Dual-Angle Protocol for Doppler Optical Coherence Tomography to Improve Retinal Blood Flow Measurement

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Purpose: To compare the performance of two different multiple-scan protocols for total retinal blood flow (TRBF) measurement using Doppler optical coherence tomography (OCT).

Methods: In the “single-angle” protocol, five Doppler scans were acquired at a single beam angle. In the “dual-angle” protocol, three scans were obtained with the OCT beam passing through the supranasal portion of the pupil and three through the infranasal portion. The data were analyzed using a custom software termed “Doppler OCT of Retinal Circulation” (DOCTORC) to generate TRBF measurements. In DOCTORC, the measurement of a vein was considered unreliable if the Doppler angle was less than 3° or the coefficient of variation of Doppler angle was more than 50%. If the summated area of unreliable veins was larger than 50% of total venous area, the measurement of TRBF was considered not acceptable.

Results: Ten subjects were scanned with both protocols. The Doppler angle (P < 0.003, paired t-test) and Doppler shift (P < 0.035) were significantly higher in the dual-angle protocol. The yield rate, percent of eyes with valid TRBF measurement, was 80% using the dual-angle protocol and 60% from single-angle protocol. An additional 42 subjects were scanned with the single-angle protocol while 84 subjects with the dual-angle protocol. Unpaired tests also showed significantly better yield rate (P = 0.03).

Conclusions: The dual-angle protocol improved Doppler shift level in OCT. This resulted in a greater percentage of cases in which TRBF could be reliably measured.

Translational Relevance: The new scan protocol improved the practicality of TRBF measurement with Doppler OCT.

Introduction

Doppler optical coherence tomography (OCT) detects Doppler shifts generated by light scattering particles moving in the direction of beam propagation. Doppler shift measurements can be made on standard OCT systems used for conventional structural imaging by using special software that analyzes the complex OCT signal. The Doppler shift is proportional to the axial component (parallel to the axis of beam propagation) of the velocity vector. Thus, both the Doppler shift and the Doppler angle are needed to estimate the retinal blood flow velocity. There are two options to measure the Doppler angle. One is to use a special OCT system with two simultaneous beams with a fixed angle offset. The difference in the Doppler shift between the two beams and the angle between them is then used to calculate velocity.¹ The other is to use a standard OCT system with a single beam and measure the orientation of the blood vessels relative to the optical axis in OCT images.²⁻⁷ We chose to use the latter because this made measurements possible using the standard retinal OCT scanners available in most clinics.

Our group developed a double circular OCT scanning pattern that allows the measurement of blood flow in all veins entering the optic nerve head, thus permitting computation of total retinal blood flow (TRBF).⁵ Wang et al.⁶ demonstrated flow measurements in healthy individuals and patients with glaucoma, diabetic retinopathy, and nonarteritic ischemic optic neuropathy using a prototype OCT system and a commercial OCT system installed with modified software featuring a double-circular scan-
nning pattern. Software algorithms were developed to automatically identify the vessels in the circular B-scans. These algorithms, however, were imprecise or failed in some cases. In addition, when vessels were closely spaced or crossing, it was sometimes difficult for the algorithm to automatically identify the same vessel in both the inner and outer circular scans, which is a critical requirement to calculate accurate Doppler angles. For this reason, we developed a semi-automated software tool, termed the Doppler OCT of Retinal Circulation (DOCTORC), to allow efficient manual identification and correction of corresponding vessel positions, and subsequent generation of retinal blood flow results. We observed that by choosing two pupil positions, locations in the pupil, thereby causing the beam to strike the retinal surface at different angles. We measured when the OCT beam is nearly perpendicular to the blood vessel (termed a “low Doppler angle”). In this situation, the Doppler shift will be very weak and difficult to distinguish from noise, making vessel identification and calculation of the Doppler angle difficult. Of note, this is a limitation for all direct Doppler angle measurement approaches. Because of this problem, one “solution” employed in previous reports was to estimate the flow in vessels with low Doppler angles by using the average velocity from neighboring vessels; however, this approach clearly reduces the measurement accuracy of the total retinal blood flow, particularly when there are regional variations in flow.

To address this problem, we conducted a pilot study in which we tested various eccentric scan acquisition angles by moving the laser beam through different locations in the pupil, thereby causing the beam to strike the retinal surface at different angles. We observed that by choosing two pupil positions, supranasal and infranasal relative to the pupil center, a large Doppler shift was present in virtually all vessels entering the optic nerve head on at least one scan. In addition, rather than requiring that flow from all vessels be computed from a single scan, we changed our analysis approach to combine Doppler data from both scans. For a given vessel, we used the data from the scan with the best Doppler shift and angle. In this study, we compared the image quality (as determined by the Doppler shift and Doppler angle), yield rate, and variability of the final TRBF results of the new dual angle Doppler scanning protocol versus the previously established single-angle protocol.

Materials and Methods

Subject Recruitment and Imaging Overview

Patients were recruited from the University of Southern California (USC; Los Angeles, CA)/Doheny Eye Institute (Los Angeles, CA) ophthalmology clinics as part of National Eye Institute-sponsored Advanced Imaging for Glaucoma Study (AIGS). The study was approved by the USC institutional review board, and the research adhered to the tenets set forth in the Declaration of Helsinki. Written informed consent was obtained from each subject after explanation of the nature and possible consequences of the study. The inclusion and exclusion criteria of the AIG study were previously reported. Briefly, healthy control participants met the following criteria in both eyes: intraocular pressures (IOP) of less than 21 mm Hg for both eyes, a normal Humphrey visual field (HVF) on achromatic standard automated perimetry by Swedish Interactive Threshold Algorithm 24-2 (HFA II; Carl Zeiss Meditec, Inc., Dublin, CA) with mean deviation (MD), Glaucoma Hemifield Test (GHT), and pattern standard deviation (PSD) within normal limits. In addition, healthy subjects had a normal appearing optic nerve head (ONH) and retinal nerve fiber layer (RNFL) on ophthalmoscopy examination, and an open angle by gonioscopy. The inclusion criteria for perimetric glaucoma (PG) participants included at least one eye that fulfilled the following criteria: (1) glaucomatous HVF with PSD or GHT outside normal limits (P < 0.05 and P < 1%, respectively) in a consistent pattern on both qualifying HVF, and (2) glaucomatous ONH or RNFL defects. The pre-perimetric glaucoma (PPG) participant group does not have glaucomatous HVF as defined for the PG group, but has glaucomatous ONH or RNFL defect. Exclusion criteria for all groups included vision less than 20/40, age younger than 40 or older than 79 years at enrollment, any ocular surgery other than cataract extraction, other diseases that might cause HVF or ONH abnormality.
and factors that might preclude the participant from performing study procedures or complete the study.

All patients were scanned with a RTVue Fourier domain OCT (FD-OCT) system (Optovue Inc., Fremont, CA) using a double circular scanning pattern (DCSP) that scans around the optic nerve head at diameters of 3.40 and 3.75 mm. With each scan acquisition, the concentric circular scans were performed six times consecutively over 2 seconds. In addition to the DCSP scans, a three-dimensional (3D) volumetric OCT scan of the optic disc and a standard color photograph of the disc were obtained.

**Single-Angle and Dual-Angle Protocols**

We developed both single- and dual-angle scan protocols to improve the yield rate of valid TRBF grading from Doppler OCT. For the single-angle protocol, the technician was required to adjust the OCT scanner until the retinal image signal had good reflection and most of the vessels had a good Doppler shift (Fig. 1A). In practice, the reflectance signal usually reached the maximum when the laser beam passed through the center of the pupil, while the Doppler shift in veins varied with laser beam position on pupil. Because the selection of the best Doppler shift was subjective, the scan quality was highly dependent on the experience of the technician. Five DCSP repeated scans were acquired at this position.

For the dual-angle protocol, the technician first adjusted the OCT scanner so that the laser beam passed through the supranasal edge of the pupil, while keeping the signal strength index (SSI) greater than 40. Three repeated DCSP scans were acquired at this position. Then the technician adjusted the OCT beam to pass through the infranasal portion of pupil where three additional DCSP scans were acquired (Fig. 1B, 1C). The adjustment was actually made by moving the OCT scanner higher or lower and observing the real time SSI after the technician obtained good OCT images.

**Doppler OCT Grading**

The DCSP scans, the 3D volume OCT scan, and the color photo of the disc served as the input for the previously described DOCTORC software. This semi-automated software allows the user to refine the position and boundaries of the automatically detected vessels prior to the calculation of TRBF, vessel cross-
sectional area, and average blood flow velocity. As previously described, the flow in each vessel was calculated from the Doppler shift in the vessel cross-sectional area and the Doppler angle between the vessel and the OCT beam. The measurement of TRBF was calculated by summing the flow from all of the veins around the optic disc. The input of DOCTORC included multiple scans. Each scan consisted of six frames on the inner ring (3.40-mm diameter) and six frames on the outer ring (3.75-mm diameter) around the optic disc. In later analyses, the data of all five or six scans of a single eye in one protocol were referred to as a visit. The OCT images of different frames on the same circle were first registered. Thus, all circular scans from the same location were aligned and averaged to improve the signal-to-noise ratio. The vessel position was automatically detected on the aligned and averaged images. The grader then manually corrected the vessel position for each scan and matched the same vessel on all scans. Following that, the vessel position of each frame was recalculated. The difference of vessel positions on the six inner and six outer rings were averaged for estimation of Doppler angle. The averaged Doppler angle and summation of Doppler shift inside the vessel were used to calculate the blood flow. For a vessel in a single scan, only measurement with both Doppler angle larger than 3° and SD of Doppler angle less than one-half of the absolute value were considered reliable. Ideally, we will have three or more reliable measurements for each vessel among six scans following dual angle protocol. Those reliable measurements were averaged to provide blood flow for this vessel. If a vein did not have any scans with reliable Doppler angle or Doppler signal, the vein was marked as not reliable. In those cases, the flow is estimated using the vessel area and the average flow speed from other reliable veins. The average flow speed is calculated by summing the flows in the reliable veins and dividing by the summed areas of those reliable veins. The estimate of flow starts from the average flow speed and is then corrected for the dependence of flow velocity on vessel area. Larger vessels have a higher average flow velocity. Thus, the correction is made based upon the slope of average velocity versus vessel diameter that we previously reported. Finally, TRBF was summed from all veins.

**Assessment of Data Quality**

To evaluate the data quality, the most important parameters were the Doppler shift inside the veins and the Doppler angle. A strong Doppler shift reduces the effect of noise caused by eye movement and helps to differentiate the vessel from the background. Larger Doppler angles reduce the effect of error in detection of the vein center. The Doppler shift was calculated after the correction of bulk motion, and the Doppler angle was estimated from the difference of the vessel center depth on the two concentric rings.

In addition to the Doppler shift and angle, the overall image quality of a visit was also evaluated. The average reflectance signal strength in a visit, and the average motion artifact in a visit were considered in the quality assessment. The reflectance signal strength was evaluated using the SSI provided by the RTVue. Motion artifact was evaluated as the pooled SD of the inner limiting membrane (ILM) in the repeated frames in each Doppler scan.

**Assessment Variability of the Flow Results**

After the grading, the variability of TRBF was estimated using several criteria. Only cases that passed all criteria were accepted as valid. Among these criteria, the most important one was the area ratio of valid veins/total veins, which is the proportion of veins with reliable flow measurements. In DOCTORC grading, we assigned a validity value to each vein. If the results did not meet the minimal criteria, then the direct flow measurement of the vein was discarded. When the area ratio of valid veins/total veins was near 1, then we assumed all veins had at least one scan that provided reliable flow measurement. When the valid venous area proportion was larger than 50%, the grading was considered acceptable.

Another criterion was the “Valid scan/Veins” (VSV).

\[
VSV = \sum_{m=1}^{M} \sum_{n=1}^{N} \frac{(A_{mn} \times W_{mn})}{\text{Total venous area}},
\]

where \(A_{mn}\) was the area of \(m^{th}\) vein on \(n^{th}\) scan. \(W_{mn}\) was 1 if \(m^{th}\) vein had reliable flow measurement on \(n^{th}\) scan; otherwise it was 0. \(M\) was the number of veins and \(N\) was the total scan number. Because the flow was averaged among qualified scans for each vessel, a higher VSV value meant that the standard error of the measurement was smaller.

**Statistical Analysis**

First, we compared the Doppler shift and Doppler angle in the main veins. We only consid-
ened veins with diameters less than 75 µm for the comparing of Doppler angle and Doppler shift. Those veins contributed to most (>80%) of the TRBF, and the signal in these veins was less affected by noise. We compared both averaged and maximum values for the Doppler shift and angle. For each vein, the averaged and maximum value was calculated from the five or six scans of same eye. The veins of different eyes were pooled together for comparison of Doppler signals and Doppler angles. Then, reflectance signal strength, VSV, yield rate (percent of eyes with valid TRBF measurement) and flow in response to variability of TRBF were also compared based on individual visits. For the cohort using same participants in two protocols, all parameters were compared between the two protocols using two-tailed paired $t$-tests except the yield rate is compared using fisher exact test. For the cohort using different participants in two protocols, all parameters were compared using two-tailed unpaired $t$-tests except the yield rate is compared using fisher exact test. The DOCTORC software and statistical analysis were programmed and performed using Matlab 2007a (Mathworks, Natick, MA).

**Results**

Two different cohorts were included in this study. The first cohort consisted of 10 subjects who had one eye scanned with the single-scan protocol and then returned at a later visit to be scanned with the dual-angle protocol. Since we were not comparing flow values, but rather the quality of the results, the temporal separation was not considered to be a confounder. Among these subjects, six eyes were healthy, two had preperimetric glaucoma, and two had perimetric glaucoma. The second, larger cohort consisted of one eye of 42 subjects who were scanned with the single-angle protocol and one eye of 84 different subjects who were scanned with the dual-angle protocol. Among the 42 subjects imaged with single-angle scan protocol, 25 eyes were healthy, three had preperimetric glaucoma, and 14 had perimetric glaucoma. Among the 84 subjects with dual-angle scan protocol, 23 eyes were healthy, 16 had preperimetric glaucoma, and 44 had perimetric glaucoma.

In Doppler OCT, the signal strength is related to scan position (Fig. 2). When the OCT beam passed through the center of the pupil (Fig. 2A), the reflectance signal strength was larger than when it passed through the infranasal pupil (Fig. 2B). However, the Doppler shift, which is more important in the calculation of blood flow, was stronger when the beam passed through the infranasal pupil. Two repeated scans of the same eyes using the two protocols were chosen to demonstrate that by having two angles, the scans in a set become complementary (Fig. 3). In the single-angle protocol (Fig. 3B), Doppler angles of vessels that were poor in the first scan were also poor in the repeated scan. In the dual-angle protocol (Fig. 3C), some vessels had a good Doppler shift at the scan with laser beam through supranasal portion of pupil, while other vessels had a good Doppler shift at scan with laser beam through infranasal portion of pupil. By combining informa-
From the two scans, flow in most retinal vessels was reliably measured. From the first cohort, venous Doppler shift and Doppler angles \( (n = 10 \text{ eyes}) \) were determined to compare the single-angle protocol with the dual-angle protocol. Average and maximum values were calculated from measurements of repeated scans for each vessel. The values for all main veins, defined as those having diameters greater than 75 \( \mu \text{m} \), around the optic discs of the 10 eyes were pooled for comparison. The average and maximum Doppler shifts acquired by the dual-angle protocol were significantly stronger \( (P < 0.001 \text{ and } = 0.003, \text{ respectively, Table 1}) \) than for the single-angle protocol. The average and maximum Doppler angle acquired by the dual-angle protocol was also significantly larger \( (P = 0.021 \text{ and } = 0.035, \text{ respectively}) \) than for the single-angle protocol.

From the first cohort, the image quality of each visit was also evaluated by reflectance signal strength and motion artifacts. There were no significant differences between the two protocols for eye movements \( (\text{Table 2}) \). Though the SSI was significantly higher for the single-angle protocol \( (P = 0.04) \), the difference was small and both were much higher than the recommended SSI value of 50 for optic nerve head scans.

From the first cohort, the variability of TRBF was determined by the yield rate (or percentage of eyes with valid flow measurement), percentage of vein area with valid flow measurement, and valid scan/veins. The dual-angle protocol was significantly better than the single-angle protocol for the percentage of vein area with valid flow measurement \( (P = 0.02, \text{ Table 3}) \). The dual-angle protocol also had a higher yield rate in providing valid flow results and VSV.

We also compared the TRBF and venous area between two scan protocols. The average TRBF is 43.1 \( \mu \text{L/min} \) for single-angle protocol, and 44.2 \( \mu \text{L/min} \) for dual-angle protocol. The average venous area is 0.0459 mm\(^2\) for the single-angle protocol, and 0.0465 mm\(^2\) for the dual-angle protocol. No significant difference was found for either TRBF of venous area using paired \( t \)-test.

Comparisons of image quality \( (\text{Table 4}) \) and variability \( (\text{Table 5}) \) were also performed on the second cohort, with a larger population that...
included 42 eyes scanned with the single-angle protocol and 84 eyes of different subjects scanned with the dual-angle protocol. No significant difference was found for reflectance signal strength and eye movement between the two protocols (Table 4). All three variability parameters showed significant difference between the two protocols (Table 5, \( P < 0.05 \)).

### Discussion

The dual-angle protocol provides significantly higher Doppler angles, thus increasing the component of the flow vector along the OCT beam axis. This increases the Doppler shifts (flow signal) for veins compared with the single-angle protocol. Thus, it provides a higher signal-to-noise ratio for flow calculations. Furthermore, this provides sharper vessel boundaries and enables more precise vessel position and Doppler angle determination. In the dual-angle protocol, acceptably large Doppler angle can usually be found for the great majority of retinal veins when the beam through position on pupil is in either supranasal or infranasional portion, thus the yield rate was higher than the single-angle protocol, which more frequently encounter veins with near-zero Doppler angle (near perpendicular vessel axis relative to the OCT beam) and therefore unmeasurable Doppler shift. The precision of angle measurement is determined by the ratio of absolute angle value relative to the magnitude of eye movement. Thus large angles provide more precise results for any given amount of movement noise.

A potential drawback of the dual-angle protocol is blocking of the OCT beam by the iris because the beam positions were intentionally place near the pupil edge. Indeed, we found that the dual-angle protocol had lower SSIs than did the single-angle protocol. However, the SSIs of scans in the dual-angle protocol were still adequate, much higher than the recommended minimum value from the vendor (SSI > 50). Therefore the SSIs in these analyses were not critical. Our experiments were performed with pupil dilation by both mydriacyl and phenylephrine eye drops. Dilation was important to provide sufficient separation between the two beam positions in the pupil in the dual-angle protocol. Thus, we recommend that dilating eye drops be always used with this protocol.

The yield rate of reliable measurement is dependent on the strength of the Doppler shift in the imaged vessels and the Doppler angles. This explains why the yield rate of the dual-angle protocol was higher than the single-angle protocol. The valid venous area proportion for the dual-angle protocol was also significantly larger than for the single-angle protocol. This indicates that the blood flow measured by the dual-angle protocol is more reliable and accurate. The larger equivalent scan number of the dual-angle protocol suggests that the repeatability may be somewhat better; however, the variances of both protocols precluded statistical significance.

The dual-angle scan requires dilation without

### Table 1. Doppler shift and Angles with Single- and Dual-Angle Protocols Tested in Same Subjects

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Doppler Shift (Radian)</th>
<th>Doppler Angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>Single angle</td>
<td>0.61 ± 0.16</td>
<td>0.81 ± 0.24</td>
</tr>
<tr>
<td>Dual angle</td>
<td>0.83 ± 0.16</td>
<td>1.20 ± 0.30</td>
</tr>
<tr>
<td>( P ) value (paired ( t )-test)</td>
<td>&lt; 0.001</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Values are means ± SDs, pooled from 56 veins of 10 eyes. Doppler phase shift is measured between adjacent axial scans 37-μs apart. Both protocols were tested in one eye each of 10 subjects.

### Table 2. Image Quality of Single- and Dual-Angle Protocols Tested in Same Subjects

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Reflectance Signal Strength Index</th>
<th>Eye Movement, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single angle</td>
<td>67.8 ± 4.3</td>
<td>28.8 ± 12.2</td>
</tr>
<tr>
<td>Dual angle</td>
<td>63.5 ± 4.7</td>
<td>33.4 ± 9.6</td>
</tr>
<tr>
<td>( P ) value (paired ( t )-test)</td>
<td>0.04</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Both protocols were tested in one eye each of 10 subjects.
which the pupil would be too small to support two different beam angles that are sufficiently separated to improve the Doppler signal. To get the best benefit of the dual-angle protocol, we prefer to put the laser beam far from the center for both supranasal and infranasal portion of pupil. The large angle difference that arises between these two positions helps to exclude flat vessels. In some eyes, the intensity signal decreased fast when the laser beam was offset from the center of pupil. In those eyes, the benefit of dual-angle protocol was limited.

With the dual-angle protocol, none of the scans were of sufficient quality for blood flow measurements in 26% of eyes. This was mainly due to poor Doppler angle, big motion error, or weak reflectance signal strength. The current software does not alert the operator to poor signal quality. Therefore real-time quality analysis could potentially improve yield rate by removing poor quality scans and informing the operator to make additional scans during the patient’s visit. We have implemented quality control software to provide real-time measurement of eye motion and pupil position estimation. Therefore, we anticipate improvements in the yield rate in near the future.

The current approach needs many repeated frames and multiple scans to exclude flat vessels and reduce the eye movement. Thus, the technique is currently more time consuming than standard structural OCT scanning. Recently, another approach has been developed to reconstruct the Doppler shift and vessel area in en face images from 3D OCT datasets. This allows the flow to be calculated without requiring measurement of Doppler angles.13 Thus, it may be more robust.

Conclusion

The dual-angle protocol improved the yield rate and reduce the variability of TRBF measurement using Doppler OCT. These enhancements are the result of improved Doppler signals and Doppler angles without significant compromise of other aspects of image qualities.

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Financial interests: Ou Tan and David Huang have a significant financial interest in Optovue Inc., a company that may have a commercial interest in the results of this research and technology. This potential individual conflict of interest has been reviewed and managed by Oregon Health & Science University. The other authors do not have a financial interest in the subject of this article.

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Table 3. Yield Rate and Variability of Blood Flow Measurement for Single- and Dual-Angle Protocols Tested in Same Subjects

<table>
<thead>
<tr>
<th>Protocol</th>
<th>% Eyes With Valid Flow Measurement</th>
<th>% Vein Area With Valid Flow Measurement*</th>
<th>VSV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single angle</td>
<td>60%</td>
<td>59% ± 22%</td>
<td>1.67 ± 0.77</td>
</tr>
<tr>
<td>Dual angle</td>
<td>80%</td>
<td>85% ± 21%</td>
<td>2.43 ± 1.08</td>
</tr>
<tr>
<td>P value (paired t-test)</td>
<td>0.24</td>
<td>0.02</td>
<td>0.09</td>
</tr>
</tbody>
</table>

* Values are means ± SDs. Both protocols were tested in one eye each of 10 subjects.

Table 4. Image Quality of Single- and Dual-Angle Protocols Tested in Separate Populations (Cohort 2)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Reflectance</th>
<th>Eye Movement, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>61.0 ± 12.8</td>
<td>30.6 ± 14.0</td>
</tr>
<tr>
<td>Dual</td>
<td>59.6 ± 11.4</td>
<td>33.5 ± 13.8</td>
</tr>
<tr>
<td>P value (unpaired t-test)</td>
<td>0.56</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Table 5. Yield Rate and Variability of Blood Flow Measurement for Single- and Dual-Angle Protocols Tested in Separate Populations (Cohort 2)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>% Eyes With Valid Flow Measurement</th>
<th>% Vein Area With Valid Flow Measurement*</th>
<th>VSV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single angle</td>
<td>57%</td>
<td>0.60 ± 0.22</td>
<td>1.65 ± 0.80</td>
</tr>
<tr>
<td>Dual angle</td>
<td>74%</td>
<td>0.81 ± 0.22</td>
<td>2.41 ± 0.94</td>
</tr>
<tr>
<td>P value (unpaired t-test)</td>
<td>0.03</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Means ± SDs; single-angle protocol, 42 eyes; double angle protocol, 84 eyes.


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