of the Human Eye

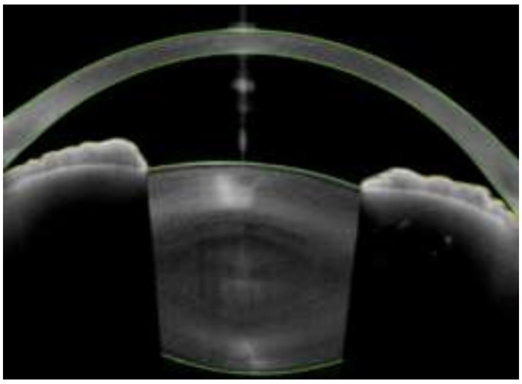

Figure 2. OCT Image of the Human Eye

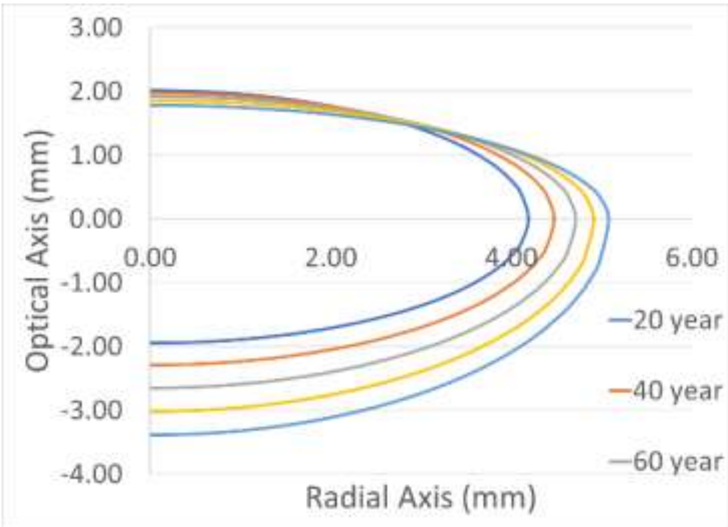

Figure 3. Age related changes in the geometric profile of the human eye crystalline lens

Table 1: Linear Regression Coefficients of Key Variables with Age

Variable	Unit	Slope	Ordinate
LD	mm	0.023	8.31
LT	mm	0.015	3.67
V	mm^3	1.666	112.59
RAL	mm	0.072	7.25
RPL	mm	0.018	5.39
LTA	mm	0.004	1.66
LTP	mm	0.011	2.01

Table 2: Key Variable Set 1

Age	LT (mm)	Volume (mm^3)	RAL (mm)
20	3.97	145.91	8.69
25	4.05	154.24	9.05
30	4.12	162.57	9.41
35	4.20	170.90	9.77
40	4.27	179.23	10.13
45	4.35	187.56	10.49
50	4.42	195.89	10.85
55	4.50	204.22	11.21
60	4.57	212.55	11.57
65	4.65	220.88	11.93
70	4.72	229.21	12.29
75	4.80	237.54	12.65
80	4.87	245.87	13.01
85	4.95	254.20	13.37
90	5.02	262.53	13.73
95	5.10	270.86	14.09
100	5.17	279.19	14.45

Table 3: Key Variable Set 2

Age	LD (mm)	LTA (mm)	LTP (mm)	RPL (mm)
20	8.38	2.02	1.95	8.69
25	8.53	2.01	2.03	9.05
30	8.68	2.00	2.12	9.41
35	8.82	1.99	2.20	9.77
40	8.95	1.98	2.29	10.13
45	9.08	1.96	2.38	10.49
50	9.20	1.95	2.47	10.85
55	9.32	1.94	2.56	11.21

Age	LD (mm)	LTA (mm)	LTP (mm)	RPL (mm)
60	9.42	1.92	2.65	11.57
65	9.53	1.90	2.74	11.93
70	9.63	1.89	2.83	12.29
75	9.73	1.87	2.93	12.65
80	9.82	1.85	3.02	13.01
85	9.91	1.84	3.11	13.37
90	9.99	1.82	3.20	13.73
95	10.08	1.80	3.29	14.09
100	10.16	1.78	3.39	14.45

Table 4: Anterior (Age/ X)

Age/X	20	40	60	80	100
0	0.00	0.00	0.00	0.00	0.00
5	0.21	0.22	0.24	0.25	0.25
10	0.42	0.45	0.47	0.49	0.51
15	0.63	0.67	0.71	0.74	0.76
20	0.84	0.90	0.94	0.98	1.02
25	1.05	1.12	1.18	1.23	1.27
30	1.26	1.34	1.41	1.47	1.52
35	1.47	1.57	1.65	1.72	1.78
40	1.68	1.79	1.88	1.96	2.03
45	1.89	2.01	2.12	2.21	2.29
50	2.09	2.24	2.36	2.45	2.54
55	2.30	2.46	2.59	2.70	2.79
60	2.51	2.69	2.83	2.95	3.05
65	2.72	2.91	3.06	3.19	3.30
70	2.93	3.13	3.30	3.44	3.55
75	3.14	3.36	3.53	3.68	3.81
80	3.35	3.58	3.77	3.93	4.06
85	3.56	3.81	4.01	4.17	4.32
90	3.77	4.03	4.24	4.42	4.57
92	3.85	4.12	4.34	4.52	4.67
94	3.94	4.21	4.43	4.62	4.77
96	4.02	4.30	4.52	4.71	4.87
98	4.11	4.39	4.62	4.81	4.98
100	4.19	4.48	4.71	4.91	5.08

Table 5: Anterior (Age/ Y)

Age/Y	20	40	60	80	100
0	2.019	1.978	1.919	1.853	1.784
5	2.017	1.976	1.917	1.851	1.782
10	2.009	1.968	1.910	1.844	1.775
15	1.997	1.956	1.898	1.832	1.764
20	1.979	1.938	1.881	1.815	1.748
25	1.955	1.916	1.858	1.794	1.728
30	1.926	1.887	1.831	1.768	1.702
35	1.892	1.853	1.798	1.736	1.672
40	1.851	1.813	1.759	1.698	1.635
45	1.803	1.767	1.714	1.655	1.593
50	1.749	1.713	1.662	1.605	1.545
55	1.687	1.652	1.603	1.547	1.490
60	1.615	1.583	1.535	1.482	1.427
65	1.535	1.503	1.459	1.408	1.356
70	1.442	1.413	1.371	1.323	1.274
75	1.336	1.309	1.270	1.226	1.180
80	1.212	1.187	1.152	1.112	1.071
85	1.064	1.042	1.011	0.976	0.940
90	0.880	0.862	0.837	0.808	0.778
92	0.791	0.775	0.752	0.726	0.699
94	0.689	0.675	0.655	0.632	0.609
96	0.565	0.554	0.537	0.519	0.500
98	0.402	0.394	0.382	0.369	0.355
100	0.000	0.000	0.000	0.000	0.000

Table 6: Posterior (Age/ X)

Age/X	20	40	60	80	100
0	0.00	0.00	0.00	0.00	0.00
5	0.21	0.22	0.24	0.25	0.25
10	0.42	0.45	0.47	0.49	0.51
15	0.63	0.67	0.71	0.74	0.76
20	0.84	0.90	0.94	0.98	1.02
25	1.05	1.12	1.18	1.23	1.27
30	1.26	1.34	1.41	1.47	1.52
35	1.47	1.57	1.65	1.72	1.78
40	1.68	1.79	1.88	1.96	2.03
45	1.89	2.01	2.12	2.21	2.29
50	2.09	2.24	2.36	2.45	2.54
55	2.30	2.46	2.59	2.70	2.79

Age/X	20	40	60	80	100
60	2.51	2.69	2.83	2.95	3.05
65	2.72	2.91	3.06	3.19	3.30
70	2.93	3.13	3.30	3.44	3.55
75	3.14	3.36	3.53	3.68	3.81
80	3.35	3.58	3.77	3.93	4.06
85	3.56	3.81	4.01	4.17	4.32
90	3.77	4.03	4.24	4.42	4.57
92	3.85	4.12	4.34	4.52	4.67
94	3.94	4.21	4.43	4.62	4.77
96	4.02	4.30	4.52	4.71	4.87
98	4.11	4.39	4.62	4.81	4.98
100	4.19	4.48	4.71	4.91	5.08

Table 7: Posterior (Age/ Y)

Age/Y	20	40	60	80	100
0	-1.951	-2.292	-2.651	-3.017	-3.386
5	-1.948	-2.289	-2.647	-3.013	-3.381
10	-1.941	-2.280	-2.637	-3.002	-3.369
15	-1.929	-2.266	-2.621	-2.983	-3.347
20	-1.911	-2.245	-2.597	-2.956	-3.317
25	-1.889	-2.219	-2.566	-2.921	-3.278
30	-1.861	-2.186	-2.529	-2.878	-3.230
35	-1.827	-2.147	-2.483	-2.826	-3.171
40	-1.788	-2.100	-2.429	-2.765	-3.103
45	-1.742	-2.046	-2.367	-2.694	-3.023
50	-1.689	-1.985	-2.296	-2.613	-2.932
55	-1.629	-1.914	-2.214	-2.520	-2.828
60	-1.561	-1.833	-2.121	-2.414	-2.709
65	-1.482	-1.741	-2.014	-2.293	-2.573
70	-1.393	-1.637	-1.893	-2.155	-2.418
75	-1.290	-1.516	-1.753	-1.996	-2.239
80	-1.170	-1.375	-1.590	-1.810	-2.031
85	-1.028	-1.207	-1.396	-1.589	-1.783
90	-0.850	-0.999	-1.155	-1.315	-1.476
92	-0.764	-0.898	-1.039	-1.182	-1.327
94	-0.666	-0.782	-0.904	-1.029	-1.155
96	-0.546	-0.642	-0.742	-0.845	-0.948
98	-0.388	-0.456	-0.527	-0.600	-0.674
100	0.000	0.000	0.000	0.000	0.000

Table 8: Age-Related Variations in Human Crystalline Lens Parameters Based on OCT Measurements- X Axis

Age/X	20	40	60	80	100
0	0.00	0.00	0.00	0.00	0.00
5	0.21	0.22	0.24	0.25	0.25
10	0.42	0.45	0.47	0.49	0.51
15	0.63	0.67	0.71	0.74	0.76
20	0.84	0.90	0.94	0.98	1.02
25	1.05	1.12	1.18	1.23	1.27
30	1.26	1.34	1.41	1.47	1.52
35	1.47	1.57	1.65	1.72	1.78
40	1.68	1.79	1.88	1.96	2.03
45	1.89	2.01	2.12	2.21	2.29
50	2.09	2.24	2.36	2.45	2.54
55	2.30	2.46	2.59	2.70	2.79
60	2.51	2.69	2.83	2.95	3.05
65	2.72	2.91	3.06	3.19	3.30
70	2.93	3.13	3.30	3.44	3.55
75	3.14	3.36	3.53	3.68	3.81
80	3.35	3.58	3.77	3.93	4.06
85	3.56	3.81	4.01	4.17	4.32
90	3.77	4.03	4.24	4.42	4.57
92	3.85	4.12	4.34	4.52	4.67
94	3.94	4.21	4.43	4.62	4.77
96	4.02	4.30	4.52	4.71	4.87
98	4.11	4.39	4.62	4.81	4.98
100	4.19	4.48	4.71	4.91	5.08
98.00	4.11	4.39	4.62	4.81	4.98
96.00	4.02	4.30	4.52	4.71	4.87
94.00	3.94	4.21	4.43	4.62	4.77
92.00	3.85	4.12	4.34	4.52	4.67
90.00	3.77	4.03	4.24	4.42	4.57
85.00	3.56	3.81	4.01	4.17	4.32
80.00	3.35	3.58	3.77	3.93	4.06
75.00	3.14	3.36	3.53	3.68	3.81
70.00	2.93	3.13	3.30	3.44	3.55
65.00	2.72	2.91	3.06	3.19	3.30
60.00	2.51	2.69	2.83	2.95	3.05
55.00	2.30	2.46	2.59	2.70	2.79
50.00	2.09	2.24	2.36	2.45	2.54
45.00	1.89	2.01	2.12	2.21	2.29

Age/X	20	40	60	80	100
40.00	1.68	1.79	1.88	1.96	2.03
35.00	1.47	1.57	1.65	1.72	1.78
30.00	1.26	1.34	1.41	1.47	1.52
25.00	1.05	1.12	1.18	1.23	1.27
20.00	0.84	0.90	0.94	0.98	1.02
15.00	0.63	0.67	0.71	0.74	0.76
10.00	0.42	0.45	0.47	0.49	0.51
5.00	0.21	0.22	0.24	0.25	0.25
0.00	0.00	0.00	0.00	0.00	0.00

Table 9: Age-Related Variations in Human Crystalline Lens Parameters Based on OCT Measurements- Y Axis

Age/Y	20 year	40 year	60 year	80 year	100 year
0	2.02	1.98	1.92	1.85	1.78
5	2.02	1.98	1.92	1.85	1.78
10	2.01	1.97	1.91	1.84	1.78
15	2.00	1.96	1.90	1.83	1.76
20	1.98	1.94	1.88	1.82	1.75
25	1.96	1.92	1.86	1.79	1.73
30	1.93	1.89	1.83	1.77	1.70
35	1.89	1.85	1.80	1.74	1.67
40	1.85	1.81	1.76	1.70	1.64
45	1.80	1.77	1.71	1.65	1.59
50	1.75	1.71	1.66	1.60	1.55
55	1.69	1.65	1.60	1.55	1.49
60	1.62	1.58	1.54	1.48	1.43
65	1.53	1.50	1.46	1.41	1.36
70	1.44	1.41	1.37	1.32	1.27
75	1.34	1.31	1.27	1.23	1.18
80	1.21	1.19	1.15	1.11	1.07
85	1.06	1.04	1.01	0.98	0.94
90	0.88	0.86	0.84	0.81	0.78
92	0.79	0.78	0.75	0.73	0.70
94	0.69	0.67	0.65	0.63	0.61
96	0.57	0.55	0.54	0.52	0.50
98	0.40	0.39	0.38	0.37	0.36
100	0.00	0.00	0.00	0.00	0.00
98.00	-0.39	-0.46	-0.53	-0.60	-0.67
96.00	-0.55	-0.64	-0.74	-0.84	-0.95
94.00	-0.67	-0.78	-0.90	-1.03	-1.16

Age/Y	20 year	40 year	60 year	80 year	100 year
92.00	-0.76	-0.90	-1.04	-1.18	-1.33
90.00	-0.85	-1.00	-1.16	-1.32	-1.48
85.00	-1.03	-1.21	-1.40	-1.59	-1.78
80.00	-1.17	-1.37	-1.59	-1.81	-2.03
75.00	-1.29	-1.52	-1.75	-2.00	-2.24
70.00	-1.39	-1.64	-1.89	-2.15	-2.42
65.00	-1.48	-1.74	-2.01	-2.29	-2.57
60.00	-1.56	-1.83	-2.12	-2.41	-2.71
55.00	-1.63	-1.91	-2.21	-2.52	-2.83
50.00	-1.69	-1.98	-2.30	-2.61	-2.93
45.00	-1.74	-2.05	-2.37	-2.69	-3.02
40.00	-1.79	-2.10	-2.43	-2.77	-3.10
35.00	-1.83	-2.15	-2.48	-2.83	-3.17
30.00	-1.86	-2.19	-2.53	-2.88	-3.23
25.00	-1.89	-2.22	-2.57	-2.92	-3.28
20.00	-1.91	-2.25	-2.60	-2.96	-3.32
15.00	-1.93	-2.27	-2.62	-2.98	-3.35
10.00	-1.94	-2.28	-2.64	-3.00	-3.37
5.00	-1.95	-2.29	-2.65	-3.01	-3.38
0.00	-1.95	-2.29	-2.65	-3.02	-3.39

Table 10: Comprehensive List of Age-Related Changes In Lens Geometry

LT (mm)	LTant (mm)	LTpost (mm)	RAL (mm)	RPL (mm)	A (mm)	RAL_LTant (mm)	RPL_LTpost (mm)	RALRatio	RPLRatio	LT_Calculated
3.97	1.74	2.23	8.69	5.75	4.39	11.05	8.62	0.79	0.67	19.67
4.05	1.76	2.29	9.05	5.84	4.44	11.21	8.64	0.81	0.68	19.85
4.12	1.78	2.34	9.41	5.93	4.50	11.38	8.65	0.83	0.69	20.03
4.20	1.80	2.40	9.77	6.02	4.56	11.54	8.67	0.85	0.69	20.21
4.27	1.82	2.45	10.13	6.11	4.62	11.70	8.69	0.87	0.70	20.40
4.35	1.84	2.51	10.49	6.20	4.67	11.87	8.72	0.88	0.71	20.58
4.42	1.86	2.56	10.85	6.29	4.73	12.03	8.74	0.90	0.72	20.77
4.50	1.88	2.62	11.21	6.38	4.79	12.19	8.76	0.92	0.73	20.96
4.57	1.90	2.67	11.57	6.47	4.85	12.35	8.79	0.94	0.74	21.15
4.65	1.92	2.73	11.93	6.56	4.90	12.52	8.82	0.95	0.74	21.34
4.72	1.94	2.78	12.29	6.65	4.96	12.68	8.85	0.97	0.75	21.53
4.80	1.96	2.84	12.65	6.74	5.02	12.84	8.88	0.98	0.76	21.72
4.87	1.98	2.89	13.01	6.83	5.08	13.01	8.91	1.00	0.77	21.92
4.95	2.00	2.95	13.37	6.92	5.13	13.17	8.94	1.02	0.77	22.12
5.02	2.02	3.00	13.73	7.01	5.19	13.33	8.98	1.03	0.78	22.31
5.10	2.04	3.06	14.09	7.10	5.25	13.50	9.01	1.04	0.79	22.51
5.17	2.06	3.11	14.45	7.19	5.31	13.66	9.05	1.06	0.79	22.71

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