The Egyptian Journal of Hospital Medicine (October 2021) Vol. 85 (2), Page 4042-4045

Macular Thickness Variations with Axial Length in Healthy Individuals: Review Article

Amena Abdullah Mohammed*, Kamal Abdelmoniem Solaiman, Medhat Mohammed Shawky, Mostafa Abdullah Abdulaziz

Ophthalmology Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding Author:** Amena Abdullah Mohammed, **E-Mail:** amenaalshrif@gmail.com

ABSTRACT

Background: In the diagnosis and evaluation of many visual illnesses, such as macular edema, macular thickness is an important metric. Gender, age, ethnicity, refraction, and axial length all have an effect on the retinal macular thickness. Preoperative calculations of intraocular lens power during cataract surgery and myopia research necessitate precise and accurate measurements of axial eye length.

Objective: To assess the macular thickness in eyes with no ocular pathology, which is important because it serves as a reference for the consequent diagnosis, and to assess the effectiveness of treatment for various macula-related illnesses.

Conclusion: Thickness of macula is not the same in all eyes, as it expected to vary with change of eye axial length, which can guide and help in various ocular diseases.

INTRODUCTION

Ophthalmic illnesses that affect the retina, such as macular degeneration, can be accurately diagnosed and treated by measuring the thickness of the retinal pigment epithelium (RPE). Thus, understanding the typical thickness and distribution is critical in diagnosing macular thickening in various ocular illnesses [(1)].

Noninvasive optical coherence tomography (OCT) allows doctors to quantify and consistently track the progression of macular thickness**.** There is a wide range of thicknesses in the macular region determined by OCT, with values ranging from 190 to 387 micrometers. The retinal thickness decreases with age in both the macular and other retinal areas, according to research [(1)].

The aim of the present review was to assess the macular thickness in eyes with no ocular pathology, which is is important because it serves as a reference for the consequent diagnosis, and to assess the effectiveness of treatment for various macula-related illnesses.

Macula:

Human eyes have an oval-shaped pigmented area known as the macula lutea, in the center of the retina. It is estimated that the diameter of the macula in humans is around 5.5 mm, and it is split into the foveola, foveal avascular zone, fovea, parafovea, and perifovea regions (Figure 1).

When compared to the clinical macula, the anatomical macula is substantially larger**.** Because the macula is crucial for central high-resolution and color vision, if the macula is diseased, such as in macular degeneration, the vision is much affected [(2)].

By the ophthalmoscopy or retinal imaging, the clinical macula can be viewed through the pupil. Its name macula lutea derived from the Latin macula meaning "spot," and lutea meaning "yellow" [(2)].

Due to presences of xanthophyll pigments, lutein and zeaxanthin, the macula appears darker and yellowish in color [(3, 4)].

They can be found all over the retina, but the macula has the highest concentration [(5)].

These pigments are scanty in the newborn, but they build up during time through dietary sources. These pigments have a role of reducing chromatic aberration, as they absorb short wavelength visible light, they may also have an antioxidant action, and protect against UVR [(4)].

Received: 18/8/2021
Accepted: 4/10/2021

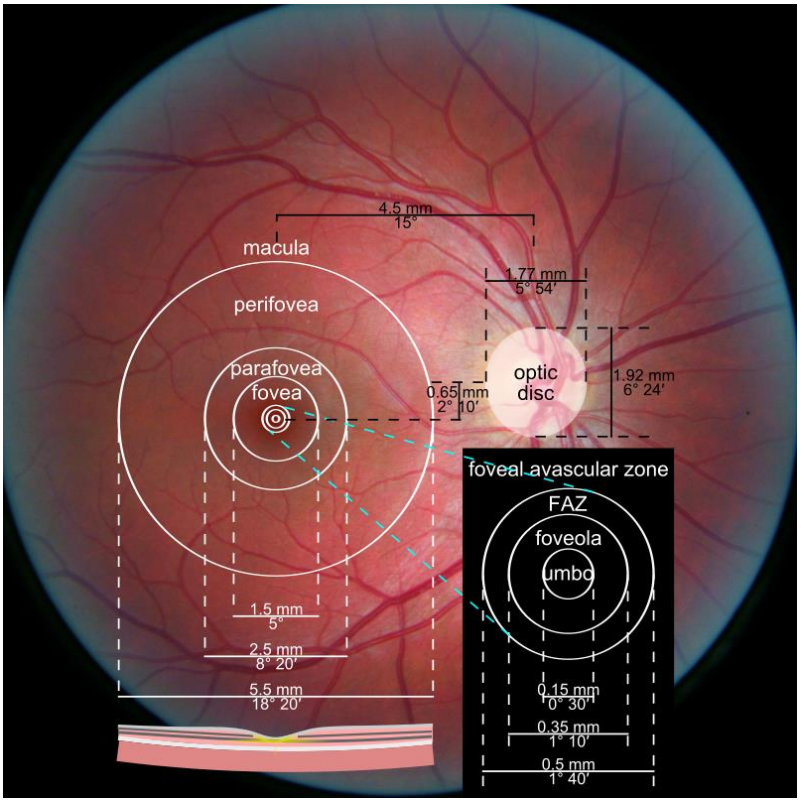

Figure (1): Retinal photo with overlay diagrams demonstrating where and how big macula, fovea, and optic disc are in the eye [(1)]

AXIAL LENGTH (AL):

Definition and Background:

The AL is the distance from the centre of anterior corneal surface to an interference peak corresponding to the retinal pigment epithelium; Bruch′s membrane. Optical or ultrasonic methods can be used to measure it. This could then be done through immersion techniques or direct contact. Use a combination of both methods provides more accurate measurement. Non-contact technologies like intra ocular lens (IOL) master offer the advantage of better accuracy, however dense cataracts can be imprecise when using optical approaches. Before, the gold standard was contact ultrasound measurements. However, because of corneal stress, contact ultrasound measurements are more likely to have subjective mistakes. A broad range of results might result from immersion because of its lack of control over the alignment of the corneas. As a result, combining several methods can yield superior results [(6)].

Almost all current formulas include it as a key input. In short eyes, IOL power is boosted by 2.5 to 3 times compared to long eyes. It's possible to do this with the use of optical or ultrasonic means (contact or immersion) (IOL Master and Lenstar). Ultrasonography, which employs mechanical waves, can be used to estimate the time it takes for a pulse to travel from the cornea to the retina. Depending on the medium, sound travels at different speeds: 1641 m/s for the lens and cornea, and 1532 m/s for aqueous and vitreous. This is then translated into a measure of distance using: Distance (m) = time (s) X velocity (m/s)[(7)].

In normal phakic eye the sound travels at an average speed of 1555 meters per second. Applanation and immersion ultrasonography both have advantages and disadvantages. Applanation is more inaccurate because to indentation, but immersion allows for more precise measurements. Optical methods employ a partial coherence laser to measure AL. Infrared light travels from the cornea to the retina in a similar manner to ultrasonography, however optical approaches use the interferometry principle thus avoiding the issue of measuring extremely high light speeds. There are no indentation mistakes because it is a non-contact method. Optical procedures can be performed using one of two instruments. Zooming in with the Zeiss IOL Master or the Haag-Streit Lenstar. IOL Master, Lenstar, and immersion ultrasonography all measured AL the same way, with no statistically significant differences. Adults' normal phakic eyes have an AL of about 24 mm [(8)].

Age Variation:

In order to better grasp complex visual pathophysiologic processes, it is necessary to study eye development. The eye's differentiation and maturation is influenced by a variety of variables. Genetic variables are by far the most significant. Ocular tissues can develop and mature in a non-physiologic manner due to neural input, refractive error, and other systemic pathological conditions [(9, 10)].

From front to back, a normal newborn's eyeball length is approximately 16 millimeters in diameter (axial length). The length of an infant's eye rises slightly to

about 19.5 millimeters during infancy and reach about 24-25 millimeters, which is the length of the adult eye at this point of development [6].

After a few months of rapid axial length elongation, which occur in the first 3 to 6 months after birth, growth slows down for the next two years, and by the time a three-year-old is born, he or she has reached adult size [11].

According to large-scale studies on the development of the eye's ocular components, the emmetropic axial length of the eye is attained by the age of 13 years. As the anterior chamber reaches its maximum depth and the crystalline lens its minimum thickness around the age of 15 years, it is also found that the crystalline lens lowers its power throughout the gradual coordinated growing stage of the eye in childhood. There is a range of 22-25 mm axial length for adults and a range of refractive power of -25.0 - +1.0 D [6].

Due to an increase in axial length, the most prevalent long-term refractive error following cataract surgery in children is myopia [12].

Importance of Measuring AL:

An IOL calculation is made using the SRK-T, Hoffer-Q, or Holladay II equation, among others. When applied to the pediatric population, these calculations may result in refractive errors due to assumptions made in the formulas, such as the corneal curvature. Preoperative evaluation of amblyopic children by pediatric cataract surgeons may be aided by the current collection, which provides the most comprehensive data set to date on axial length growth in normally developing children's eyes [10].

Pathological axial myopia can result in potentially life-threatening visual problems. Retinal detachment, staphyloma, schisis, subretinal neovascularization, and tilted optic nerve head are among the conditions that may cause amblyopia [13].

Early identification and therapy may be possible using an axial length growth model. As a child grows, the dosage of atropine can be adjusted accordingly. Patients with congenital glaucoma may also benefit from the new model's diagnostic and management capabilities. Using this technique and chart to monitor pediatric glaucoma will be essential. In children, glaucoma damage can lead to an increase in axial length, which can be used as an additional tool for ophthalmologists in their decision-making and treatment of this blinding disease [10].

Macular Thickness and Axial Length Are Linked:

Some investigations have shown that an increase in axial length causes the sclera at the posterior pole to be mechanically stretched, resulting in vitreal traction on the fovea, which causes it to thicken [14]. Another study found that myopic eyes' retinas were stretched in response to ocular development, resulting in a reconstructed fovea. Foveal reconstruction results in a reduction in thickness of the parafoveal tissue. The fovea was thicker, the parafovea and perifovea were thinner, and the axial length was longer. In high myopia eyes with an axial length of 25.5 mm or more, the thickness and contour of the outer macula could be changed more by axial elongation. The authors of the study came at the conclusion that until an axial length of 25.5 mm, the mean foveal thickness did not grow considerably, with increased thickness beginning at 25.5–26.0 mm. With increasing axial elongation, the parafoveal and perifoveal thicknesses decreased, and the slope steepened at a 25.5 mm axial length [15].

A possible correlation between retinal thinning and elongation is possible. Thus, the AL and the degree of refractive error may be associated with the thickness of the macular tissue in the fovea and parafovea [16]. According to previous studies, it has been found that myopic expansion of the globe was mostly due to axial lengthening, with just a small amount of growth in the horizontal and vertical globe diameters [17]. According to research, larger axial lengths resulted in an increase in disc-to-fovea distance, although the length of macular Bruch's membrane did not differ between the two groups [18].

Due to the formation and expansion of the parapapillary gamma zone, which is a region of the temporal optic disc border free of Bruch's membrane, the disc-fovea distance increases [18, 19]. Macular thickness should not be influenced by increased axial length of Bruch's membrane in the macular region if Bruch's membrane does not lengthen. This is because the retinal pigment epithelium and connected photoreceptors are anchored to Bruch's membrane [20].

Retinal thickening was linked with axial globe length in the pre-equatorial and equatorial regions; however, the foveal retinal thickness was mostly unaffected by axial length in myopic subjects Elongation is most likely to occur in the eye's anterior and posterior regions, according to research [21].

CONCLUSION

Macular thickness is not the same in all eyes, as it expected to vary with change in the axial length of the eye, which can guide and help in various ocular diseases.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

REFERENCES

1. **Gupta P, Sidhartha E, Tham Y *et al.* (2013)**. Determinants of macular thickness using spectral domain optical coherence tomography in healthy eyes: the Singapore Chinese Eye study. Investigative Ophthalmology & Visual Science, 54(13): 7968–7976.
2. **Kolb H, Fernandez E, Nelson R (2011):** Simple anatomy of the retina. The organization of the retina and visual system, Webvision (available website). https://webvision.med.utah. edu/book/part-i-foundations/simple-anatomy-of-the-retina.

3. **Park S, Sigelman J, Gragoudas E (1994):** The anatomy and cell biology of the retina. In Tasman W, Jaeger EA, editors: Duane's foundations of clinical ophthalmology, vol 1, Philadelphia, Lippincott. https://iovs.arvojournals.org/article.aspx?articleid=2126713
4. **Rapp L, Maple S, Choi J (2000):** Lutein and zeaxanthin concentrations in rod outer segment membranes from perifoveal and peripheral human retina. Invest Ophthalmol Vis Sci., 41: 1200-1205.
5. **La Cour M, Ehinger B (2006):** The Retina. The biology of the eye, Fischbarg J, ed. Amsterdam, the Netherlands, Elsevier, Pp. 195–252.
6. **Sahin A, Hamrah P (2012):** Clinically relevant biometry. Curr Opin Ophthalmol., 23:47–53.
7. **Bhardwaj V, Rajeshbhai G (2013):** Axial length, anterior chamber depth-a study in different age groups and refractive errors. J Clin Diagn Res., 7(10):2211-2212.
8. **Tadros D, Trivedi R, Wilson M *et al.* (2016):** Ocular axial growth in pseudophakic eyes of patients operated for monocular infantile cataract: a comparison of operated and fellow eyes measured at surgery and 5 or more years later. J AAPOS., 20(3):210–213.
9. **Bach A, Villegas V, Gold A *et al.* (2019):** Axial length development in children. Int J Ophthalmol., 12(5):815-819.
10. **Hou W, Norton T, Hyman L *et al.* (2018):** Axial elongation in myopic children and its association with myopia progression in the correction of myopia evaluation trial. Eye Contact Lens, 44(4): 248-259.
11. **Delshad S, Collins M, Read S *et al.* (2020):** The human axial length and choroidal thickness responses to continuous and alternating episodes of myopic and hyperopic blur. PLoS One, 15(12): 243-46.
12. **Plager D, Kipfer H, Sprunger D *et al.* (2002):** Refractive change in pediatric pseudophakia: 6-year follow-up. J Cataract Refract Surg., 28(5):810–815.
13. **Ohno-Matsui K, Wu P, Yamashiro K *et al.* (2021):** IMI pathologic myopia. Invest Ophthalmol Vis Sci., 62(5): 5-9.
14. **Huang J, McAlinden C, Huang Y *et al.* (2017):** Meta-analysis of optical low-coherence reflectometry versus partial coherence interferometry biometry. Sci Rep., 7: 43414**.**
15. **Dubis A, McAllister J, Carroll J (2009):** Reconstructing foveal pit morphology from optical coherence tomography imaging. British Journal of Ophthalmology, 93: 1223-1227.
16. **Sarhan A, Zaky M, Hassan B (2020):** Determining the correlation between axial length/spherical equivalent and macular thickness in myopia. Menoufia Medical Journal, 33(2): 534-539.
17. **Vurgese S, Panda-Jonas S, Jonas J (2012):** Scleral thickness in human eyes. PLoS One, 7: 296-302.
18. **Jonas R, Wang Y, Yang H *et al.* (2015):** Optic disc-fovea distance, axial length and parapapillary zones. The Beijing Eye Study 2011. PLoS One, 10: 138-143.
19. **Jonas J, Jonas S, Jonas R *et al.* (2012):** Parapapillary atrophy: histological gamma zone and delta zone. PLoS One, 7: 37-43.
20. **Yin G, Wang Y, Zheng Z *et al.* (2012):** Ocular axial length and its associations in Chinese. The Beijing Eye Study. PLoS One, 7: 72-76.
21. **Jonas J, Xu L, Wei W *et al.* (2016):** Retinal thickness and axial length. Investigative Ophthalmology & Visual Science, 57: 1791-1797**.**