• Clinical Research •

Retinal vessel density alteration after FS-LASIK for myopia with different axial lengths

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Abstract
● **AIM:** To compare the effects of different types of negative pressure suction on the macular and optic disc retinal vessel density (VD) in myopic patients with different axial lengths (ALs) undergoing femtosecond laser-assisted excimer laser *in situ* keratomileusis (FS-LASIK) by optical coherence tomography angiography (OCTA).

● **METHODS:** A prospective, nonrandomized, controlled study. Participants underwent FS-LASIK surgery were divided into the short AL group (SAL, 22≤AL<26 mm) and the long AL group (LAL, 26≤AL<28 mm) according to the different ALs. Further, the two groups were divided into subgroups according to the corneal flap using VisuMax or WaveLight FS200 femtosecond laser (FS) platform. All patients underwent OCTA before the surgery and 1-day/1-week/1-month after the surgery. ANOVA statistically analyzed data with two-factor repeated measurement in SPSS.

● **RESULTS:** Totally 108 participants (108 eyes, 18–35y) were divided into SAL group [22 patients (4 males and 18 females) were treated with VisuMax, and 24 (3 males and 21 females) were treated with WaveLight FS200] and LAL group [34 patients (4 males and 30 females) were treated with VisuMax, and 28 patients (6 males and 22 females) were treated with WaveLight FS200]. In the LAL group, there was no significant difference in macular superficial capillary plexuses vessel density (SCP-VD) in the fovea and perifovea region, but compared with the VisuMax subgroup, SCP-VD in the parafoveal region (t=2.647, P=0.010) and the whole area (t=2.030, P=0.047) in WaveLight FS200 subgroup decreased at one day after the operation and increased to a preoperative level at 1-week and 1-month after operation. There was no significant difference between SCP-VD in the two SAL subgroups, neither of deep capillary plexuses vessel density (DCP-VD) and optic nerve head vessel density (ONH-VD) in the SAL and LAL groups.

● **CONCLUSION:** With the increase of AL and suction intensity, a transient decrease of SCP-VD in the macular region is observed at 1d postoperatively during FS-LASIK, and it increases to preoperative level at 1-week and 1-month postoperatively. However, the AL and suction intensity do not affect the macular DCP-VD and ONH-VD.

● **KEYWORDS:** optical coherence tomography angiography; myopia; FS-LASIK; axial length; vessel density
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INTRODUCTION

With the increasing prevalence of myopia globally, it has increasingly become a serious worldwide health problem and even reached an epidemic level in East and Southeast Asia[1-2]. Correspondingly, more patients choose corneal refractive surgery to correct myopia. Femtosecond laser-assisted excimer laser *in situ* keratomileusis (FS-LASIK) has been one of the most commonly used refractive surgery methods since its clinical application. A unique suction ring is routinely used to fix the eyeball in corneal flap cutting, which leads to immediate intraocular pressure (IOP) rising. The IOP can rapidly rise to over 65 mm Hg and return to normal after removing the suction ring[3-4]. Although the fundus blood flow and oxygen supply can be adjusted automatically in the retina[5-6], several studies have shown that the blood flow was reduced significantly with the excessive IOP increase[7-8].
Shoji *et al*[9] show that retinal vessel density (VD) is more sensitive to IOP fluctuations than the thickness of ganglion

cell complex, and sudden IOP increase can lead to ischemia-reperfusion injury, including retinal ganglion cell death and optic nerve or retina damage[8,10]. Theoretically, the smaller the diameter of blood vessels, the more sensitive the changes in IOP, and the greater the influence of IOP fluctuation on retinal hemodynamics. In addition, several studies have demonstrated that myopia patients can experience changes such as thinning of retinal vessels and a decrease of VD with the axial length (AL) extension[11-14]. However, there is no significant change in retinal thickness[15].

As a new non-invasive, high-resolution, and visual image scanning technology, optical coherence tomography angiography (OCTA) can quickly collect and quantitatively analyze retinal VD of the macular region and optic nerve head (ONH) region. However, many studies have shown that AL can affect the results of retinal VD measured by OCTA[14,16]. Many scholars have observed and analyzed the changes in retinal VD before and after surgery for different types of myopia[17-19]. However, there are few reports on the correlation between AL and retinal VD changes.

In this study, VD of superficial capillary plexuses (SCP) and deep capillary plexuses (DCP) in the macular area and ONH area was measured by OCTA in patients with different ALs before and after FS-LASIK to analyze its influence on VD changes. Given the differences in vacuum suction intensity and duration time in different FS platforms, we compared both VisuMax (Carl Zeiss Meditec AG, Oberkochen, Germany) and WaveLight FS200 (Alcon Laboratories, Fort Worth, TX, USA) FS laser facilities to provide a more comprehensive and rigorous reference basis for clinical rational treatment.

PARTICIPANTS AND METHODS

Ethical Approval All the patients underwent FS-LASIK in the Department of Ophthalmology, Beijing Tongren Hospital, Affiliated with Capital Medical University from May to December 2021. The study adhered strictly to the Declaration of Helsinki and was approved by the Beijing Tongren Hospital Review Board (No.TRECKY2020-090). Informed consent was signed by all the participants included in this study. The research has been retrospectively registered on the Chinese Clinical Trial Registry website (No.ChiCTR2100047478).

Subjects and Eligibility Criteria The subjects were randomly selected from patients who applied to undergo FS-LASIK surgery in the department. Inclusion criteria: 1) age:18–35 years old; 2) best corrected visual acuity of logMAR≤0; 3) spherical diopter≥-10.0 D or cylindrical diopter≥-2.0 D, diopter stable within two years (growth≤0.50 D); 4) postoperative residual central corneal thickness ≥280 μm. Exclusion criteria: 1) AL<22 mm, or AL≥28 mm; 2) spherical equivalent <-12.0 D; 3) unable to achieve good quality images or complete the inspection after repeated measurements; 4) history of eye surgery, trauma, or severe systemic diseases.

Baseline Examination All the patients underwent examinations such as visual acuity, non-contact tonometer, slit lamp microscopy, manifest refraction, mydriatic refraction, AL measurements (Lenstar LS 900, HAAG-STREIT AG, Switzerland), corneal topography (TMS-4, Tomey, Japan), OCT (RTVue-100, Optovue, USA) and wide-field fundus examination (Daytona, P200T, Optos, UK) routinely before operation.

OCTA Scan Protocol OCTA (software version V2018.1.1.63; Optovue, Inc., Fremont, CA, USA) was also examined pre-operatively and 1-day/1-week/1-month postoperatively. Examinations were operated by the same technician, and those with overall quality indicators under seven were not adopted. The macular images are acquired in high definition (HD) AngioRetina [6.0] mode with a 6×6 mm^2 circular scanning area centered on the macular fovea, which is divided into fovea region (a circle with 1 mm diameter), parafovea region (a 2 mm wide round annulus around the fovea region), perifovea region (a 3 mm wide round annulus around the parafovea region) and the whole area region (6×6 mm^2) automatically by the system software. Meanwhile, the software automatically divides the layers of SCP and DCP. The ONH images are acquired in HD AngioDisc [4.5] mode with a 4×4 mm^2 circular scanning area centered on the optic disc, which is dived into the disc inside the region (a 2 mm diameter circle centered on the optic disc), a peripapillary region (a 1 mm annulus region around the disc) and the whole area region (a 4×4 mm^2 circular area). The software automatically quantifies VD (%) of all the above areas (Figure 1).

Operation and Medication All patients completed FS-LASIK successfully. They were divided into VisuMax and WaveLight FS200 subgroups according to the FS laser platform for corneal flap creation, of which the thickness was 100–110 μm and the diameter was 8.1–8.5 mm. Optical zone ablation of 6.0–6.5 mm was performed after the flap was separated and lifted by the WaveLight EX500 (Alcon Laboratories, Fort Worth, TX, USA). Then the flap was repositioned.

The vacuum suction duration time was 23.10±1.49s in the VisuMax, and the highest IOP value might reach over 65 mm Hg during the suction[4]. Regarding the WaveLight FS200, the IOP value could reach as high as 90 mm Hg, and the duration time was about 26.14±3.66s[20]. The same experienced surgeon performed surgeries.

All patients were regularly dripped with topical antibiotics (levofloxacin 0.5%; Santen Pharmaceutical Co., Ltd.) and artificial tears (sodium hyaluronate eye drops 0.3%; Santen Pharmaceutical Co., Ltd) *q.i.d.* three days before and after surgery, and Deproteinized Calfblood Extract Eye Gel bid

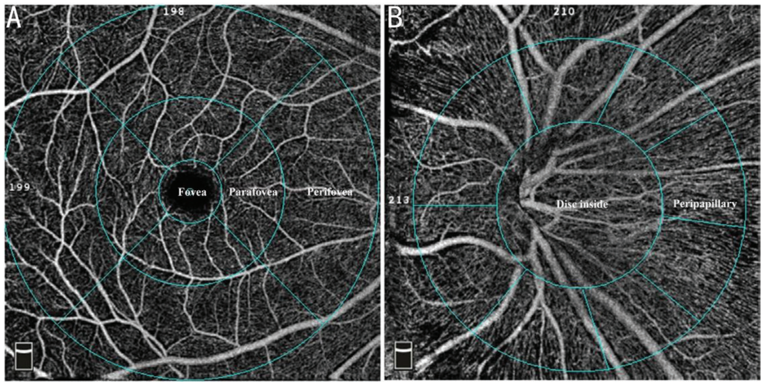

Figure 1 The retinal VD distribution A: VD distribution of the macular 6×6 mm^2 circle area, with a 1 mm diameter circular macular fovea region centered on the foveal avascular zone, a 1–3 mm annular parafovea region in the middle, and a 3–6 mm annular perifovea region outside; B: VD distribution of the optic disc 4×4 mm^2 circle area, with a 2 mm diameter circular disc inside as the center and a 1 mm annular peripapillary region outside. VD: Vessel density.

Table 1 Comparison of preoperative baseline parameters mean±SD

Groups	SAL			LAL		
	VisuMax	FS200	*P*	VisuMax	FS200	*P*
n (right eyes)	22	24		34	28	
Gender (M/F)	4/18	3/21		4/30	6/22	
Age (y)	26.64±6.45	26.66±4.77	0.986	26.94±3.99	25.29±4.03	0.111
SE (D)	-5.96±1.26	-5.29±2.05	0.193	-8.17±1.15	-8.01±1.21	0.598
AL (mm)	25.19±0.83	25.26±0.50	0.713	26.64±0.40	26.72±0.46	0.487

SD: Standard deviation; M: Male; F: Female; SE: Spherical equivalent; AL: Axial length; SAL: Short axial length; LAL: Long axial length.

after surgery; topical steroids (fluorometholone 0.1%; Santen Pharmaceutical Co., Ltd.) were initially dispensed *q.i.d.* postoperatively and tapered off over four weeks. In one week, water and dirt should be avoided after the surgery. Moreover, attention should always be paid to the corneal flap in case of injury. All the patients underwent OCTA before surgery and 1-day/ 1-week/1-month after surgery.

Statistical Analysis A prospective nonrandomized controlled design. Patients were divided into the SAL group (22≤AL<26 mm) and the LAL group (26≤AL<28 mm) according to the preoperative ALs[16,21-22]. Meanwhile, the two groups were divided into two subgroups (VisuMax and WaveLight FS200) according to the FS platform for making corneal flaps. SPSS22.0 analyzed all the data and was generally distributed through the Kolmogorov Smirnoff normality test and expressed as mean±standard deviation (SD). The parameters between the two groups and at each time point within the group were compared by ANOVA with two-factor repeated measurement, with $P<0.05$ as the statistically significant difference.

RESULTS

Comparison of General Data A total of 108 patients were included, and the data from the right eye were selected for statistical analysis. In the SAL group, 22 patients (4 males and 18 females) were treated with VisuMax, and 24 (3 males and 21 females) were treated with WaveLight FS200. In the LAL group, 34 patients (4 males and 30 females) were treated with VisuMax, and 28 patients (6 males and 22 females) were treated with WaveLight FS200. All data were normally distributed.

There was no significant difference in age, SE, and AL between the subgroups in the SAL and LAL groups before the surgery ($P>0.05$), as shown in Table 1. The 108 patients were followed up on 1-day/1-week/1-month after the operation. All surgeries were completed without complications.

Comparison of SCP-VD in the Macular Area In the SAL group, there was no significant difference in SCP-VD of the fovea, parafovea, perifovea, and whole area (6×6 mm^2) in the macular region between two subgroups with VisuMax and WaveLight FS200 FS platform in general, which was not affected by time. There was also no significant difference in SCP-VD measured at different time points in each subgroup. Simultaneously, there was no significant difference in SCP-VD between the two subgroups in the above areas at pre-operation and 1-day/1-week/1-month post-operation.

In the LAL group, there was no significant difference in SCP-VD of the above macular areas between the two subgroups, which was not affected by time. There was also no significant difference in SCP-VD measured at different time points in each subgroup. When comparing the SCP-VD at each time point between the two subgroups, there were statistically significant differences between the two subgroups in parafovea (t=2.647, P=0.010) and whole area (t=2.030, P=0.047) at one day after the operation. In other words, SCP-VD in parafovea and the whole area of the WaveLight FS200 subgroup were significantly lower than those in the VisuMax subgroup. However, there was no significant difference in SCP-VD of fovea and perifovea between the two subgroups one day after the operation, and it was the same for the SCP-VD in all above macular areas between the two subgroups at 1-week and 1-month post-operation (Table 2).

Comparison of DCP-VD in the Macular Area In both SAL and LAL groups, there was no significant difference in DCP-VD of the fovea, parafovea, perifovea, and whole area (6×6 mm^2) of the macular area with VisuMax and WaveLight FS200 FS platforms, which was not affected by time. There was also no significant difference in DCP-VD measured at different time points in each subgroup. At the same time, there was no significant difference in DCP-VD between the two subgroups in all above areas at pre-operation and 1-day/1-week/1-month post-operation (Table 3).

Comparison of ONH-VD In both SAL and LAL groups, there was no significant difference of VD in disc inside, peripapillary, and whole area (4×4 mm^2) of ONH area with VisuMax and WaveLight FS200 FS laser platforms, which were not affected by time. There was also no significant difference in ONH-VD measured at different time points in each subgroup. Meanwhile, no significant differences were found in ONH-VD between the two subgroups at pre-operation and 1-day/1-week/1-month post-operation (Table 4).

DISCUSSION

With the increasing prevalence of myopia, more research has focused on ocular fundus changes and myopia treatment. OCTA has been widely used in retinal hemodynamics *in vivo* due to its high resolution and non-contact. In addition, the retinal circulation network can be automatically stratified and quantitatively analyzed by split spectrum amplitude decorrelation angiography algorithm combined with inside AngioPlex software[23] to evaluate the automatic regulation ability of retinal vessels more sensitively in different conditions[5,24]. Many studies have shown that AL elongation causes the retinal structure's stretching and the blood vessels to thin, making the retinal circulatory system more sensitive to IOP changes. In this study, we compared the macular and ONH VD in myopic patients with different ALs before and after the corneal flap procedure to evaluate the impact of the IOP sudden spike based on the VisuMax and WaveLight FS200 FS platforms.

This study demonstrated that in the SAL group, there was no significant difference in SCP-VD of the fovea, parafovea, perifovea, and whole area in the macular region between VisuMax and WaveLight FS200 FS laser platforms before and 1-day/1-week/1-month after the operation. However, in

Table 2 Comparison of macular SCP-VD at pre-operation and 1-day/1-week/1-month post-operation in SAL and LAL groups

mean±SD

SCP	SAL							LAL						
	Preop.	1d	1wk	1mo	Time	Time×group	Group	Preop.	1d	1wk	1mo	Time	Time×group	Group
Fovea														
VisuMax	20.08±6.48	19.59±6.55	20.33±7.01	19.63±7.02				21.46±7.16	21.27±7.23	21.03±7.37	20.73±6.86			
FS200	20.08±6.19	19.27±6.49	19.61±7.02	19.08±6.79				22.90±7.53	22.55±7.26	23.11±7.82	23.10±7.96			
P	0.997	0.867	0.732	0.787	0.074	0.599	0.837	0.444	0.490	0.287	0.212	0.744	0.224	0.335
Parafovea														
VisuMax	53.63±2.77	53.06±4.69	54.64±1.96	52.87±2.22				54.03±2.83	54.03±3.06	54.02±2.46	53.18±3.70			
FS200	54.63±2.60	53.06±1.97	54.09±2.77	53.40±3.92				53.09±3.78	52.08±2.65	53.65±3.20	53.11±2.68			
P	0.215	0.997	0.441	0.581	0.050	0.159	0.675	0.267	0.010	0.610	0.927	0.287	0.192	0.133
Perifovea														
VisuMax	51.33±2.78	51.72±3.44	52.30±2.86	51.31±2.21				51.94±2.74	52.53±2.27	52.21±2.50	51.68±2.90			
FS200	51.99±2.59	51.01±1.83	51.97±2.66	52.12±2.99				52.08±2.46	51.57±1.52	52.13±2.11	51.99±2.29			
P	0.408	0.383	0.684	0.307	0.339	0.203	0.861	0.836	0.060	0.888	0.642	0.354	0.218	0.751
Whole area (6 mm×6 mm)														
VisuMax	50.97±2.49	51.12±3.49	51.92±2.46	50.76±1.99				51.55±2.61	51.93±2.37	51.74±2.39	51.15±2.92			
FS200	51.69±2.44	50.58±1.69	51.53±2.60	51.48±3.07				51.49±2.52	50.87±1.53	51.65±2.22	51.43±2.30			
P	0.328	0.503	0.604	0.361	0.228	0.292	0.820	0.921	0.047	0.882	0.677	0.654	0.239	0.610

SAL: Short axial length; LAL: Long axial length; SCP: Superficial capillary plexuses; VD: Vessel density.

Table 3 Comparison of macular DCP-VD at pre-operation and 1-day/1-week/1-month post-operation in SAL and LAL groups

mean±SD

DCP	SAL							LAL						
	Preop.	1d	1wk	1mo	Time	Time×group	Group	Preop.	1d	1wk	1mo	Time	Time×group	Group
Fovea														
VisuMax	35.88±7.58	35.48±8.28	35.67±8.10	35.28±8.46				37.76±7.55	37.79±7.67	38.48±7.87	37.50±7.67			
FS200	35.83±7.43	34.91±7.55	35.95±7.21	34.93±7.21				39.47±7.45	39.29±7.40	39.65±7.07	39.48±7.62			
P	0.982	0.809	0.900	0.883	0.111	0.651	0.940	0.376	0.440	0.544	0.314	0.203	0.593	0.400
Parafovea														
VisuMax	57.66±3.84	57.75±4.09	57.85±2.99	56.52±4.32				55.05±4.78	56.36±3.80	56.94±3.58	55.67±3.61			
FS200	57.01±3.29	56.09±2.53	58.32±3.69	57.72±4.21				55.32±4.55	54.94±4.49	55.81±5.51	55.60±4.75			
P	0.541	0.101	0.643	0.344	0.346	0.176	0.816	0.826	0.182	0.334	0.949	0.219	0.217	0.508
Perifovea														
VisuMax	52.31±6.30	54.11±7.33	54.44±4.96	52.65±7.28				50.17±5.71	52.58±4.79	53.52±5.54	51.30±5.31			
FS200	52.55±5.17	51.91±4.21	55.32±5.28	54.13±5.92				50.73±6.27	50.31±5.73	51.44±6.82	51.32±6.62			
P	0.885	0.212	0.564	0.451	0.183	0.390	0.922	0.714	0.094	0.190	0.816	0.175	0.178	0.323
Whole area (6 mm×6 mm)														
VisuMax	53.04±5.40	54.41±6.50	54.68±4.38	53.03±6.43				50.91±5.31	52.96±4.44	53.86±4.92	51.89±4.76			
FS200	53.08±4.61	52.37±3.67	55.45±4.77	54.40±5.41				51.44±5.60	51.03±5.22	52.09±6.26	51.94±5.98			
P	0.982	0.192	0.573	0.439	0.219	0.358	0.972	0.705	0.121	0.216	0.969	0.149	0.149	0.422

SAL: Short axial length; LAL: Long axial length; DCP: Deep capillary plexuses; VD: Vessel density.

Table 4 Comparison of ONH-VD at pre-operation and 1-day/1-week/1-month post-operation in SAL and LAL groups

mean±SD

ONH	SAL							LAL						
	Preop.	1d	1wk	1mo	Time	Time×group	Group	Preop.	1d	1wk	1mo	Time	Time×group	Group
Disc inside														
VisuMax	65.33±2.71	64.15±2.30	64.89±2.48	64.09±3.10				65.41±2.22	65.07±3.14	64.97±2.28	64.16±2.81			
FS200	64.88±2.16	64.20±2.79	64.54±2.51	64.98±2.51				65.06±2.26	64.58±2.35	63.93±2.57	64.38±1.95			
P	0.539	0.955	0.652	0.300	0.199	0.402	0.954	0.541	0.496	0.097	0.724	0.067	0.293	0.402
Peripapillary														
VisuMax	59.47±2.92	59.11±2.91	59.63±3.22	58.99±2.55				58.29±3.06	58.24±2.74	58.35±2.79	58.12±3.29			
FS200	59.04±2.39	58.60±2.67	58.41±2.58	59.23±2.43				58.19±2.61	58.12±2.66	57.90±2.55	58.14±2.47			
P	0.592	0.544	0.167	0.753	0.500	0.228	0.491	0.896	0.670	0.509	0.986	0.944	0.853	0.737
Whole area (4.5 mm×4.5 mm)														
VisuMax	57.66±2.13	57.26±2.24	57.81±2.49	57.07±1.88				56.59±2.52	56.59±2.52	56.19±2.44	55.66±3.08			
FS200	57.25±2.19	56.54±2.46	56.54±2.51	57.15±2.11				56.57±2.42	55.98±2.35	55.80±2.04	56.02±2.31			
P	0.534	0.319	0.102	0.892	0.391	0.217	0.308	0.977	0.336	0.509	0.618	0.080	0.285	0.766

SAL: Short axial length; LAL: Long axial length; ONH: Optic nerve head; VD: Vessel density.

the LAL group, the SCP-VD of parafovea and the whole area in the macular region of the WaveLight FS200 subgroup at 1-day post-operation decreased significantly compared with pre-operation, the differences were statistically significant compared with the VisuMax subgroup. The SCP-VD of the fovea and perifovea region decreased slightly, and there were no statistical differences compared with the VisuMax subgroup. Then, the SCP-VD of the above macular region increased to a level close to pre-operation at 1-week and 1-month post-operation. It demonstrated that the SCP-VD of macular parafovea and the whole area region decreased significantly in the LAL group at 1-day post-operation. It was consistent with the results of Zhang *et al*[23]. However, no significant changes were found in the SAL group postoperatively. These demonstrated that the retinal vascular caliber narrowed, and microvascular density decreased with the AL extension[25]. As a result, it was more sensitive to IOP fluctuation[12,26].

There were no significant changes of SCP-VD in the macular fovea region before and after surgery in both the SAL and LAL groups. We speculated that it was a tiny circle with a 1mm diameter centered on the macular fovea with many avascular areas. As a result, little blood flow could be detectable. However, there were still controversial opinions about the correlation between ocular AL and avascular area[27-29]. Fujiwara *et al*[27] found no significant correlation between AL and foveal avascular zone (FAZ) after adjusting age, gender, VD, and refractive error. Zhou *et al*[28] showed that an increase in AL was significantly correlated with a lower FAZ area in univariate regression analysis. There was no correlation in the multivariate regression analysis. Both of them calculated the circular FAZ region. However, the diameter was 0.6 mm in Zhou's study[28] but 1 mm in this study. In addition, the retinal VD of macular parafovea significantly decreased compared with the perifoveal area in the FS200 LAL subgroup. We speculated that the reason might be that the macular fovea was the thinnest and most posterior of the retina, and the closer to the fovea, the more susceptible it was to mechanical stretch with axial elongation. This has been confirmed by the research of Liu *et al*[13].

There was no significant difference of SCP-VD in all the above macular areas before and after the operation with VisuMax femtosecond laser platform in different ALs, which was considered to be related to the following factors. First, a curved interface was used in the VisuMax FS laser platform, and the volume displacement was significantly smaller than that of the WaveLightFS200 with a flat interface during flattening[30], which had also been verified by Vetter *et al*[4]. Second, compared to the suction on the bulbar conjunctiva of the WaveLight FS200 FS platform, the suction ring of the VisuMax FS platforms located at the corneal margin and the required negative pressure suction intensity was lower to fix the eyeball. Correspondingly, the IOP increase of the VisuMax FS platform was lower during operation. Furthermore, due to the shorter suction duration, the impact on retinal microcirculation was relatively small, and the probability of intraoperative conjunctival bleeding was also reduced accordingly[31].

In both SAL and LAL groups, there was no significant difference in DCP-VD in all the above macular areas before and after the operation, and there was no significant difference at each time point between the two subgroups. Sung *et al*[25] believed that longer AL was significantly related to the reduction of superficial microvasculature. However, the effect on deep microvasculature was not significant, which was also confirmed by our research. We surmised that it might be related to the denser blood vessels in the parafoveal area of DCP[11]. Furthermore, the DCP images might be less precise than the SCP ones with the projection artifact to reduce the reliability of the quantitative analysis of DCP by software[32]. However, Zhang *et al*[23] believed that DCP-VD decreased one day after the operation, which was inconsistent with our study. It might be related to the high suction intensity of the IntraLase FS laser platform they used, which was much higher than that of the VisuMax and WaveLight FS200 FS laser platforms[20]. However, their research showed that DCP-VD in the macular area recovered to the preoperative level at 1-month post-operation, which was identified with our results.

There were also no changes in ONH-VD in either the SAL or LAL groups, indicating that the ONH-VD was unaffected by the sudden IOP change. This was consistent with the results of Chen *et al*[33]. However, only the VisuMax FS laser platform was used in their study, while the WaveLight FS200 FS laser platform was also included in our research.

Above all, there were no significant changes in macular DCP-VD and ONH-VD in different ALs and FS laser platforms after the operation. The Macular SCP-VD decreased significantly in the LAL group with WaveLight FS200 FS laser platform one day postoperatively, and then it returned to the preoperative level at 1-week and 1-month post-operation. However, there were no significant changes in the macular SCP-VD region of the LAL group with VisuMax FS laser platform and SAL group with two FS laser platforms at all time points postoperatively. These results indicated that the longer the AL and the greater the intraoperative negative pressure suction intensity, the more sensitive the retinal microcirculation was to the IOP fluctuation. For the LAL patients, the negative pressure intensity of WaveLight FS200 was slightly stronger, and attention should be paid to avoiding overlong operation time to prevent increased risk. Fortunately, the VD was mainly affected in the early post-operation and recovered to the preoperative level later.

However, the study has several limitations. First, the small sample size in the SAL group may result in data bias. Second, there were more women than men (7 men and 39 women in the SAL group; 10 men and 52 women in the LAL group). Although some studies believed that gender had no significant effect on VD in parafoveal or pericapillary areas[34], the proportion was not appropriate. Furthermore, the projection artifact may also lead to deviation in measurement and quantitative analysis in DCP. Nevertheless, the conclusion of this study may be acceptable with these limitations. In general, both VisuMax and WaveLight FS200 FS laser platforms are safe and reliable in clinical application, and transient IOP alteration does not lead to long-term changes in retinal microcirculation.

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