Assessment of iris volume in glaucoma patients with type 2 diabetes mellitus by AS-OCT

Ying Su, Qing-Shu Ge, Zong-Yi Li, Qian-Wen Bu, Die Hu, Long-Fang Zhou, Xiao-Jing Pan

1School of Clinical Medicine, Weifang Medical University, Weifang 261021, Shandong Province, China
2Eye Institute of Shandong First Medical University, Qingdao Eye Hospital of Shandong First Medical University, Qingdao 266071, Shandong Province, China
3State Key Laboratory Cultivation Base, Shandong Provincial Key Laboratory of Ophthalmology, Qingdao 266071, Shandong Province, China
4School of Ophthalmology, Shandong First Medical University, Qingdao 266071, Shandong Province, China

Co-first authors: Ying Su and Qing-Shu Ge
Correspondence to: Xiao-Jing Pan. Eye Institute of Shandong First Medical University, Qingdao 266071, Shandong Province, China. panxjcrystal@163.com

INTRODUCTION

Glaucoma is the main cause of permanent blindness worldwide, and it is a major public health issue. Glaucoma affected 64.3 million people in 2013, which will increase to 111.8 million in 2040. Primary open angle glaucoma (POAG) and primary angle-closure glaucoma (PACG) are two different types of glaucoma based on the anatomy. PACG, which has a narrow anterior chamber angle, is three times more likely to induce significant bilateral vision impairment than POAG. Traditional risk factors for atrial angle closure include anatomical features such as a small anterior chamber, a short eye axis, the thickness of the lens, and anterior displacement of the lens location. In addition, the iris volume and the position of the entire iris relative to the meshwork are two factors that determine how close the anterior chamber angle is to apposition. The findings of recent research strongly suggest that the iris contributes substantially to the progression of angle closure.

Diabetes mellitus (DM) is another prevalent cause of vision loss in people, and it can cause raised intraocular pressure (IOP) by interfering with the function of the trabecular meshwork. Some studies have found that DM can protect against glaucoma, while others have found that DM can aggravate glaucoma. The exact relationship between the two still remains a matter of debate. In PACG patients, POAG patients, and normal subjects, a large iris volume is correlated with an increased risk of glaucoma.

AIM: To examine the change of iris volume measured by CASIA2 anterior segment optical coherence tomography (AS-OCT) in glaucoma patients with or without type 2 diabetes mellitus (T2DM) and explore if there is a correlation between hemoglobin A1c (HbA1c) level and iris volume.

METHODS: In a cross-sectional study, 72 patients (115 eyes) were divided into two groups: primary open angle glaucoma (POAG) group (55 eyes) and primary angle-closure glaucoma (PACG) group (60 eyes). Patients in each group were separately classified into patients with or without T2DM. Iris volume and glycosylated HbA1c level were measured and analyzed.

RESULTS: In the PACG group, diabetic patients’ iris volume was significantly lower than those of non-diabetics (P=0.02), and there was a significant correlation between iris volume and HbA1c level in the PACG group (r=-0.26, P=0.04). However, diabetic POAG patients’ iris volume was noticeably higher than those of non-diabetics (P=0.01), and there was a significant correlation between HbA1c level and iris volume (r=0.32, P=0.02).

CONCLUSION: Diabetes mellitus impact iris volume size, as seen by increased iris volume in the POAG group and decreased iris volume in the PACG group. In addition, iris volume is significantly correlated with HbA1c level in glaucoma patients. These findings imply that T2DM may compromise iris ultrastructure in glaucoma patients.

KEYWORDS: glaucoma; diabetes mellitus; iris volume; glycosylated hemoglobin; optical coherence tomography

DOI:10.18240/ijo.2023.05.11

Citation: Su Y, Ge QS, Li ZY, Bu QW, Hu D, Zhou LF, Pan XJ. Assessment of iris volume in glaucoma patients with type 2 diabetes mellitus by AS-OCT. Int J Ophthalmol 2023;16(5):743-747
This study was performed in accordance with the principles of the Declaration of Helsinki and with the approval of the Ethics Committee of Qingdao Eye Hospital [No.(2022)25]. All of the subjects signed informed consent.

Subjects The study was performed on 115 eyes of 72 patients who were diagnosed with POAG or PACG at Qingdao Eye Hospital. The patients were divided into two groups. The first group consisted of 55 POAG eyes, including diabetic POAG, which comprised 25 eyes, and POAG without T2DM, which comprised 30 eyes. The second group consisted of PACG patients with or without T2DM, each contained 30 eyes. Patients with diabetic glaucoma in each group made up the primary case group, and patients without T2DM in each group comprised the matched comparison group.

Individuals with T2DM aged 40 to 80 were eligible for inclusion. Exclusion criteria were as follows: 1) severe systemic disease except T2DM; 2) any history of ocular surgery or laser treatment; 3) any eye trauma history; 4) inability to fixate for eye examination; 5) episodes of acute angle closure and large dislocation.

Clinical Examinations All subjects underwent a standardized ophthalmic examination. Venous blood samples were collected for the level of HbA1c assessed at Qingdao Eye Hospital. Thorough ophthalmological examinations were conducted, including visual acuity, autorefraction, slit lamp examination, IOP, and ocular biometric measurement, and examined by CASIA2 AS-OCT. IOP measurement was performed using a non-contact tonometer Canon TX-20P. The IOLMaster 700 (Carl Zeiss Meditec AG, Jena, Germany) was used to measure ocular biometry, including central cornea thickness (CCT), lens thickness (LT), axial length (AL), and anterior central chamber depth (ACD). All subjects were examined by a skilled physician.

Continuous variables was assessed using the Pearson correlation coefficient. The three-dimensional angle analysis is carried out on three-dimensional angle analysis scans, which is a volume scan with 16 and 13 mm length and depth measurements, respectively [23]. The three-dimensional angle analysis is carried out on 16 AS-OCT pictures from 16 distinct three-dimensional angles [24]. As a result, the present study used CASIA2 AS-OCT to evaluate the change of iris volume in glaucoma patients with or without type 2 diabetes mellitus (T2DM) and whether there was a correlation between iris volume and glycosylated hemoglobin A1c (HbA1c) level.

RESULTS

Demographic and Clinical Data of Study Participants The mean ages of the study and the control groups in the POAG patients with diabetes were 40 to 80 years. The mean ages of the study and the control groups in the POAG patients with diabetes were 40 to 80 years. The mean ages of the study and the control groups in the POAG patients with diabetes were 40 to 80 years. The mean ages of the study and the control groups in the POAG patients with diabetes were 40 to 80 years. The mean ages of the study and the control groups in the POAG patients with diabetes were 40 to 80 years. The mean ages of the study and the control groups in the POAG patients with diabetes were 40 to 80 years.

Figure 1 CASIA2 anterior segment optical coherence tomography (AS-OCT) cross-sectional image with scleral spur, corneal boundaries, and iris boundaries Scleral spurs were manually identified (denoted in red). The software built-in to the OCT automatically detected the boundaries of the cornea and iris (shown in blue and green, respectively).
The mean TISA500 of diabetic POAG patients was higher (diabetic: 0.14±0.09, non-diabetic: 0.16±0.07, \( P = 0.02 \)). In the PACG group, there was a significant difference in the iris volume, which was 32.55±4.12 in the diabetic eyes and 34.55±4.12 in the non-diabetic eyes (\( P = 0.01 \)).

### Table 1: Demographic characteristics and clinical data of study participants

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>POAG+DM (n=55)</th>
<th>Non-diabetic (n=30)</th>
<th>( P )</th>
<th>PACG+DM (n=60)</th>
<th>Non-diabetic (n=30)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>17/25</td>
<td>16/30</td>
<td>-</td>
<td>20/30</td>
<td>19/30</td>
<td>-</td>
</tr>
<tr>
<td>Age (y)</td>
<td>61.00±10.18</td>
<td>59.56±12.47</td>
<td>0.72</td>
<td>66.60±7.15</td>
<td>65.21±7.67</td>
<td>0.56</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>12/5</td>
<td>12/4</td>
<td>-</td>
<td>7/13</td>
<td>8/11</td>
<td>-</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>7.92±1.10</td>
<td>5.39±0.43</td>
<td>&lt;0.01</td>
<td>7.34±0.78</td>
<td>5.67±0.39</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>IOP (mm Hg)</td>
<td>19.88±7.31</td>
<td>18.06±6.92</td>
<td>0.35</td>
<td>20.47±8.98</td>
<td>21.89±10.55</td>
<td>0.58</td>
</tr>
<tr>
<td>AL (mm)</td>
<td>24.32±1.35</td>
<td>24.50±1.72</td>
<td>0.67</td>
<td>22.73±0.82</td>
<td>22.62±0.81</td>
<td>0.61</td>
</tr>
<tr>
<td>ACD (mm)</td>
<td>3.10±0.40</td>
<td>3.24±0.33</td>
<td>0.17</td>
<td>2.36±0.36</td>
<td>2.42±0.40</td>
<td>0.57</td>
</tr>
<tr>
<td>LT (mm)</td>
<td>4.59±0.27</td>
<td>4.38±0.37</td>
<td>0.02</td>
<td>5.12±0.39</td>
<td>4.81±0.31</td>
<td>0.001</td>
</tr>
<tr>
<td>CCT (µm)</td>
<td>528.08±39.54</td>
<td>513.97±29.84</td>
<td>0.14</td>
<td>543.10±32.83</td>
<td>560.47±45.96</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 2: Comparison between the parameters of two groups in the CASIA2 AS-OCT examination

<table>
<thead>
<tr>
<th>Parameters</th>
<th>POAG+DM (n=55)</th>
<th>Non-diabetic (n=30)</th>
<th>( P )</th>
<th>PACG+DM (n=60)</th>
<th>Non-diabetic (n=30)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornea volume (mm³)</td>
<td>88.61±8.11</td>
<td>86.17±7.89</td>
<td>0.26</td>
<td>69.02±11.80</td>
<td>73.28±11.32</td>
<td>0.15</td>
</tr>
<tr>
<td>Anterior chamber volume (mm³)</td>
<td>147.99±32.60</td>
<td>151.14±31.25</td>
<td>0.72</td>
<td>77.81±27.20</td>
<td>81.93±20.13</td>
<td>0.51</td>
</tr>
<tr>
<td>Iris volume (mm³)</td>
<td>37.67±4.72</td>
<td>34.55±4.12</td>
<td>0.01</td>
<td>29.36±4.50</td>
<td>32.55±5.50</td>
<td>0.02</td>
</tr>
<tr>
<td>AOD500 (mm)</td>
<td>0.39±0.23</td>
<td>0.41±0.19</td>
<td>0.68</td>
<td>0.26±0.18</td>
<td>0.21±0.12</td>
<td>0.19</td>
</tr>
<tr>
<td>TISA500 (mm²)</td>
<td>0.14±0.09</td>
<td>0.16±0.07</td>
<td>0.56</td>
<td>0.10±0.08</td>
<td>0.08±0.05</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Table 3: Pearson’s correlation test

<table>
<thead>
<tr>
<th>Parameters</th>
<th>POAG group (n=55)</th>
<th>PACG group (n=60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iris volume (mm³)</td>
<td>0.32</td>
<td>0.02</td>
</tr>
<tr>
<td>Correlations</td>
<td>( r = 0.32 )</td>
<td>( r = -0.26 )</td>
</tr>
<tr>
<td>POAG: Primary open angle glaucoma; PACG: Primary angle-closure glaucoma.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DISCUSSION

In our study, we used the CASIA2 AS-OCT, which has a fast scan speed and allows 360° imaging of the iris, to perform a comprehensive three-dimensional assessment of iris volume. Based on these collected statistics, we compared and analyzed the iris volume of non-diabetic and diabetic patients in the POAG and PACG groups individually. To the best of our knowledge, this is the first study to assess iris volume in glaucoma patients with T2DM. It was discovered that diabetic PACG patients’ iris volume was smaller than those of non-diabetic PACG patients. The difference is that the iris volume of POAG from T2DM patients was found to be larger than that of non-diabetic POAG patients.

One possible explanation for the iris volume reduction in PACG patients results from ischaemic damage. In our study, there have been significant thickening changes in terms of lens thickness changes in diabetic POAG and PACG patients.
Iris volume in glaucoma patients with diabetes

compared to the non-diabetic glaucoma population. Previous literature has reported a thicker lens in diabetics than in non-diabetics, consistent with our analysis of glaucoma patients\(^{[21,25-28]}\). PACG eyes had higher level of vascular endothelial growth factor members (vascular endothelial growth factor B, vascular endothelial growth factor C) and receptor (vascular endothelial growth factor receptor-2), suggesting that PACG has a compensatory mechanism to protect the iris vasculature from ischaemic damage\(^{[27]}\). During hyperglycemia, extra glucose in the lens is changed into sorbitol. Poorly permeable sorbitol builds up in the lens. The influx of water from the aqueous humor into the lens as a result of the difference in osmotic pressure that occurs when blood glucose levels drop leads to lenticular swelling\(^{[21,26,28,29]}\). Hyperglycemia causes thicker lenses, iris compression, and decreased iris blood volume. It is expected to result in PACG patients’ compensatory mechanisms failing, iris thinning, and iris volume reduction.

The iris is the only tissue in the anterior chamber with a vasculature network, and intra-iris vascular blood flow diffuses from the iris interstitium through the microvascular endothelium to the anterior chamber for fluid exchange with atrial fluid. The decreased iris volume may be due to the diabetic PACG patients’ altered iris microvascular structure, according to previous studies that showed how hyperglycemia can alter the iris’ ultrastructure by triggering signaling pathways\(^{[16,30-31]}\).

As for the increased iris volume in POAG, the possibility is that it may take some time for the microstructure to transform into macroscopic volume. Meng et al\(^{[31]}\) assessed the iris volume of 117 diabetic patients aged 40 to 80 using swept-source AS-OCT and it was concluded that larger iris volume was significantly correlated with shorter duration of DM. It has been demonstrated that in patients with long-term diabetic conditions, the iris muscle cells and nerves undergo degenerative change\(^{[33-35]}\). We hypothesized that diabetic duration was related to iris volume in POAG patients. In glaucoma patients, short duration of DM increases iris volume, whereas long duration of DM decreases iris volume. More research is needed to confirm the link between iris volume and diabetic duration in glaucoma patients.

Furthermore, in the POAG groups, HbA1c level was significantly positively associated with iris volume, while in the PACG groups, HbA1c level was significantly negatively associated with iris volume, implying that glycemic control affects iris volume in glaucoma patients.

Additionally, we are aware of some of the limitations of our study. First, the relatively small sample size, which could be explained by the stringent inclusion and exclusion criteria, could be seen as a potential limitation. Second, the inclusion of both eyes in some glaucoma patients might be biased because ophthalmic variables are typically similar between the eyes of the same person. Third, the diabetic duration was not available in this study. Further investigation with diabetic duration would aid in determining the change in iris volume in glaucoma diabetic patients.

In conclusion, we found that T2DM increased iris volume in POAG patients, which may narrow the anterior chamber angle, and decreased iris volume in PACG patients, which affects the iris blood supply. These suggest that T2DM appears to be a risk factor for glaucoma patients. These findings, if confirmed in a larger longitudinal study, should prompt researchers to reconsider the pathophysiologic role of T2DM in the natural history of glaucoma.

ACKNOWLEDGEMENTS

Foundation: Supported by Natural Science Foundation of Shandong Province (No.ZR2020MH172).

Conflicts of Interest: Su Y, None; Ge QS, None; Li ZY, None; Bu QW, None; Hu D, None; Zhou LF, None; Pan XJ, None.

REFERENCES


