Measurement of early changes in anterior chamber morphology after cataract extraction measured by anterior segment optical coherence tomography

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Abstract

Objective: To evaluate the serial changes in anterior chamber depth (ACD) and angle parameters early after catarac5t surgery using anterior segment optical coherence tomography (ASOCT).

Methods: This was a retrospective chart review, case-control study; 150 eyes of 106 patients who underwent cataract surgery. Based on ACD and angle findings, the eyes were classified into two groups, open-angle eyes (87 eyes) and narrow-angle eyes (63 eyes). ASOCT was used to measure ACD and angle parameters (angle opening distance, angle recess area, trabecular iris space area, and trabecular iris angle (TIA [1])). Serial changes in each group were measured before, 1 day, 1 week, and 1 month after cataract surgery, and the differences between the two groups were compared.

Results: ACD and all angle parameters in both groups at each examination time after cataract surgery were significantly different from the preoperative values ($p<0.01$). In addition, all angle parameters significantly differed between the two groups at each examination time after cataract surgery ($p<0.001$). However, ACD after surgery was not significantly different, irrespective of ACD before surgery. ACD and TIA500 both showed significantly greater changes from before surgery to 1 day after surgery in narrow-angle eyes compared to open-angle eyes ($p<0.001$).

Conclusions: Cataract surgery increases ACD and all angle parameters early after the surgery. However, the degree of angle widening in narrow-angle eyes was not as much as that in open-angle eyes, suggesting that factors other than the lens influence the angle closure.

Keywords

Anterior chamber depth · Phacoemulsification · Early after cataract · Anterior segment optical coherence tomography

Introduction

Primary angle closure (PAC)[2] is associated with anatomical narrowing of the iridocorneal angle, a shorter distance between the iris and trabecular meshwork, and can lead to development of acute primary angle closure. Therefore, preventive laser iridotomy may be performed to widen the angle.[3,4] However, laser iridotomy carries the risk of hyphema, elevated intraocular pressure (IOP), cataract progression, and bullous keratopathy. Therefore, cataract surgery is sometimes selected instead of laser iridotomy for angle widening in PAC.[5-8]

Noninvasive methods that enable in vivo or in situ visualization of tissues provide key information about the pathophysiology of diseases. Many optical or ultrasonic methods are being used to analyze the anterior segment of the eye. [1] Gonioscopy and ultrasound biomicroscopy (UBM) have mainly been used to evaluate the effectiveness of angle widening after cataract surgery.[9-11]However, because gonioscopy and UBM require contact with the ocular surface, infection or wound dehiscence may occur. Thus, gonioscopy and UBM are inappropriate for observation just after surgery, and their early postoperative use has not been reported. Meanwhile, anterior segment optical coherence tomography (ASOCT), which has recently been developed, provides better resolution compared to conventional UBM. ASOCT is a non-contact technique that can be performed in a short time, but ASOCT for angle analysis after cataract surgery has seldom been reported.[12-16] Visante OCT (carl Zeiss Meditec,Dublin,CA) is one of the first such devices and has commonly been used and validated by ophthalmologists in anterior segment analyses The Visante OCT ia a time domain OCT with a scan rate of 2048 A-scans/sec, an axial resolution of up to 18 microns and a transverse spatial resolution of up to 60 microns. Different biometric measurements can be performed characterizing the angle, anterior chamber depth and corneal thickness in a semi-automatic manner with good repeatability and reproducibility. [1]

Many studies have reported that anterior chambers were deeper postoperatively in patients undergoing cataract surgery. [17-20]

We conducted this prospective study using a swept source ASOCT, Casia® OCT to evaluate the serial changes in anterior chamber depth (ACD) and angle parameters in the early postoperative period after cataract surgery, including the AOD (angle opening distance), the ARA (angle recess area), the TISA (trabecular iris space area), and the TIA (trabecular iris angle). The angle changes before and after cataract surgeries in 2 groups of patients with either open or narrow angles were assessed in this work.

Patients and Methods

1. Patients

This study included 150 eyes in 106 consecutive patients who underwent cataract surgery at Jikei University School of Medicine Katsushika Medical Center in after April 2010. The study was approved by the Ethics Committee at Jikei University School of Medicine, and all patients provided their informed consent.
The Emery-Little Classification system was used for the classification of the severity of cataracts. For cataract surgery, a sclerocorneal incision (2.8mm) followed by anterior capsulotomy, nuclear fragmentation by phacoemulsification was performed. An acrylic foldable intraocular lens was fixated with in the capsule. A single intraocular lens (IOL) ,the AcrySof® IQ Monofocal Single-Piece IOL (SN60WF, Alcon Laboratories, Inc., Fort Worth, TX, USA) was implanted in all cases in this study. The optic diameter was 6.0 mm, the overall length 13.0 mm, and the optic was the Biconvex aspheric type.
Based on ACD and angle findings, the eyes were classified into two groups: open-angle eyes and narrow-angle eyes, for prospective evaluation. In this study, neither group included subjects with a history or diagnosis of glaucoma nor patients who were treated with anti-glaucoma medications.
ACD was assessed using the Van Herick technique: open-angle eyes, grade Ó3; narrow-angle eyes, grade Ò 2. Angle findings were also assessed using Shafferôs classification: open-angle eyes, grade Ó3; narrow-angle eyes, grade Ò2. Using the Scheie classification, grade ÒI was defined as open-angle eyes and grade ÓII as narrow-angle eyes.

2. Methods

Swept source ASOCT (SS-1000 CASIA; Tomey Co. Ltd. Nagoya, Japan) was performed before, 1 day, 1 week, and 1 month after cataract surgery. All eyes were imaged without dilation (non-mydriasis). All measurements were done in a light room. For analysis, the scleral spur (SS) at the boundary of the sclera and choroid was identified by three physicians (KK, GT, and KK), and angle parameters were automatically measured on the temporal side. 3 physicians chose and agreed on the area of measurement on the computer screen at the same time. ACD (mm) and angle parameters, including (1) AOD (angle opening distance) 250, 500, 750 [εm], (2) ARA (angle recess area) 500, 750 [εm^2], (3) TISA (trabecular iris space area) 500, 750 [εm^2], and (4) TIA (trabecular iris angle) 500 [deg], were compared between the two groups.

ACD and each angle parameter were defined as follows: ACD is defined as the distance from the posterior surface of the central cornea to the anterior surface of the lens (Fig. 1). AOD 250 (500) (750) is defined as the length of a perpendicular from the trabecular meshwork to the iris at a point 250 (500) (750) εm from the SS (Fig. 2A). ARA 500 (750) is defined as the triangular area formed by the AOD 500 (750), the angle recess, the iris surface, and the inner corneoscleral wall (Fig. 2B). TISA 500 (750) is defined as the trapezoidal area with the following boundaries: anteriorly, the AOD 500 (750); posteriorly, a line drawn from the SS perpendicular to the plane of the inner scleral wall to the opposing iris, superiorly, the inner corneoscralar wall; and inferiorly, the iris surface (Fig. 2C). TIA 500 is measured with the apex (angle recess) and the arms passing through the point 500εm from the SS and the point perpendicular opposite on the iris surface (Fig. 2D).

Statistical analysis was performed using the R software package 3224 (version 1.8.1, The R Foundation, http://www.r-project.org). Data were analyzed using the Wilcoxon signed-rank test, repeated measures analysis of variance, Spearmanȏs rank correlation coefficient, and analysis of covariance. A p value<0.05 was considered as statistically significant.

Results

87 eyes of 64 patients had open-angles (men: 50 eyes; women: 37 eyes; mean age: 72.7±9 years) and 63 eyes of 42 patients had narrow-angles (men, 19 eyes; women, 44 eyes; mean age: 72.5±7 years). There were 35, 43 and 9 eyes with Emery-Little classification grades of 2, 3, and 4, in the open-angle group respectively. In the narrow angle group, the respective number of eyes for the same respective grades were 24, 36, and 3 eyes. There was no significant difference between the two groups in respect to Little Emery Grades ($p > 0.05$). There were no significant intraoperative or postoperative complications. Mean age did not differ significantly between the groups.

The intraocular pressures (mean ± SD) before, the day after s, a week after, and a month after surgery were 14.2 ± 2.7, 13.5 ± 2.6, 13.1 ± 2.7, 13.4 ± 2.3 mmHg for the open-angle group, and 14.4 ± 2.7, 14.3 ± 1.8, 14.3 ± 1.7, 13.8 ± 2.2 mmHg for the narrow-angle group, respectively. There was no significant difference between the two groups at each measurement time ($p > 0.05$).

ACD and all angle parameters (AOD 250/500/750, ARA500/750, TISA500/750 and TIA500) in both groups at each examination time starting the day after cataract surgery (POD 1) were significantly different from the preoperative values ($p<0.01$) (Fig. 3A-I). The preoperative baseline values of the open-angles group and the narrow-angles group were significantly different ($p<0.001$) (Fig. 3A-I). There were no significant changes after POD 1 (Fig. 3A-I). In addition, all angle parameters were significantly different between the two groups at POD 1, 1 week and 1 month after surgery ($p<0.001$) (Fig. 3A-H). However, ACD was not significantly different, irrespective of the angle depth before surgery, with similar depth in both groups starting on POD 1 (Fig. 3I). ACD and TIA500 showed significantly greater changes from the preoperative values to POD 1 in narrow-angle eyes compared to the open-angle eyes ($p<0.001$) (Fig. 4H, 4I), whereas the AOD 250/500/750, ARA500/750, and TISA500/750 were not significantly different (Fig. 4A-G).

Discussion

In this study, eyes before and after cataract surgery were classified into 2 groups as open-angle eyes or narrow-angle eyes, and the serial changes in ACD and angle parameters in both groups were evaluated beginning the day after surgery (POD 1).

Reports to date on angle widening before and after cataract surgery in narrow-angle eyes have shown significant increases. [9]-13 The present study also showed an early postoperative increase in ACD and all angle parameters. Moreover, in both the narrow-angle and open-angle eye groups, no return to preoperative values was observed on POD 1 or later. Although the angle parameters did not increase to the same extent in narrow-angle eyes as in open-angle eyes, the ACD in narrow-angle eyes did increase to the same extent as in open-angle eyes. In addition, ACD and TIA showed greater changes from the preoperative values to POD 1 in the narrow-angle eyes compared to the open-angle eyes. This suggests that these two factors are most affected by lens extraction in narrow-angle eyes.

However, angle parameters in the narrow-angle eyes, despite the fact that ACD increased to the same extent as in open-angle eyes, did not increase to the same extent as angle parameters in open-angle eyes on POD 1 and afterward. This suggests that, even after lens extraction, some eyes still have residual narrow-angle factors related to axial length, ciliary body, iris configuration, and posterior eye segment. Therefore, although cataract surgery is effective as a means to relieve pupillary block, increasing the space between the iris and cornea, and decreasing the risk of elevated IOP, there may still be residual operant narrow-angle factors.

ASOCT, unlike UBM, can be used for non-contact measurement even right after cataract surgery without risk of infection or wound dehiscence. Thus, early postoperative analysis is possible by measuring data starting on the day after surgery. Furthermore, ASOCT has better resolution (about 10εm) compared to UBM (about 50εm). Therefore, ASOCT is useful for detailed angle evaluation, the degree of angle widening can be quantitatively assessed, and the imaging procedure is convenient, imposing fewer burdens to the patients, and can be performed in a shorter time. [21] However, although the interobserver variability is small, [22] identifying the scleral spur (SS) can be difficult. In the present study, even though the position of the SS was determined by a consensus of the 3 physicians, there were cases in that identifying the SS was still difficult. The influence of eye position must also be considered, and future improvements for easier analysis, including meticulously setting of a fixation target for imaging and improved resolution, are required.

Several limitations of our study warrant mention. First of all, in the current study the narrow-angle eyes had a variety of different causes such as relative pupillary block or plateau iris. Future investigation with stratification of these factors will be necessary. Secondly all measurements in this study were performed in a bright room with the same brightness. Further comparisons with measurements in a dark room are also required.

ASOCT is a useful technique to quantitatively evaluate the angle findings, but because the ciliary body cannot be examined in detail, conventional contact methods such as gonioscopy or UBM are still needed for pathological assessment and classification required to diagnose angle closure or plateau iris.

Conflict of interest statement

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakersôbureaus;membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Figure Legends

Fig. 1 Optical coherence tomography scan showing ACD (anterior chamber depth) measurement from posterior central corneal to anterior lens surface.

Fig. 2 Optical coherence tomography scan showing calculator of AOD (angle opening distance), ARA (angle recess area), TISA (trabecular iris space area), TIA (trabecular iris angle) parameters.

Figs. 3 Composite figure showing time-dependent changes of AOD, ARA, TISA, TIA, and ACD parameters. Fig. 3A to I show significantly different the baseline values of the open-angles group and the narrow-angles group were (**: $p < 0.001$). Figure 3A to C show significant increase of AOD from baseline 1day and 1week, 1month visits for each setting (*: $p < 0.01$, **: $p < 0.001$). Figure 3D to E show significant increase of ARA from baseline to 1day and 1week, 1month visits for each setting (*: $p < 0.01$, **: $p < 0.001$). Figure 3F to G show significant increase of TISA from baseline to 1day and 1week, 1month visits for each setting (*: $p < 0.01$, **: $p < 0.001$). Figure 3H shows significant increase of TIA from baseline to 1day and 1week, 1month visits for each setting (*: $p < 0.01$, **: $p < 0.001$). Figure 3I shows significant increase of ACD from baseline to 1day and 1week, 1month visits for each setting (*: $p < 0.01$, **: $p < 0.001$).

Figs.4 Composite figure of regression analysis showing time-dependent changes of AOD, ARA, TISA, TIA, ACD parameters. Fig. 4H and 4I reveal that ACD and TIA500 showed significantly greater changes from the preoperative values to POD 1 in narrow-angle eyes compared to the open-angle eyes ($p<0.001$). AOD: angle opening distance, ARA: angle recess area, TISA: trabecular iris space area, TIA: trabecular iris angle, ACD: anterior chamber depth

Fig1.

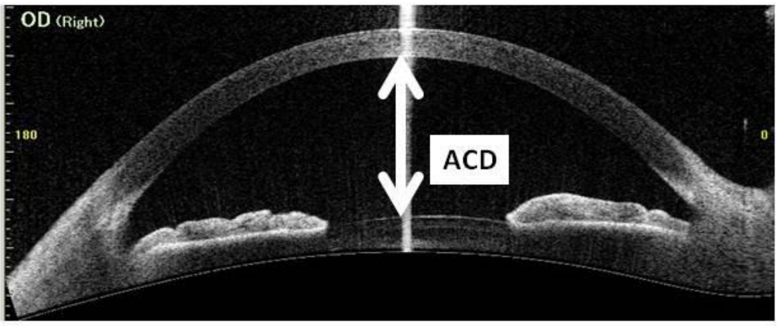
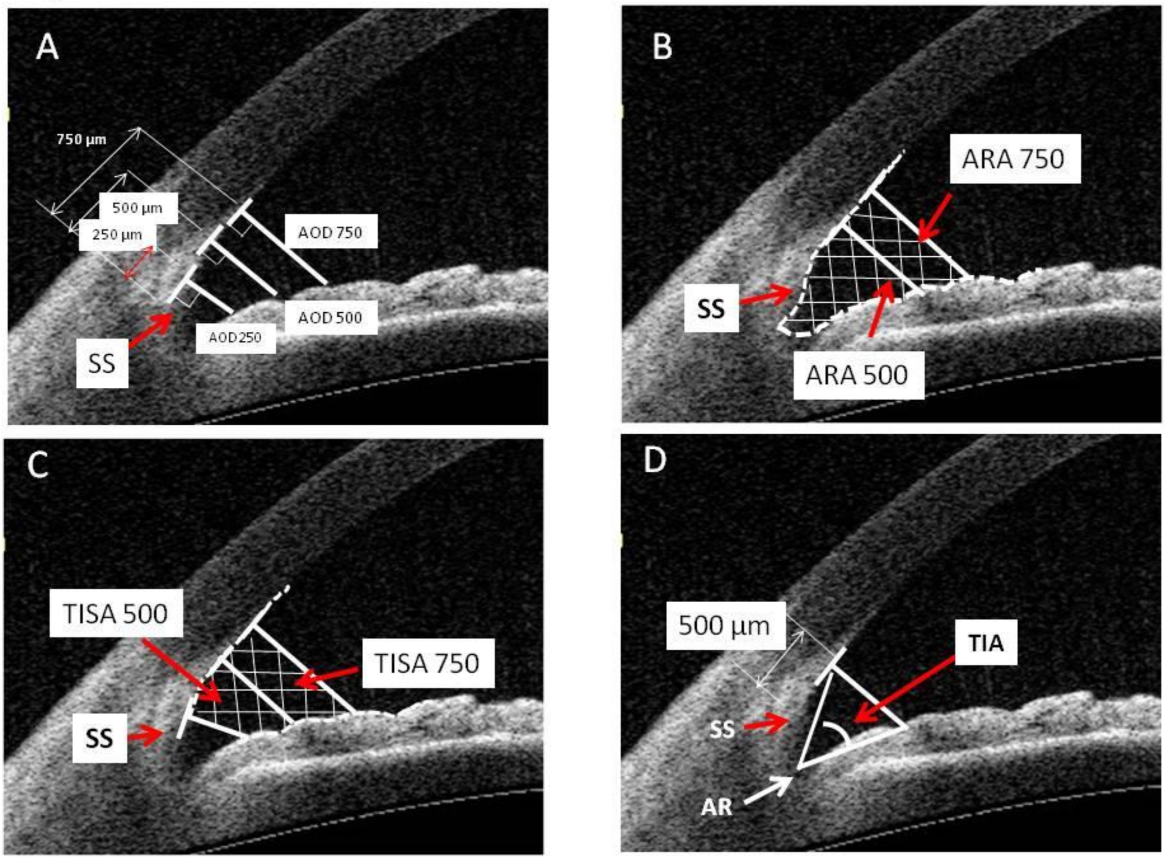


Fig2.


A
750 µm
500 µm
250 µm
AOD 750
AOD 500
AOD250
SS
B
ARA 750
SS
ARA 500
C
TISA 500
TISA 750
SS
D
500 µm
TIA
SS
AR

1

◆ : open angle ■ : narrow angle

Fig.3G) TISA750(μm²)

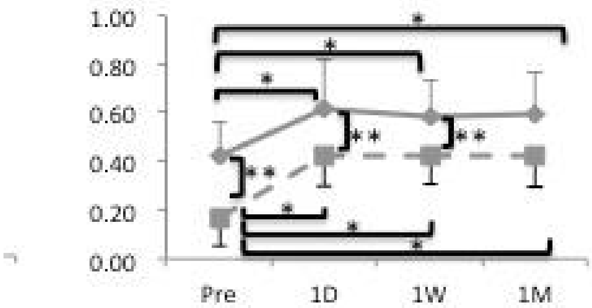


Fig.3H) TIA500(deg)

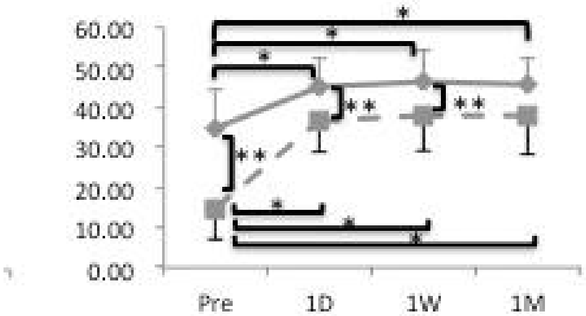
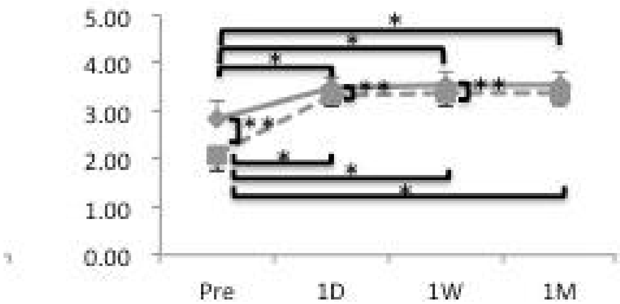
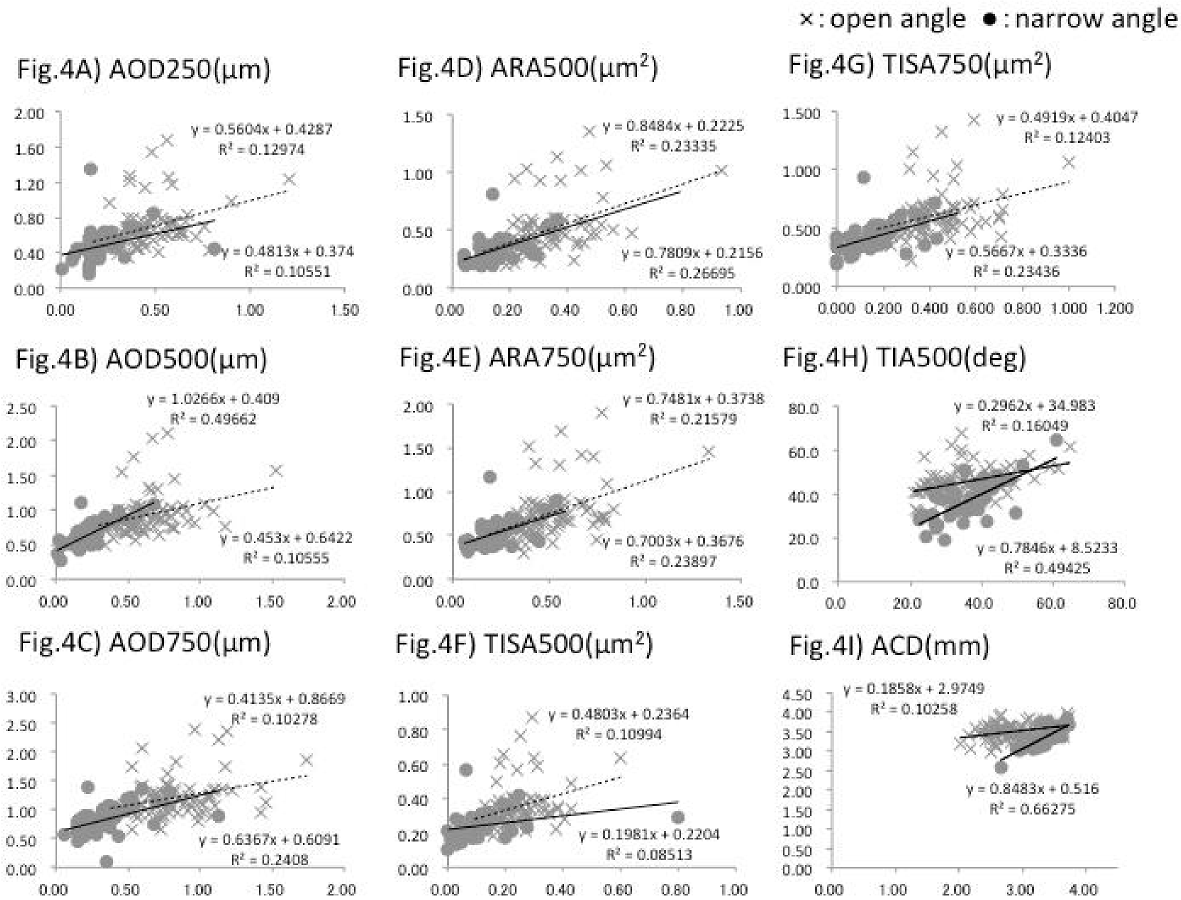


Fig.3I) ACD(mm)




×: open angle ●: narrow angle
Fig.4A) AOD250(μm)
y = 0.5604x + 0.4287
R² = 0.12974
y = 0.4813x + 0.374
R² = 0.10551
Fig.4D) ARA500(μm²)
y = 0.8484x + 0.2225
R² = 0.23335
y = 0.7809x + 0.2156
R² = 0.26695
Fig.4G) TISA750(μm²)
y = 0.4919x + 0.4047
R² = 0.12403
y = 0.5667x + 0.3336
R² = 0.23436
Fig.4B) AOD500(μm)
y = 1.0266x + 0.409
R² = 0.49662
y = 0.453x + 0.6422
R² = 0.10555
Fig.4E) ARA750(μm²)
y = 0.7481x + 0.3738
R² = 0.21579
y = 0.7003x + 0.3676
R² = 0.23897
Fig.4H) TIA500(deg)
y = 0.2962x + 34.983
R² = 0.16049
y = 0.7846x + 8.5233
R² = 0.49425
Fig.4C) AOD750(μm)
y = 0.4135x + 0.8669
R² = 0.10278
y = 0.6367x + 0.6091
R² = 0.2408
Fig.4F) TISA500(μm²)
y = 0.4803x + 0.2364
R² = 0.10994
y = 0.1981x + 0.2204
R² = 0.08513
Fig.4I) ACD(mm)
y = 0.1858x + 2.9749
R² = 0.10258
y = 0.8483x + 0.516
R² = 0.66275