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Schlemm's Canal in OCT Images in Glaucoma Patients and Healthy Subjects

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Abstract

Objective: To determine by means of optical coherence tomography (OCT) whether there are changes in Schlemm's canal (SC) in primary open-angle glaucoma (POAG) compared to healthy controls and whether the SC dimension varies during the treatment facilitating the outflow of intraocular humor through the uveoscleral pathway.

Patients and methods of examination: 62 eyes of 31 POAG patients (22 women aged 27-83 and 9 men aged 26-80) were included in our set. The patients did not suffer from any other disease of the anterior segment of the eye. Intraocular pressure (IOP) was compensated by drug treatment and its values were in the range of 10-20 mmHg. The group was compared with 92 eyes of 46 healthy subjects (33 women aged 19-71 and 13 men aged 39-79). The SC of all of them was examined by anterior segment OCT-system with a Visante OCT Carl Zeiss Meditec Inc. in horizontal meridian No. 3 and 9.

Results: The comparisons show that the values of right and left eyes of controls (p=0.474) and patients (p=0.143) did not differ. The re-external (0.00029), le-external (p=0.0031), re-internal (p=0.0015), le-internal (p=0.0002) SC dimensions between the control and patient groups differed significantly with the controls always having values significantly higher than the glaucoma patients. Treatment by prostaglandins and beta-blockers did not affect the size of the SC (p=0.23 to 0.95).

Conclusion: In POAG eyes, SC size is smaller than in the eyes of the control group. Eyes on prostaglandin treatment had the same size than those on beta blockers.

Keywords: Schlemm's canal; POAG; OCT

Introduction

The major drainage structures of aqueous humor are the conventional or trabecular out flow pathways, which are comprised of the trabecular mesh work, the juxtacanalicular connective tissue, the endothelial lining of Schlemm´s canal, the collecting channels and the aqueous veins [1].

In this study, we tried to find, by means of optical coherence tomography (OCT), whether there were changes in Schlemm's canal (SC) in primary open-angle glaucoma (POAG) compared to healthy controls and whether the dimensions of the SC varies during the treatment facilitating the outflow of intraocular humor through the uveoscleral pathway.

Patients and Methods

62 eyes of 31 POAG patients (22 women aged 27-83 and 9 men aged 26-80. Mean age- 58) were included in our set. The patients did not suffer from any other disease of the anterior segment of the eye. Intraocular pressure (IOP) was compensated by drug treatment, and its values were in the range of 10-20 mmHg. The group was compared with 92 eyes of 46 healthy subjects (33 women aged 19-71 and 13 men aged 39-79. Mean age -53). The SC of all the eyes were examined using the anterior segment OCT-system with a Visante OCT Carl Zeiss Meditec Inc. (Time-domain AS OCT) in the horizontal meridian at No. 3 and 9.

Consequently, SC size is marked on the right eye as re-internal or re-external and similarly, the left eye as le-external or le-internal (Tables 1 and 2). To avoid data distortion, all the tests and measurements were performed by only one physician. SC was measured in its longer dimension (Figure 1). For evaluation of the right and left eyes of the controls, and following that of the patients, the paired t-test was always used. For comparison of the parameters of the SC size between controls and patients in the study group, the two-sample t-test was used. To assess the prostaglandins and beta-blockers influence on SC size, the non-parametric two-option Mann-Whitney´s test was used.

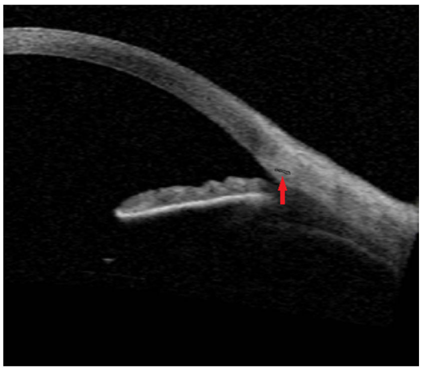

Figure 1: The arrow shows the SC location.

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Results

Measured values of SC size of the right and left eyes, namely at points of intersection of horizontal meridian at No. 3 and 9, are shown in Tables 1 and 2. Statistical values are then introduced in Figures 2-5.

For comparison of the right and left eyes both in controls and patients with glaucoma, the paired t-test was used. When comparing the SC between the right and left eye, always on the same side, we did not find a statistically significant difference in control eyes (re-external and le-external, p=0.383, re-internal and le-internal, p=0.474).

We arrived at a similar conclusion even in glaucoma eyes (re-external and le-external, p=0.143, re-internal and le-internal, p=0.104).

We also compared SC size on the same eye in the control eyes (re-external and re-internal, p=0.912, le-external and le-internal, p=0.533. We did not find statistically significant difference in SC size in the same eye.

We have arrived at a similar conclusion even in glaucoma left eyes (le-external and le-internal, p=0.45). Paradoxically, we have found a statistically significant difference in the right eye re-external and re-internal, p=0.00009.

Gender/ Year of birth	re-external diameter	re-internal diameter	le-external diameter	le-internal diameter	re-IOP	le-IOP
F/1959	0.35	NM	0.4	0.39	14	14
F/1969	0.39	0.41	NM	0.43	18	15
F/1986	0.38	0.4	NM	0.39	11	12
F/1989	0.39	0.39	0.38	0.39	10	10
F/1942	0.35	0.33	0.35	0.28	16	16
F/1940	0.39	0.33	0.39	0.41	15	15
F/1975	0.3	0.29	0.32	0.34	13	15
F/1965	NM	0.4	0.38	0.4	15	16
F/1951	0.39	NM	0.41	0.41	14	14
F/1985	0.39	0.38	NM	0.41	14	15
F/1961	0.39	0.39	0.42	0.39	12	12
F/1994	0.4	0.41	0.41	0.42	14	15
F/1948	0.41	0.4	0.39	0.38	17	17
F/1943	0.4	0.41	0.4	0.38	12	13
F/1964	0.38	0.28	0.23	0.27	18	18
F/1959	0.38	NM	0.37	NM	10	11
F/1959	0.38	0.39	0.4	0.41	14	14
F/1954	0.4	0.38	NM	0.4	14	14
F/1984	0.4	0.4	NM	NM	17	17
F/1975	0.41	0.38	NM	NM	18	18
F/1952	0.39	NM	0.39	0.38	14	19
F/1953	0.42	0.39	0.42	0.39	20	20
F/1950	0.42	NM	0.39	0.39	16	17
F/1953	0.42	NM	0.42	0.42	15	16
F/1943	NM	0.41	NM	0.41	17	15
F/1945	0.42	0.41	0.4	0.37	18	17
F/1983	NM	NM	0.4	0.37	17	18
F/1943	0.32	0.25	0.28	0.27	18	18
F/1958	0.41	0.39	0.39	NM	16	15
F/1956	NM	NM	0.4	0.39	10	11
F/1945	0.38	NM	0.4	0.39	13	12
F/1989	0.41	0.41	0.4	0.42	10	11
F/1982	0.39	NM	0.41	0.39	14	15
M/1954	0.37	0.38	0.38	0.41	15	14
M/1964	0.39	0.44	0.39	0.44	12	15
M/1972	0.3	0.32	0.25	0.3	12	11
M/1943	0.4	0.4	NM	NM	15	14
M/1935	0.4	0.34	0.4	0.33	12	13
M/1974	0.39	0.41	NM	0.41	19	19
M/1957	NM	NM	0.39	0.39	19	18
M/1934	0.42	0.43	0.39	NM	18	17
M/1950	0.42	0.42	NM	0.42	14	13
M/1952	0.43	NM	0.41	0.4	14	14
M/1965	0.39	0.41	0.41	NM	18	17
M/1957	NM	NM	0.38	0.39	20	20
M/1955	0.39	NM	0.41	0.39	13	15

Table 1: SC values in the control group.

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Gender/ Year of birth	re-external diameter	re-internal diameter	le-external diameter	le-internal diameter	re-IOP	le-IOP	Therapy
F/1970	0.36	0.37	0.38	0.37	19	19	latanoprost
F/1975	0.3	NM	0.35	0.32	16	15	timolol
F/1932	0.3	NM	0.32	0.33	11	12	latanoprost
F/1962	0.29	0.33	0.28	0.3	14	14	latanoprost
F/1944	0.37	NM	0.35	0.35	19	20	latanoprost
F/1935	0.37	0.39	0.38	NM	14	10	timolol
F/1942	0.33	0.35	NM	NM	20	20	latanoprost
F/1959	NM	NM	0.36	0.38	18	18	latanoprost
F/1946	0.33	0.35	NM	NM	18	18	latanoprost
F/1948	NM	0.33	NM	0.32	12	12	timolol
F/1930	0.37	0.37	NM	NM	13	15	timolol
F/1950	NM	0.34	NM	0.33	13	13	timolol
F/1937	0.34	NM	0.32	NM	13	13	latanoprost
F/1964	0.27	0.3	0.3	0.27	17	16	latanoprost
F/1986	0.2	0.25	NM	NM	16	16	timolol
F/1930	0.33	0.36	0.34	0.37	14	14	latanoprost
F/1930	0.37	0.37	0.38	NM	20	20	latanoprost
F/1951	0.39	NM	0.36	NM	18	18	latanoprost
F/1933	NM	0.37	0.37	0.38	11	12	timolol
F/1946	NM	0.36	0.38	0.32	15	16	latanoprost
F/1965	NM	0.37	0.35	0.37	17	16	latanoprost
F/1984	0.33	0.36	NM	0.27	12	15	latanoprost
M/1933	0.29	0.31	0.28	0.32	18	16	latanoprost
M/1959	0.29	0.31	0.3	NM	14	14	latanoprost
M/1987	NM	0.35	NM	0.35	20	20	latanoprost
M/1978	0.34	0.39	0.36	0.38	20	20	latanoprost
M/1963	0.35	NM	0.37	0.38	14	15	latanoprost
M/1953	NM	NM	0.34	0.36	17	17	latanoprost
M/1974	0.36	NM	0.38	0.39	18	17	timolol
M/1982	NM	0.3	NM	0.31	17	18	latanoprost
M/1960	0.37	0.37	NM	NM	17	17	latanoprost

Table 2: SC values in glaucoma eyes.

A more important finding was the comparison of glaucoma eyes with those of the control group. In all eyes, there was a statistically significant difference with the control group having SC of greater dimension. The summary data are shown in Table 3. Here the values of SC in both measured areas in both the control and glaucoma groups are given. Importantly, we found no statistically significant difference in IOP between control and glaucoma eyes. This means that in our sample, the IOP does not affect SC size.

Discussion

Until OCT tools were introduced, SC dimension was known only from histological findings. The average width of Schlemm's canal, determined by histological sections, is 387.5 ± 7.7 µm [2]. SC sizes in histological preparations were also investigated by Allingham et al. [3]. They showed that glaucomatous eyes had significantly smaller SC compared with a control group of healthy eyes. This reduction in SC dimension may account for approximately half of the decrease in outflow facility observed in POAG eyes.

SC dimension was investigated by ultrasound (80-MHz and Ultrasound probe) at the 12 o´clock position by Irshad et al. [4]. The average canal diameter was 121 µm (± 45 µm). The canal diameter in hyperopes was larger than canal diameter in myopes (180 ± 69 µm vs. 122 ± 45 µm; P <0.001). SC diameter was smaller in patients with previous glaucoma surgery compared with patients without surgery (98 ± 4 µm; P <0.01).

Kagemann et al. [5] investigated SC using Spectral-domain OCT and found that, in glaucoma patients, SC was smaller than in the controls. They also found that SC was significantly larger on the nasal side than on the temporal one. Our results are in agreement with the above mentioned studies. We have only not proven the difference in the size of the SC in the nasal versus temporal part. Similarly, Usui et al. [6] did not find a difference in the nasal in comparison with the temporal SC part as well.

We investigated the SC using Time-Domain AS OCT. Our results of a smaller SC in glaucoma eyes are in accordance with the above cited studies. Nevertheless, it was not possible to investigate the SC in every individual. The answer to that failure can be found in the article of Geering et al. [7]. The authors detailed the evaluation of angle structures, including SC and trabecular meshwork and explained the difficulties with the AS-TD-OCT. Detection of SC seemed to be beyond the limits of current technology. Even in histology, this structure is often difficult to see because of the variable of the slit-like and often septate canal, which measures between 200 and 400 µm in the meridional axis but only 10 to 25 µm in the opposite axis approaching the lateral and axial resolution of our OCT system.

We were also interested in possible changes of SC dimensions in the course of different anti-glaucoma treatments. We were inspired by the publication of Chen et al. [8] who found that the application of travoprost to healthy subjects brings about the expansion of SC. In our study with glaucoma patients, we noted no difference in SC size when they were treated with beta-blockers and prostaglandins.

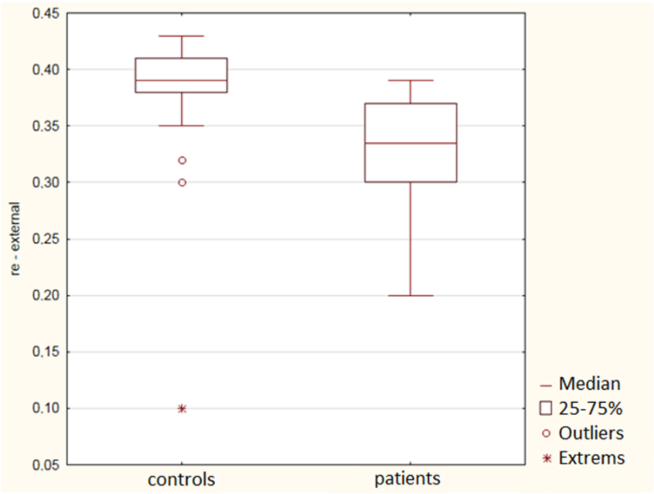

Figure 2: The SC size in the temporal part of the right eye horizontal meridian.

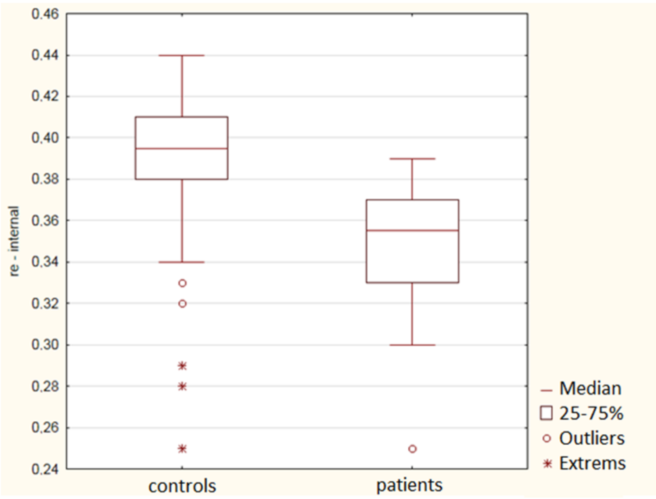

Figure 3: The SC size in the nasal part of the right eye horizontal meridian.

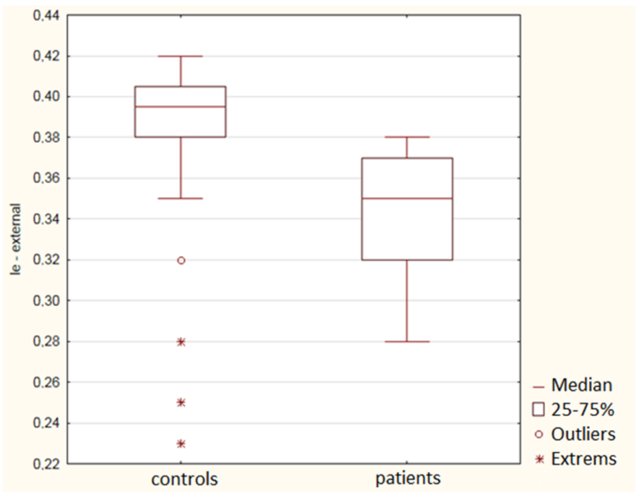

Figure 4: The SC size in the temporal part of the left eye horizontal meridian.

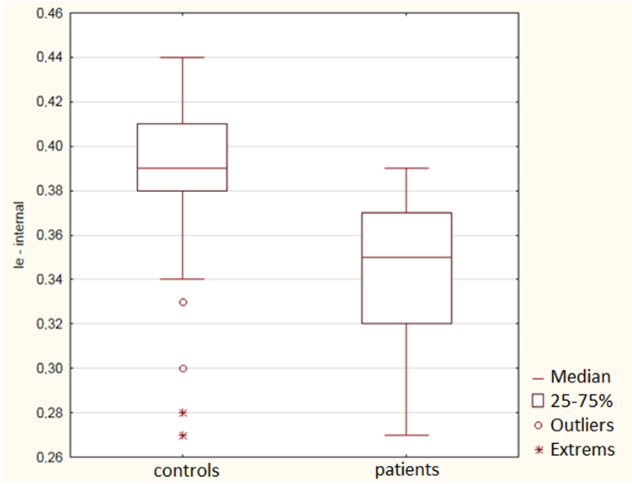

Figure 5: The SC size in the nasal part of the left eye horizontal meridian.

	Controls	Glaucoma	P
re-external	0.38175	0.32955	0.000293
re-internal	0.38062	0.34545	0.003102
le-external	0.38222	0.34524	0.001587
le-internal	0.38385	0.34143	0.000222
re-IOP	14.8913	15.933	0.117715
le-IOP	15.108	19.000	0.102253

Table 3: The average SC sizes (in millimeters) in the eyes of the control group and in those of glaucoma patients.

Conclusion

In POAG eyes, SC size is smaller than in the eyes of the control group. Eyes on prostaglandin treatment had the same size than those on beta blockers.

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