



A comparative study of the discrepancy in the horizontal white- to-white measurement using Calipers Vs. Pentacam

Thesis

**Submitted for partial fulfilment of Masters
Degree in Ophthalmology**

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Cairo - 2018

Introduction

The horizontal corneal white-to-white (WTW) diameter measurement is an essential value and has multiple applications in the field of ophthalmology. It is defined as the distance between the two corneal limbal areas horizontally (Chen and Osher, 2016).

There are many means of measuring the horizontal WTW, which includes the Pentacam, the IOL Master and Manual Calipers. Both the Pentacam and Manual Calipers measure the external white-to-white diameter, whereas the IOL Master measures the internal white-to-white diameter.

The current accepted standards of normal horizontal WTW diameter as seen in **Figure 1**, is greater than 11.0 mm and less than 13.0 mm (Chen and Osher, 2016).

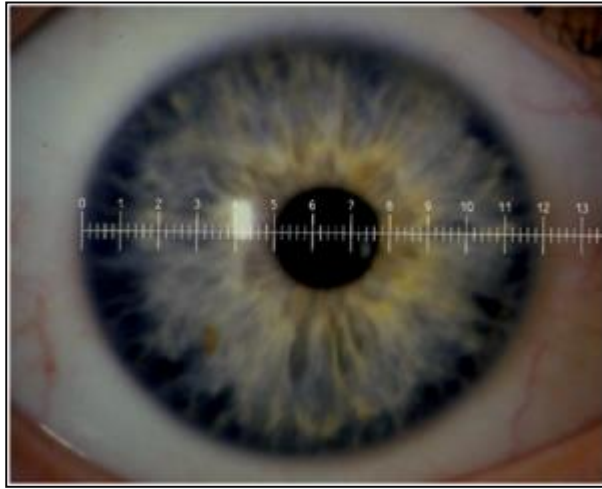


Figure 1 Horizontal Corneal White-to-White Diameter (Photo by specialeyesqc.com)

The Pentacam HR (OCULUS, Germany) is a device that combines a rotating Scheimpflug camera with a static camera to acquire multiple photographs of the anterior eye segment. The Scheimpflug camera rotates along with a monochromatic slit light source around the optical axis to obtain the slit images. This rotating system performs a corneal scan from zero to 180 degrees and each of the photographs is an image of the cornea at a specific angle as seen in **Figure 2**. It also has a WTW camera, to automatically measure the horizontal WTW diameter of the cornea (Sinjab, 2015).

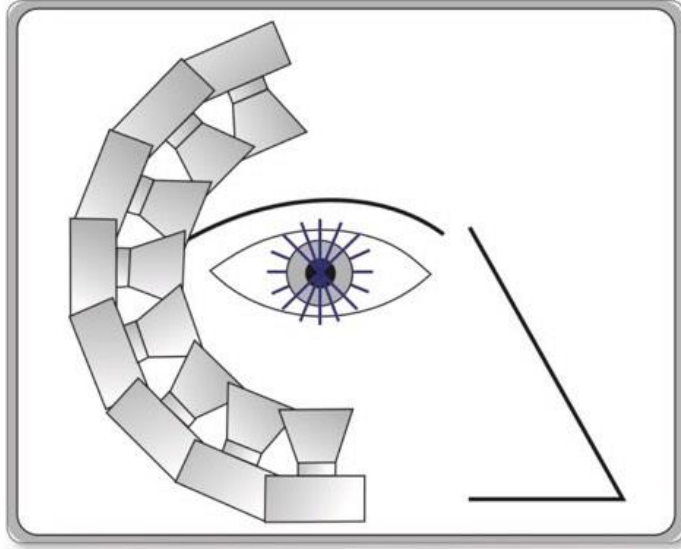


Figure 2 The rotating Scheimpflug Camera (Image by Sinjab MM, Step by Step: Reading Pentacam Topography, 2015)

The IOL Master is considered to be the Gold Standard in optical biometry. It uses the principle of Partial Coherence Interferometry (PCI) to obtain the axial length of the eye with high precision and hence calculating the intraocular lens (IOL) power. The IOL Master also automatically measures the horizontal white-to-white diameter of the cornea as shown in **Figure 3** (Akman *et al.*, 2016).

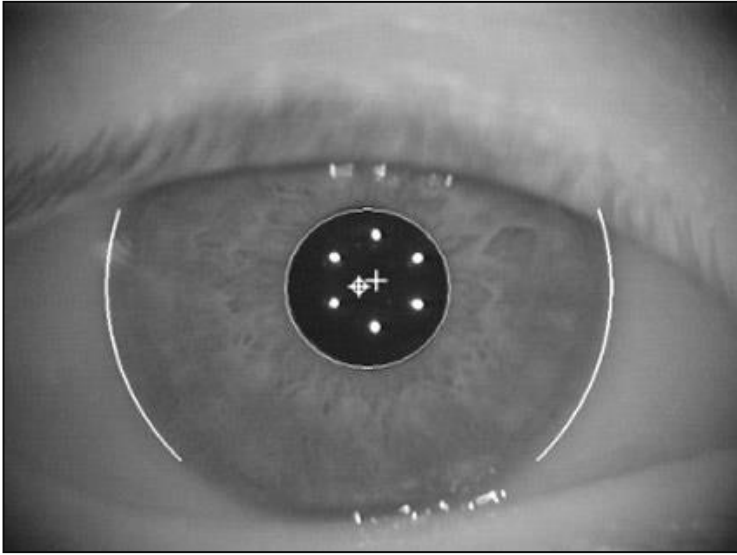


Figure 3 The view of the horizontal white-to-white measurement screen as seen with the IOL Master (Photo by Bradley D. Strong, MD)

As for the Manual Calipers, we will be using the Bausch & Lomb Storz Ophthalmics E-2404 Castroviejo Caliper seen in **Figure 4**, which measures from 0 to 20 mm in 0.5 mm increments, with a scale reading on both sides. The measurement will be performed under the slit lamp biomicroscope.

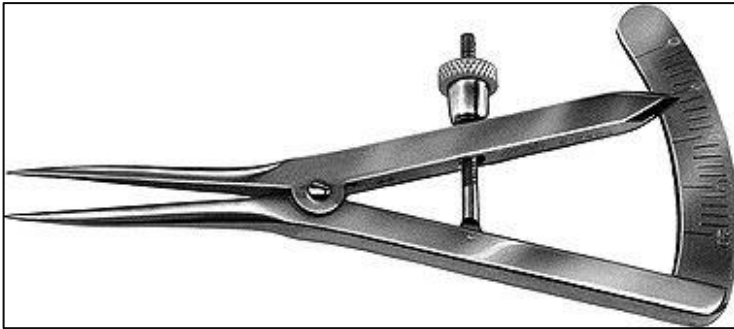


Figure 4 The Bausch & Lomb Storz Ophthalmics E-2404 Castroviejo Caliper (Photo by storzeve.com)

There are many clinical uses of the horizontal WTW measurement, including identification of:

- Microphthalmia
- Relative Anterior Microphthalmia
- Microcornea
- Macrophthalmia
- Megalocornea
- Congenital Glaucoma

As from the surgical point of view, surgeons have relied on the horizontal WTW measurement for sizing of some types of intraocular lenses like Implantable Collamer Lenses (ICL) and angle supported phakic IOLs (Chen and Osher, 2016).

Aim of the Work

The aim of this study is to measure the accuracy of the Pentacam white-to-white camera in measuring the horizontal corneal WTW diameter in comparison to the Manual Calipers in the general population, which is considered to be the basic standard.

Chapter 1

Anatomy of the Anterior Segment

The cornea is the transparent anterior one fifth of the globe, covering the iris, pupil and the anterior chamber. It accounts for approximately two thirds of the total optical power of the eye, acting as its main refractive surface (Cassin and Solomon, 2011).

Moreover, it has unmyelinated nerve endings sensitive to touch and temperature. It does not have any blood vessels, but instead, it receives its oxygen and nourishment from the tear film and aqueous humour respectively (NEI, 2016).

The cornea appears to be oval from a front view, measuring approximately 12 mm horizontally and 11 mm vertically. This is because the sclera encroaches on the superior and inferior borders of the cornea. However, the cornea appears to be circular from its posterior aspect, measuring 11.7 mm all around (DelMonte and Kim, 2011)

It was always known that the cornea is formed of 5 layers, namely; epithelium, Bowman's membrane, stroma, Descemet's membrane and endothelium.

However, researchers in the United Kingdom have recently discovered a new layer in the cornea which they dubbed "Dua's Layer" after its main discoverer Professor Harinder S. Dua of the University of Nottingham (Dua *et al.*, 2013).

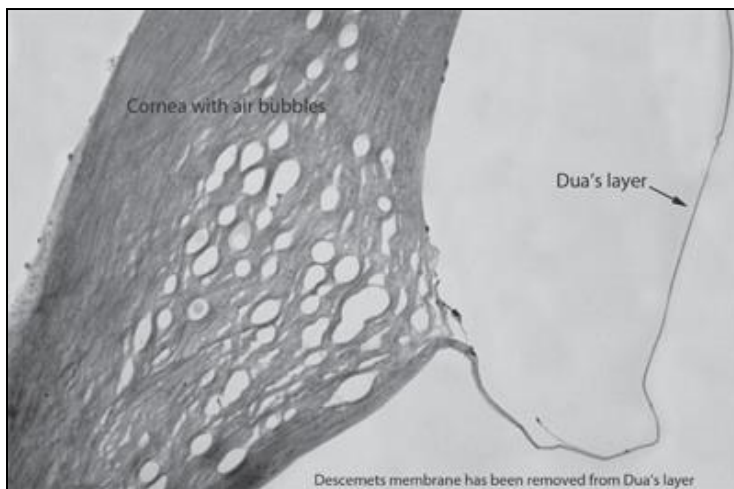


Figure 5 Electron Microscope image of a corneal graft, after researchers injected air in it, to separate the different layers of the cornea (Photo by Harinder S. Dua, 2013, MD, PhD)

It is defined as a tough, well defined, acellular lining about 10-15 μm thick, found between the corneal stroma and the Descemet's membrane. The discovery of this layer may have

implications in many conditions such as descemetocoele and acute corneal hydrops in keratoconus as well as its use in deep anterior lamellar keratoplasty (DALK) (Dua *et al.*, 2013).

The anterior chamber of the eye lies between the iris posteriorly and the cornea anteriorly. It has an average depth of 3 mm which can be increased in axial myopia or decreased in axial hypermetropia (Rhoades *et al.*, 2017).

The posterior chamber is bound by the iris and the ciliary body anteriorly and the lens and vitreous face posteriorly. It is connected to the anterior chamber through a small opening in the iris called the pupil (Rhoades *et al.*, 2017).

The angle of the anterior chamber lies at the junction of the cornea and the iris. It is of critical value due to its role in aqueous circulation through the conventional pathway. It is formed of the following structure from anterior to posterior arrangement: Schwalbe's line, trabecular meshwork, Schlemm's canal, scleral spur, anterior border of ciliary body and iris as shown in **Figure 6** (Rhoades *et al.*, 2017).

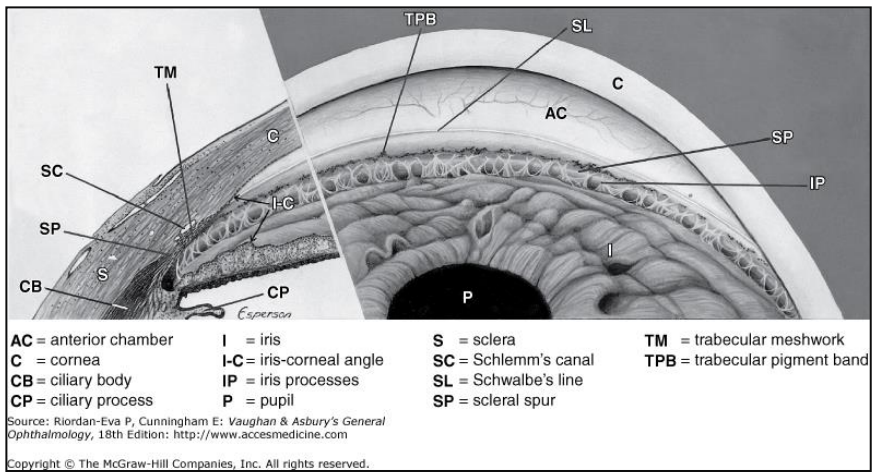


Figure 6 Structures of the angle of the anterior chamber (Image by Riordan-Eva P, Cunningham E. Vaughan & Asbury's General Ophthalmology, 18th edition, 2011)

The iris is a diaphragm, whose periphery is attached to the anteromedial aspect of the ciliary body. It is about 12 mm in diameter, 0.6 mm thick at the collarette (the thickest part) and 0.5 mm at the periphery. It has an opening slightly nasal to its centre called the pupil. The pupil is responsible for regulating the amount of light entering the eye (Bron *et al.*, 1998).

There are two slightly different WTW measurements that are used clinically within the field of Ophthalmology. The external WTW corneal diameter measurement, which corresponds to the distance between the two corneal limbal areas horizontally and the internal WTW corneal diameter, which corresponds to the distance between the two ends of the angle of the anterior

chamber horizontally, also known as the angle to angle (ATA) diameter.

The difference between the external WTW and the ATA diameter has not been consistently determined. Several studies were done and found that the ATA is larger than the external WTW by approximately 0.36 to 1.88 mm (Kohnen *et al.*, 2006; Wilczynski *et al.*, 2010).

While others found that the ATA diameter was significantly smaller than the WTW diameter by 0.49 to 0.92 mm. This is very important in determining the correct power for the anterior chamber lens implantation (Nemeth *et al.*, 2010; Pinero *et al.*, 2008).

Moreover, several studies were done since then to evaluate the difference between the external WTW diameter and the sulcus to sulcus (STS) diameter. Two recent studies by Kawamorita, et al and Reinstein, et al found significantly larger STS diameters as compared to WTW of 0.41 mm and 0.89 mm, respectively (Reinstein *et al.*, 2009; Kawamorita *et al.*, 2010). However, others have failed to find a statistically significant correlation between the external WTW and the STS diameter (Fea *et al.*, 2005; Werner *et al.*, 2004).

Chapter 2

Uses of Horizontal Corneal White-to-White Diameter

The horizontal corneal white to white diameter measurement has diverse clinical applications in the field of ophthalmology. In the clinic setting, it can be used to help in identifying and diagnosing multiple diseases and signs like:

- **Microphthalmia**

It is an abnormality of the eye balls that develops during neonatal period. In this condition, one or both eye balls are abnormally small. The antero-posterior diameter of the eye in adults is less than 20 mm. In children it is often significantly less than that. In severe cases, it should be distinguished from Anophthalmia in which there is a missing eyeball. It may or may not result in severe vision loss (Khan and Traboulsi, 2005).

- **Relative Anterior Microphthalmia**

It is a condition of the eyes, in which, the axial length is normal but there is a disproportionately smaller anterior chamber. A study done by Nihalani, Bharti R. et al in 2005 had the following inclusion criteria for RAM: horizontal corneal diameter ≤ 11 mm, anterior chamber depth ≤ 2.2 mm, axial length > 20 mm and no morphological malformations (Nihalani *et al.*, 2005).

- **Microcornea**

It is defined as a cornea less than 10 mm in diameter. It is thought that microcornea occurs secondary to an arrest in corneal development due to overgrowth of the tips of the optic cup (Nischal, 2002).

- **Macrophthalmia**

A condition where the eyeball is unusually large or the eyes are abnormally large in size due to anomalous eye development.

- **Megalocornea**

It is a rare non-progressive enlargement of the cornea ≥ 13 mm, associated with normal intraocular pressure. The cornea and limbus are enlarged but the cornea itself is histologically normal with normal thickness (Saatci *et al.*, 1997).



Figure 7 A case of Bilateral Megalocornea (Photo by Robert W. Enzenauer, MD)

- **Congenital Glaucoma**

It is defined as an increase in intraocular pressure that is present since birth, caused by improper development of the eye's aqueous outflow system, with consequent damage to the ocular structures, leading to loss of vision. It is an autosomal recessive trait (López-Garrido *et al.*, 2013).

Moreover, in the operating room, surgeons have relied upon the horizontal white to white diameter measurements in identifying the correct size for some types of intraocular lenses like for example:

- Haptic size calculation in angle-supported IOLs, anterior chamber IOLs and Implantable Collamer Lens.