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# Comparative Study of Anterior Chamber Angle and Depth Recorded with Pentacam and AS-OCT SD “Spectralis”

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### Authors' contributions

This work was carried out in collaboration between both authors. Author EP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NM managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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## ABSTRACT

**Aims:** To compare the anterior chamber angle values recorded by Pentacam and AS-OCT SD “Spectralis” (Heidelberg Engineering) and present the correlation between the two devices.

**Sample and Study Design:** A total of 50 patients were examined at the Private Ophthalmology Clinic O.M.M.A. Ophthalmological Institute. All participants volunteer to participate in this study where the data was kept anonymous. Patients aged 18-45 years without a pathological history were selected. All of them were emmetropes or with ametropia ranged  $\pm 0.75$  D. There was no separation between hyperopic, myopic or emmetropic patients.

**Place and Duration of Study:** University of West Attica Dept Biomedical Science Course Optics & Optometry in collaboration with Private Ophthalmology Clinic O.M.M.A. during the period between January 2019 to October 2019.

**Methodology:** In this study, two basic structures of the eye are measured with the help of two devices of different principle of operation. Specifically, the study of the angle of the anterior chamber (ACA) as well as the depth of the chamber (ACD). The two devices are compared.

**Results:** The ACA for both devices had mean difference of  $-2,004^\circ$  for the R.E. while the mean difference for L.E. was  $1,986^\circ$ . Pentacam arithmetic mean ACA (R.E.) was  $37,638 \pm 2,98^\circ$  and AS-

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OCT "Spectralis"  $35,766 \pm 2,90^\circ$  with Correlation coefficient 0,7063 ( $P < 0,0001$ ). Pentacam arithmetic mean ACA (L.E.) was  $37,638 \pm 2,98^\circ$  and AS-OCT "Spectralis"  $35,652 \pm 2,79^\circ$  with Correlation coefficient 0,7569 ( $P < 0,0001$ ). The ACD for both devices had mean difference of  $-0,3028$  for the R.E. while the mean difference for L.E. was  $-0,2860$ . Pentacam arithmetic mean ACD (R.E.) was  $3,5866 \pm 0,20$  and AS-OCT "Spectralis"  $3,2838 \pm 0,20$  with Correlation coefficient 0,4201 ( $P = 0,0024$ ). Pentacam arithmetic mean ACD (L.E.) was  $3,558 \pm 0,21$  and AS-OCT "Spectralis"  $3,2720 \pm 0,20$  with Correlation coefficient 0,4023 ( $P = 0,0038$ ).

**Conclusion:** Values of ACA measured by Pentacam and AS-OCT "Spectralis" were similar within the sample population of normal eyes right and left ( $P < 0,0001$ ). ACD measured by Pentacam and AS-OCT "Spectralis" showed also similar results the sample population of normal eyes for the right eye ( $P = 0,0024$ ) and left ( $P = 0,0038$ ).

**Keywords:** Anterior chamber angle; AS-optical coherence tomography; "Spectralis"; comparison; "Pentacam"; aqueous humor; anterior chamber depth.

## 1. INTRODUCTION

The anterior chamber is an area which is delimited by the back surface of the cornea, the endothelium and the anterior surface of the iris and the front capsule of the crystalline lens. The anterior chamber angle is formed peripherally from the end of the cornea to the end of the iris root. The anterior chamber angle contains the trabecular meshwork (TM), the scleral spur (SS), the ciliary body (CB) and the root of the iris. The depth of the anterior chamber is important because it determines the aqueous humor flow which is related to the intraocular pressure (IOP) of the eye [1,2,3,4].

The contents of the anterior chamber are the aqueous humor helps maintain intraocular pressure (IOP) and is involved in the metabolism of the avascular crystalline lens and cornea. It is produced at the ciliary body non-pigmented epithelium (a ring-shaped tissue) at a rate of, 2,4– 3,4  $\mu\text{l}/\text{min}$ . There is considerable variation in anterior chamber depth, depending on age, refractive error, and genetics. In general, in hyperopic patient, the central depth of the anterior chamber ranges from 3 mm to 3.5 mm, in emmetropes from 3.1 to 3.6 mm and in myopes from 3.3 to 3.8 mm. [4,5,6,7,8]

The depth of the anterior chamber decreases with age, most likely due to thickening of the lens. By the age of 15, the anterior chamber depth is between approximately 3.6-3.65 mm. At the ages of 15 to 35, this depth has been found between 3 mm and 3.7 mm, and between 35 and 55, ranging from 2.8 to 3.3 mm. [9,10,11,12, 13,14].

The intraocular pressure is constant (normal levels 15-20 mm Hg) [15,16]. If unregulated pressure above 20 mmHg causes pressure on the optic nerve causing atrophy of the optic fibers and nerve damage. The anterior chamber angle is an important anatomical structure for differentiating the two types of glaucoma: open-angle glaucoma, which is the most common type of glaucoma, and closed-angle glaucoma. Modern medical treatment of open-angle glaucoma aims to reduce the production of aqueous humor and increase the aqueous outflow.

Perhaps the most common marking system is based on the angle formed between the iris surface and the trabecular meshwork (Shaffer grading system) [17]. The clinical methods for assessing the anterior chamber angle and depth include the Pen torch method, Smith's method, Van Herrick's technique, Split limbal technique, Gonioscopy, Scheimpflug corneal topography systems based on Shiflung technique, OCT-Anterior (Optical Coherence Tomography). The first 5 methods are subjective because they rely on the clinician skill. The last two are objective and they should be evaluated for their correlation.

There has been a lot of researches that try to image and record ACA and ACD [18-25]. Different devices and different methodologies for ACA and ACD showed how important it is to know the values of the angle and the depth especially in glaucoma monitoring and treatment [26-31].

## 2. METHODOLOGY

The sample consists of 50 patients where both their eyes (R.E. & L.E.) were examined at the

Private Ophthalmology Clinic OMMA Ophthalmological Institute. All participants volunteer to participate in this study and their data was kept anonymous and they volunteered to participate

Patients aged 18-45 years without a pathological history were selected. All of them were emmetropes or with a low ametropia ranged  $\pm 0.75$  D. There was no separation between hyperopic, myopic or emmetropic patients. Pentacam uses a rotating Scheimpflug

camera and takes multiple images of the anterior segment of the eye. This generates three-dimensional images and calculate measurements of the eye especially anterior segment angle at 360°. The reference point and all the measurements for the anterior chamber angle was taken at the angle 90-270°. In the case of AS-OCT SD "Spectralis" (Heidelberg Engineering) all measurements derived from the manual recording of the operator. In the overview of the shot, the depth of the front chamber (ACD) is given.

Chart 1. Shaffer system

| Grade | Angle width | Description      | Risk of closure |
|-------|-------------|------------------|-----------------|
| 4     | 45° - 35°   | Wide open        | Impossible      |
| 3     | 35° -20°    | Wide open        | Impossible      |
| 2     | 20°         | Narrow           | Possible        |
| 1     | ≤ 10°       | Extremely narrow | Probable        |
| Slit  | Slit        | Narrowed to slit | Probable        |
| 0     | 0°          | Closed           | Closed          |

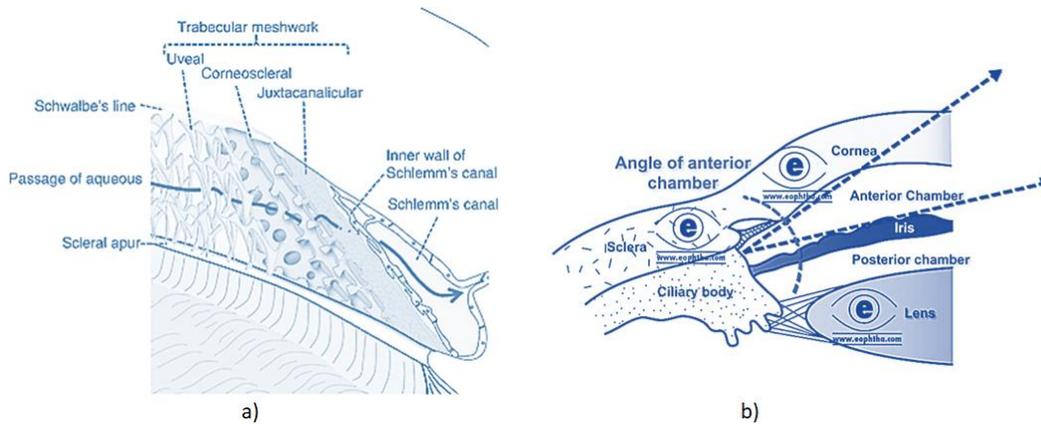


Fig. 1. Anatomy and delimitation of anterior chamber angle

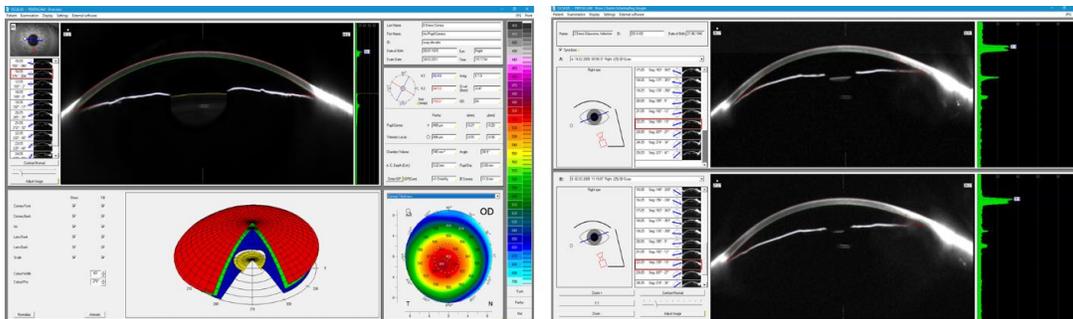
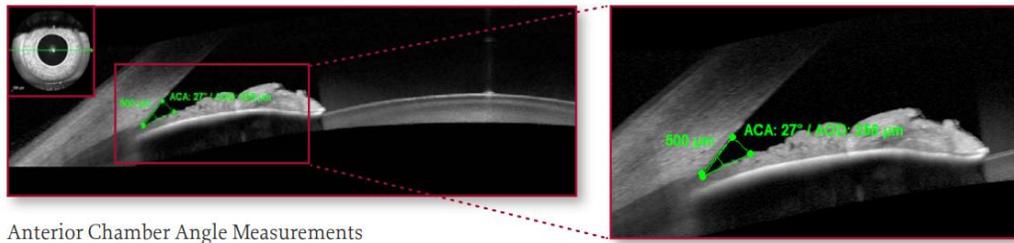


Fig. 2. Angle measurements all around the limbus and anterior chamber depth. Pentacam [32]



**Fig. 3. Angle measurement at the limbus and anterior chamber depth. AS-OCT “spectralis” heidelberg engineering [33]**

Unlike Pentacam the process of angle measurement is not automated and the result is directly related to the quality and skill of the operator's reception. Precisely for this reason we chose to use the angle located at 90-270°.

### 3. RESULTS AND DISCUSSION

#### 3.1 Statistical Study

The values for anterior chamber depth measured with Pentacam and AS-OCT SD “Spectralis” are given in the following Table 1.

The values of the comparison of the 2 devices for the R.E. are given in Table 2.

#### 3.2 Anterior Chamber Angle

Regarding the anterior chamber angle (ACA) the measurements taken with Pentacam and AS-OCT “Spectralis” are given in Table 5.

The values of the comparison of the 2 devices for the R.E. are given at the Table 6.

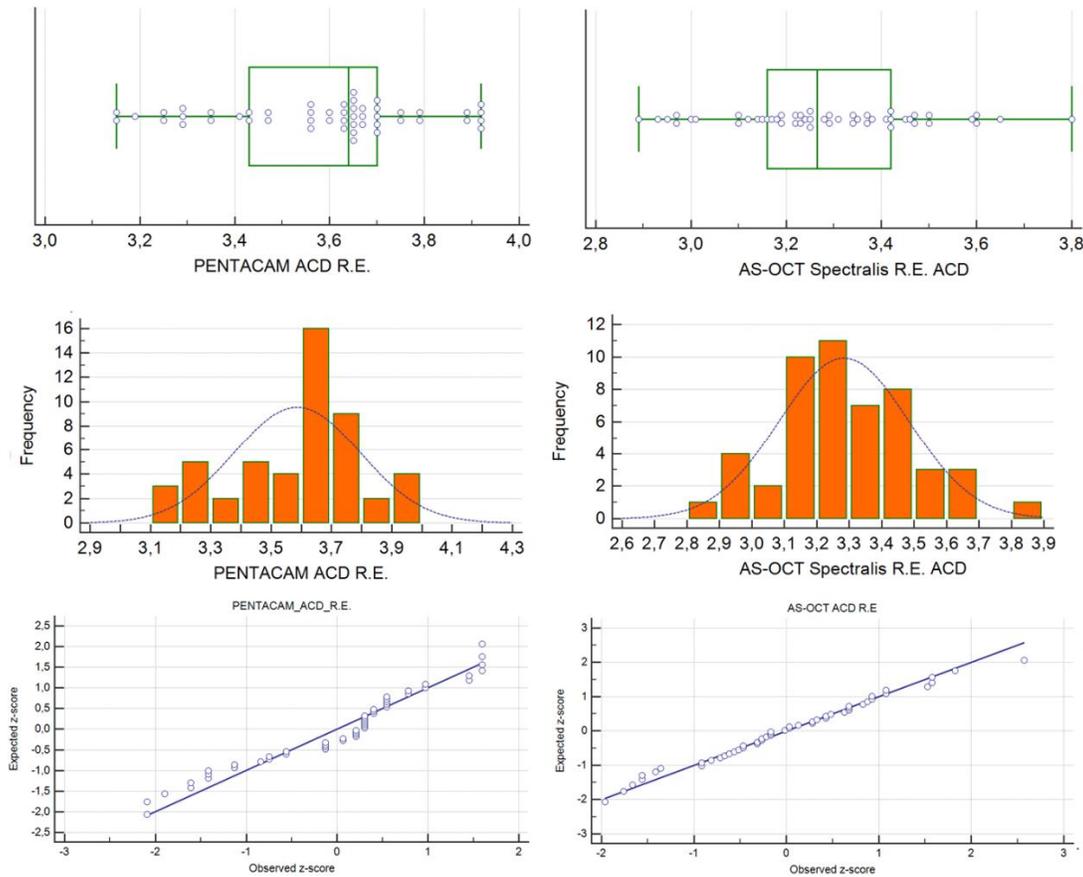
The Table 9 shows the correlation between these two devices for ACD and ACA.

**Table 1. Measurements of pentacam and AS-OCT “spectralis” for ACD (R.E.)**

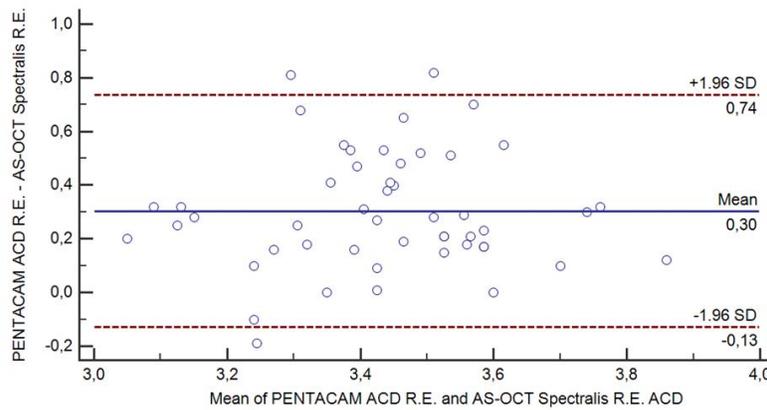
| Pentacam<br>R.E. Anterior chamber<br>depth |                    | AS-OCT SD “Spectralis”<br>R.E. Anterior chamber<br>depth |                    |
|--|--------------------|--|--------------------|
| Sample size                                | 50                 | Sample size  | 50                 |
| Arithmetic mean                            | 3,5866             | Arithmetic mean  | 3,2838             |
| 95% CI for the mean                        | 3,5272 to 3,6460   | 95% CI for the mean                                      | 3,2267 to 3,3409   |
| Median                                     | 3,6400             | Median   | 3,2650             |
| 95% CI for the median                      | 3,5600 to 3,6579   | 95% CI for the median                                    | 3,2200 to 3,3579   |
| Variance                                   | 0,04362            | Variance   | 0,04033            |
| Standard deviation                         | 0,2089             | Standard deviation                                       | 0,2008             |
| Coefficient of Skewness                    | -0,4329 (P=0,1888) | Coefficient of Skewness                                  | 0,1499 (P=0,6410)  |
| Coefficient of Kurtosis                    | -0,4353 (P=0,5344) | Coefficient of Kurtosis                                  | -0,1302 (P=0,9974) |

**Table 2. Results of t test and correlation coefficient for (R.E.)**

| Paired samples t-test                 | Pentacam R.E. Anterior chamber depth vs AS-OCT SD “Spectralis” R.E. Anterior chamber depth |
|---------------------------------------|--|
| Mean difference                       | -0,3028  |
| Standard deviation of mean difference | 0,2207   |
| Standard error of mean difference     | 0,03121  |
| 95% CI                                | -0,3655 to -0,2401   |
| Test statistic t                      | -9,702   |
| Two-tailed probability                | P < 0,0001   |
| Correlation coefficient r             | 0,4201   |
| Significance level                    | P=0,0024   |



**Fig. 4. Box-and-Whisker plot, histogram with normal curve, correlation scatter diagram with reduced major axis regression line for the right eye (R.E.) of ACD measurements with Pentacam and AS-OCT “Spectralis” respectively.**



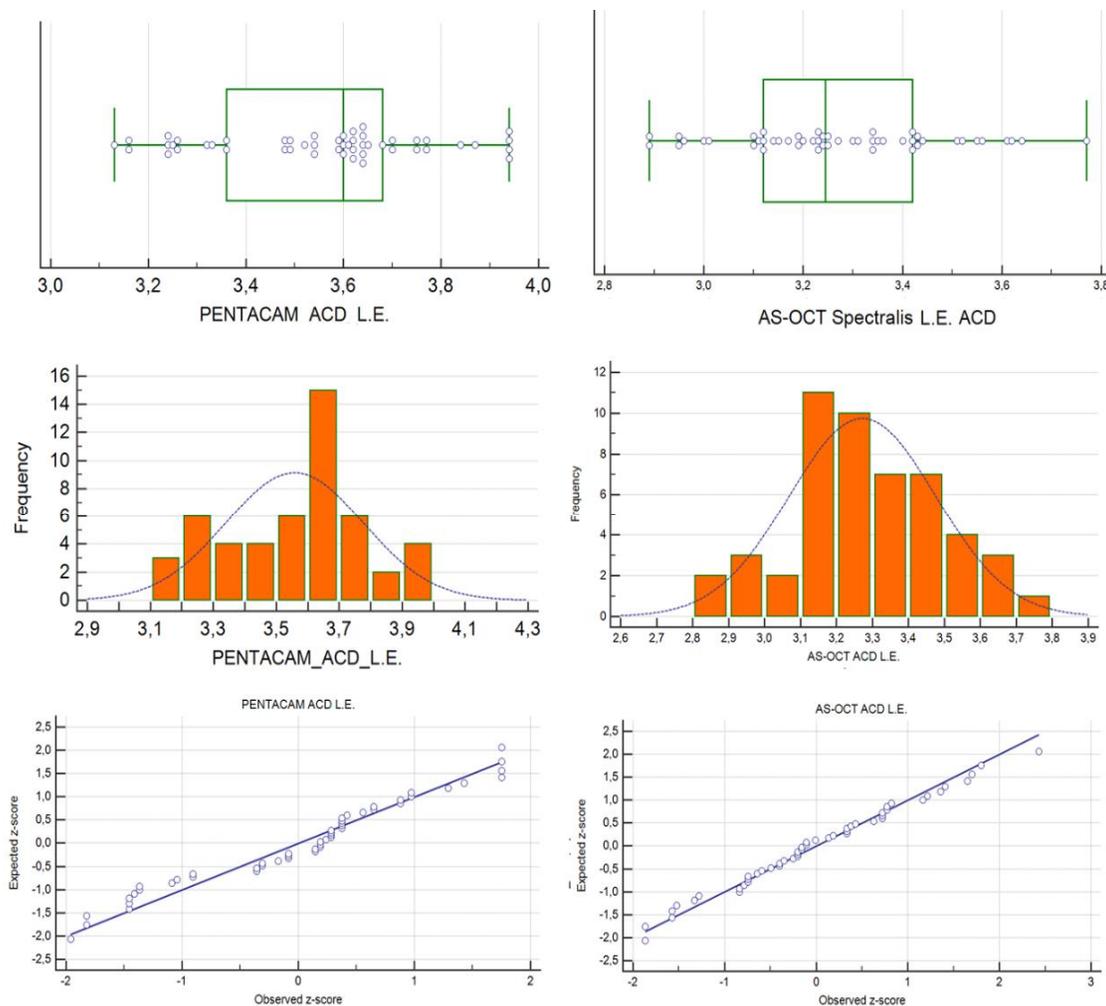
**Fig. 5. Bland & Altman plot comparing the two measuring devices for the right eye on ACD**

This study showed that Pentacam and the anterior segment optical coherence tomography (, Heidelberg Engineering, provide rapid and quantitative images comparing to the

conventional gonioscopy. Their cross-sectional images of the anterior chamber angle (ACA) and anterior chamber depth (ACD) may be used to screen for occlude angles interchangeable.

**Table 3. Measurements of Pentacam and AS-OCT “Spectralis” for ACD**

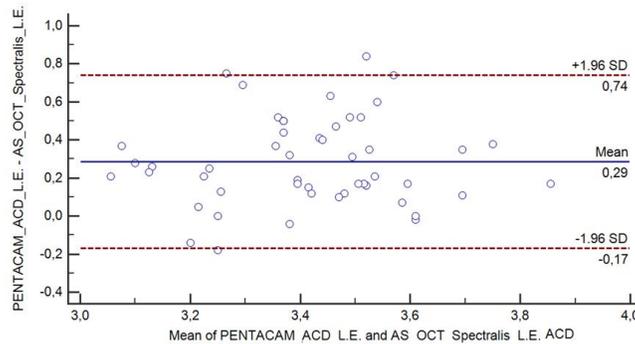
| Pentacam<br>L.E. Anterior chamber<br>depth |                    | AS-OCT SD “Spectralis”<br>L.E. Anterior chamber<br>depth |                    |
|--|--------------------|--|--------------------|
| Sample size                                | 50                 | Sample size  | 50                 |
| Arithmetic mean                            | 3,5580             | Arithmetic mean  | 3,2720             |
| 95% CI for the mean                        | 3,4960 to 3,6200   | 95% CI for the mean                                      | 3,2138 to 3,3302   |
| Median                                     | 3,6000             | Median   | 3,2450             |
| 95% CI for the median                      | 3,5321 to 3,6400   | 95% CI for the median                                    | 3,1960 to 3,3400   |
| Variance                                   | 0,04762            | Variance   | 0,04191            |
| Standard deviation                         | 0,2182             | Standard deviation                                       | 0,2047             |
| Coefficient of Skewness                    | -0,2131 (P=0,5090) | Coefficient of Skewness                                  | 0,1884 (P=0,5587)  |
| Coefficient of Kurtosis                    | -0,5745 (P=0,3353) | Coefficient of Kurtosis                                  | -0,3051 (P=0,7351) |



**Fig. 6. Box-and-Whisker plot, histogram with normal curve, correlation scatter diagram with reduced major axis regression line for the left eye (L.E.) of ACD measurements with Pentacam and AS-OCT “Spectralis” respectively**

**Table 4. Results of t test and correlation coefficient for (L.E.)**

| Paired samples t-test                 | Pentacam L.E. Anterior chamber depth vs AS-OCT SD "Spectralis" R.E. Anterior chamber depth |
|---------------------------------------|--|
| Mean difference                       | -0,2860  |
| Standard deviation of mean difference | 0,2315   |
| Standard error of mean difference     | 0,03274  |
| 95% CI                                | -0,3518 to -0,2202   |
| Test statistic t                      | -8,736   |
| Two-tailed probability                | P < 0,0001   |
| Correlation coefficient r             | 0,4023   |
| Significance level                    | P=0,0038   |



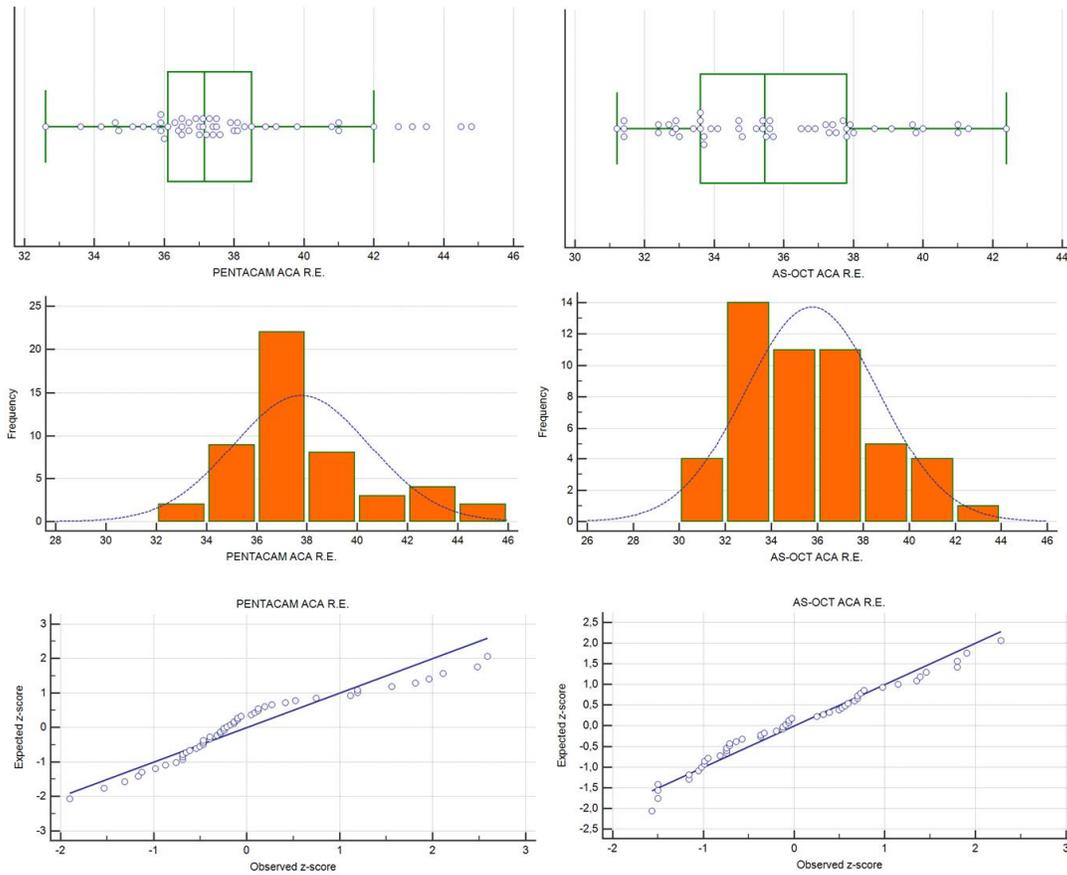
**Fig. 7. Bland & Altman plot comparing the two measuring devices for the left eye on ACD**

**Table 5. Measurements of Pentacam and AS-OCT "Spectralis" for ACA (R.E.)**

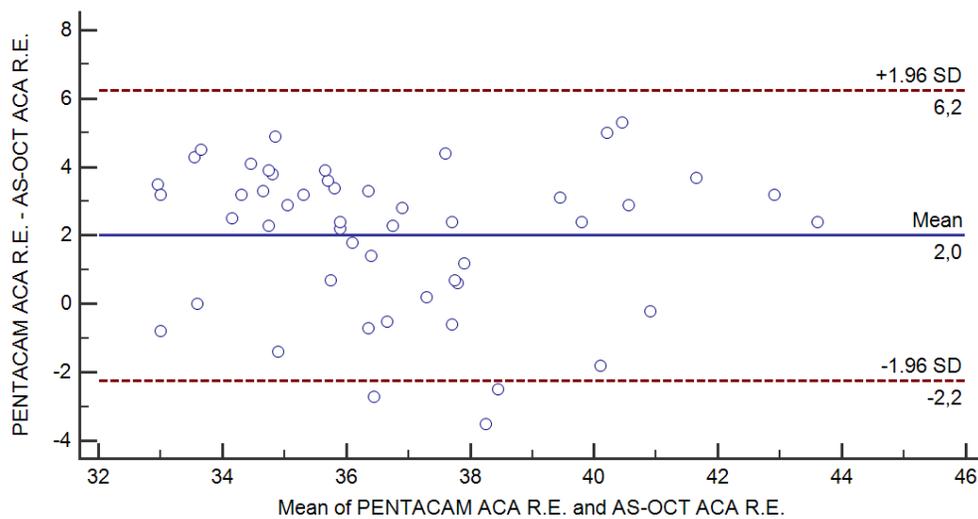
| Pentacam R.E. Anterior chamber angle |                    | AS-OCT SD "Spectralis" R.E. Anterior chamber angle |                    |
|--------------------------------------|--------------------|--|--------------------|
| Sample size                          | 50                 | Sample size  | 50                 |
| Arithmetic mean                      | 37,7700            | Arithmetic mean                                    | 35,7660            |
| 95% CI for the mean                  | 36,9980 to 38,5420 | 95% CI for the mean                                | 34,9400 to 36,5920 |
| Median                               | 37,1500            | Median   | 35,4500            |
| 95% CI for the median                | 36,6207 to 37,7190 | 95% CI for the median                              | 34,0207 to 37,0190 |
| Variance                             | 7,3781             | Variance   | 8,4480             |
| Standard deviation                   | 2,7163             | Standard deviation                                 | 2,9065             |
| Coefficient of Skewness              | 0,9450 (P=0,0083)  | Coefficient of Skewness                            | 0,3929 (P=0,2308)  |
| Coefficient of Kurtosis              | 0,6886 (P=0,2595)  | Coefficient of Kurtosis                            | -0,6685 (P=0,2215) |

**Table 6. Results of t test and correlation coefficient for (R.E.)**

| Paired samples t-test                 | Pentacam R.E. Anterior chamber angle vs AS-OCT SD "Spectralis" R.E. Anterior chamber angle |
|---------------------------------------|--|
| Mean difference                       | -2,0040  |
| Standard deviation of mean difference | 2,1620   |
| Standard error of mean difference     | 0,3058   |
| 95% CI                                | -2,6184 to -1,3896   |
| Test statistic t                      | -6,554   |
| Two-tailed probability                | P < 0,0001   |
| Correlation coefficient r             | 0,7063   |
| Significance level                    | P<0,0001   |



**Fig. 8. Box-and-Whisker plot, histogram with normal curve, correlation scatter diagram with reduced major axis regression line for the right eye (R.E.) of ACA measurements with Pentacam and AS-OCT “Spectralis” respectively**



**Fig. 9. Bland & Altman plot comparing the two measuring devices for the right eye on ACA**

**Table 7. Measurements of Pentacam and AS-OCT “Spectralis” for ACA (L.E.)**

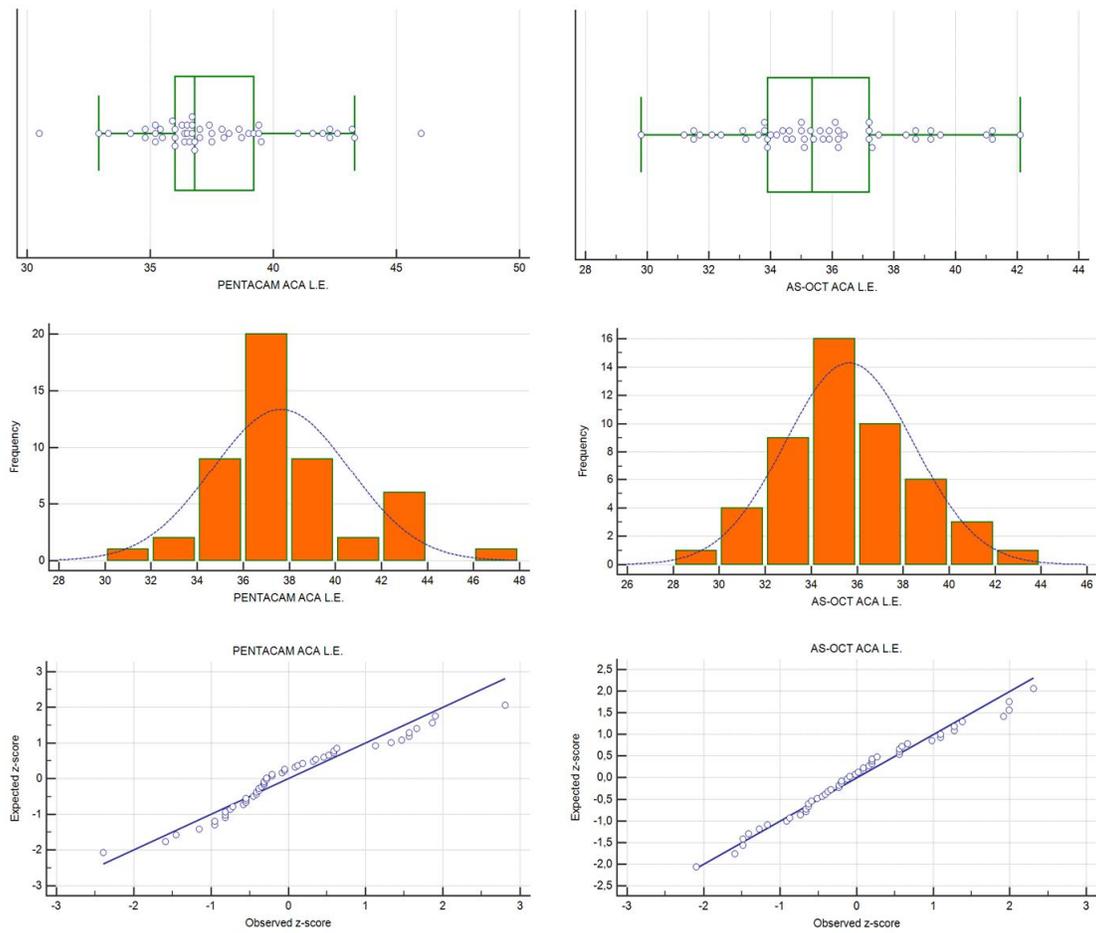
| <b>Pentacam</b>                    |                    | <b>AS-OCT SD “Spectralis”</b>      |                    |
|------------------------------------|--------------------|------------------------------------|--------------------|
| <b>L.E. Anterior chamber angle</b> |                    | <b>L.E. Anterior chamber angle</b> |                    |
| Sample size                        | 50                 | Sample size                        | 50                 |
| Arithmetic mean                    | 37,6380            | Arithmetic mean                    | 35,6520            |
| 95% CI for the mean                | 36,7906 to 38,4854 | 95% CI for the mean                | 34,8591 to 36,4449 |
| Median                             | 36,8000            | Median                             | 35,3500            |
| 95% CI for the median              | 36,4603 to 37,9397 | 95% CI for the median              | 34,5603 to 36,2000 |
| Variance                           | 8,8914             | Variance                           | 7,7846             |
| Standard deviation                 | 2,9818             | Standard deviation                 | 2,7901             |
| Coefficient of Skewness            | 0,5909 (P=0,0792)  | Coefficient of Skewness            | 0,3514 (P=0,2817)  |
| Coefficient of Kurtosis            | 0,6373 (P=0,2840)  | Coefficient of Kurtosis            | -0,1184 (P=0,9859) |

**Table 8. Results of t test and correlation coefficient for (L.E.)**

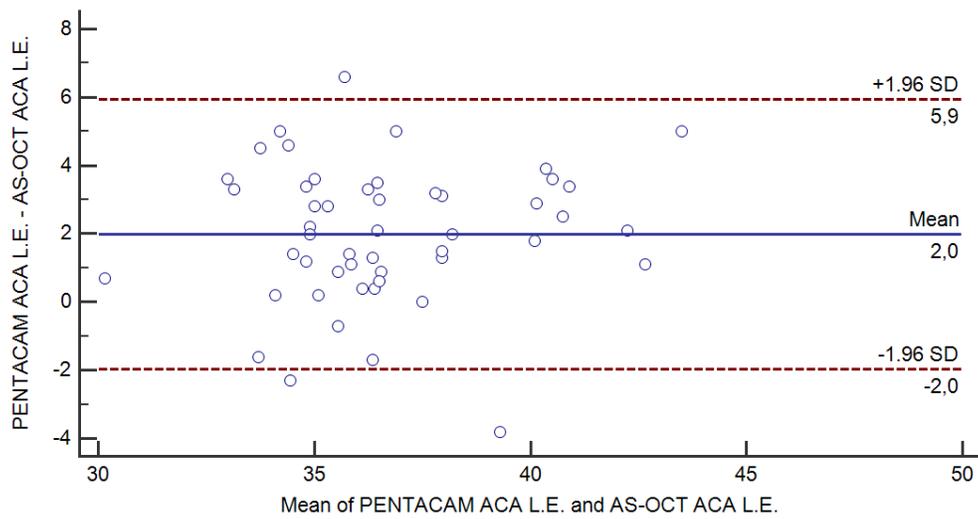
| <b>Paired samples t-test</b>          | <b>Pentacam L.E. Anterior chamber angle vs AS-OCT SD “Spectralis” L.E. Anterior chamber angle</b> |
|---------------------------------------|---|
| Mean difference                       | -1,9860   |
| Standard deviation of mean difference | 2,0205  |
| Standard error of mean difference     | 0,2857  |
| 95% CI                                | -2,5602 to -1,4118  |
| Test statistic t                      | -6,950  |
| Two-tailed probability                | P < 0,0001  |
| Correlation coefficient r             | 0,7569  |
| Significance level                    | P<0,0001  |

**Table 9. Correlation between two devices for ACD and ACA**

|                               | <b>Pentacam</b> | <b>AS-OCT “Spectralis”</b> |
|-------------------------------|-----------------|----------------------------|
| <b>ACA R.E.</b>               |                 |                            |
| Arithmetic mean R.E.          | 37,77 ± 2,71°   | 35,766 ± 2,90°             |
| Mean difference               | -2,004          |                            |
| Correlation coefficient r     | 0,7063          |                            |
| Significance level            | P<0,0001        |                            |
| Two-tailed probability t-test | P < 0,0001      |                            |
| <b>ACA L.E.</b>               |                 |                            |
| Arithmetic mean L.E.          | 37,638 ± 2,98°  | 35,652 ± 2,79°             |
| Mean difference               | -1,986          |                            |
| Correlation coefficient r     | 0,7569          |                            |
| Significance level            | P<0,0001        |                            |
| Two-tailed probability t-test | P < 0,0001      |                            |
| <b>ACD R.E.</b>               |                 |                            |
| Arithmetic mean R.E.          | 3,5866 ± 0,20   | 3,2838 ± 0,20              |
| Mean difference               | -0,3028         |                            |
| Correlation coefficient r     | 0,4201          |                            |
| Significance level            | P=0,0024        |                            |
| Two-tailed probability t-test | P < 0,0001      |                            |
| <b>ACA L.E.</b>               |                 |                            |
| Arithmetic mean L.E.          | 3,558 ± 0,21    | 3,2720 ± 0,20              |
| Mean difference               | -0,286          |                            |
| Correlation coefficient r     | 0,4023          |                            |
| Significance level            | P=0,0038        |                            |
| Two-tailed probability t-test | P < 0,0001      |                            |



**Fig. 10. Box-and-Whisker plot, histogram with normal curve, correlation scatter diagram with reduced major axis regression line for the left eye (L.E.) of ACA measurements with Pentacam and AS-OCT “Spectralis” respectively**



**Fig. 11. Bland & Altman plot comparing the two measuring devices for the left eye on ACA**

#### 4. CONCLUSION

In this study only normal subjects with open angle were included with very small refractive errors so any pathology was excluded in our sample. The angle of the anterior chamber is an important anatomical structure for differentiating the two types glaucoma: Open-angle glaucoma, which is the most common type of glaucoma and closed angle glaucoma.

The modern medical treatment open angle glaucoma is accomplished by the reduction of production of aqueous humor and by the increase of the aqueous humor outflow. Also, another possible treatment for closed angle glaucoma is the iridectomy surgery. According to the above gonioscopy is an additional important tool for monitoring and treating glaucoma reducing the acute rise in intraocular pressure.

In this study, measurements of ACA (Anterior chamber angle) and ACD (Anterior chamber angle) were evaluated by two imaging devices Pentacam and AS-OCT "Spectralis". Their data were similar between them, and showed good reproducibility and agreement between these two methods.

#### CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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