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Research Article

Long-Term Results of Combined Technology of Optimized YAG-Laser Trabeculostomy in the Treatment of Primary Open-Angle Glaucoma

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Abstract

Purpose: The purpose of this survey is to evaluate ocular symptoms and to understand relation between dry eye disease, years of experience at work among microscope users associated to electronic industry in India.

Methods: This is a cross-sectional, questionnaire based prospective study. Subjects aged between 18 to 30 years working in electronic industry with microscopes were included who did not have any history of ocular disease and surgery. Data related to their demographics, ocular symptoms, DEQ-5 questionnaire and CISS questionnaire were obtained from all the subjects. Data was entered in to excel and a statistical analysis including Spearman's rank correlation coefficient were applied using SPSS software.

Results: Studying a sample of 246 participants, it was revealed that tiredness of eye, loss of concentration were the most common, and floating of objects was the least common symptom among all asthenopia related symptoms. 37.40% of the total participants are suffering from symptoms of dry eye disease. A positive correlation (0.308) between the DEQ-5 score and experience at work has been found in this study.

Conclusion: Symptoms of dry eye and eye tiredness are commonly seen among microscope users of electronic industry. Yearly ocular evaluation and dry eye assessment are recommended for electronic industry workers working with microscopes. Taking a brief, frequent break during work can provide relief from tired eyes symptom.

Keywords: Microscope; Asthenopia; Dry Eye; Electronic Industry; Eye Tiredness

Introduction

Glaucoma is one of the most relevant ophthalmology problems. The number of glaucoma patients in the world in 2020 amounted to about 80 million people, and by 2040 it may increase to 112 million. More than 11 million people are completely blind from glaucoma today. In the Russian Federation, glaucoma ranks first among the causes of blindness and low vision [1].

Normalization of ophthalmotonus is the goal in glaucoma treatment, the assessment of its effectiveness is based on the achievement of an individual level of intraocular pressure (IOP), stabilization of visual functions based on the results of standard automated perimetry, absence of glaucoma optic neuropathy progression according to ophthalmoscopy, optical coherence tomography (OCT) of the optic nerve disc and retina. Despite the variety and hypotensive effect of antiglaucoma drugs, laser and surgical methods of treatment continue to play a leading role [1].

The main treatment methods of primary open-angle glaucoma early stages include laser surgery techniques aimed at reducing increased ophthalmotonus by improving the intraocular fluid outflow through the trabecular network of the Schlemm's canal. One of the first developers of laser operations on the trabecula was professor M.M. Krasnov (1972), who proposed to perform goniopuncture using a short-pulse ruby laser. The operation involved application of 20-25 laser pulses to the trabecula per session with a power of 0.05-0.25 J. The hypotensive effect of this technology was achieved by creating a direct pathway between the anterior chamber of the eye and the collector channels. Intraocular pressure decreased by 12 mmHg on average, ophthalmotonus normalization was observed in 90% of cases, its compensation was observed within 5 years. However, excessive laser energy led to damage and subsequent scarring of the trabecula and increased the risk of hyphema in the early postoperative period [2].

Argon laser trabeculoplasty (ALT) was proposed in 1979 by J.Wise and S.Witter. This technique was widely used in ophthalmologic practice and, according to multicenter studies, demonstrated high efficacy in patients with primary open-angle glaucoma who combined hypotensive therapy with ALT. In this operation, 100 applications are made around the entire circumference of the Schlemm's canal, with the diameter of the applied spot being 50 μm, the power being 400 - 1200 mW, and the exposure being 0.1s. Hypotensive effect was achieved due to active trabecula damage with change of its tension (plasty), where burn scar tissue changes stretched the trabecular network and improved its permeability to intraocular fluid. Focal depigmentation, sometimes with the formation of gas bubbles, was achieved with power selection [3].

However, numerous morphologic studies have shown that ALT leads to coagulative destruction of the trabecular network of the Schlemm's canal at the points of laser applications. A fibrous vascular membrane may form between them, resulting in decreased intraocular fluid outflow, increased ophthalmotonus, and decreased efficiency in further repeated laser surgeries [4-6].

In 1995, the technique of selective laser trabeculoplasty (SLT, selective photothermolysis) using Nd:YAG laser was developed by M.A. Latina., *et al*. [7]. In this method, pulses are applied to the pigmented trabecula zone in the lower sector with a circumferential coverage of 180°. The number of pulses varies from 50 to 70 per operation. According to the proposed technique, a sub-threshold maximum energy is selected during the procedure, which does not cause the formation of cavitation bubbles - «Champagne Bubbles». The average value of the procedure energy is 0.5 mJ, spot diameter is 400 μm. IOP reduction after SLT is associated with the destruction of pigmented cells of the trabecular network and biological response to laser exposure: increased expression of cytokines (IL-1, IL-6, IL-8, TNF-α), which increase the activity of matrix metalloproteinases, activate the migration of macrophages, which eventually causes photothermolysis of pigment granules, remodeling of extracellular matrix and improvement of intraocular fluid outflow due to clearing the trabecular zone from debris [8].

Further improvement of the technique led to the development of new variants of its execution. Ivanova E.S., Tumanyan N.R., Lyubimova T.S., Subkhangulova E.A. (2012) proposed to use selective laser activation of the trabecula (SLAT) for maximum cl of the trabecular membrane and improving the intraocular fluid outflow. This causes 1.5 - 2 times more significant and prolonged hypotensive effect than SLAT according to the standard method [9].

Laser activation of the trabecula (LAT) involves the application of 50 - 60 applications in the projection of the Schlemm's canal along the 180° circumference of the YAG laser with a wavelength of 1064 nm, spot diameter of 8 - 10 μm, power of 0.8 - 1.1 mJ, and exposure of 3 ns, which leads to the formation of a shock wave over the surface of the trabecula, which drives the anterior chamber fluid, realizing the «flushing» of the trabecular slits under pressure. However, according to studies, the hypotensive effect after LAT is less stable than after SLT [10].

In suprathreshold SLT, the minimum energy is selected, causing the effect of microcavitation bubble formation. This method has a deeper impact of laser energy on pigment granules, their defragmentation and subsequent, more significant photothermolysis, which leads to a more complete clearing of trabecular tissue and improved intraocular fluid outflow. According to the authors' data, the early energy level at this modification of SLT is 0.3 mJ, then it is increased by 0.1 mJ up to the threshold effect - appearance of microcavitation bubbles. The energy value at suprathreshold SLT is higher than the established threshold by only 0.1 - 0.2 mJ [11].

However, the lack of persistent hypotensive effect of laser surgeries led to the search for new methods and combinations with different mechanism of influence on the trabecula. There are known works of combined laser glaucoma surgeries: trabeculopuncture and laser trabeculoplasty, one-stage or staged performance of SLT and ALT [12], but these methods have the following disadvantages:

- Lack of assessment of the topography of the collector channels relative to the Schlemm's canal,
- High applied laser power,
- Non-compliance with laser energy dosing,
- Application of ALT as a stage of surgery with coagulating effect may lead to IOP increase in the early postoperative period, formation of fibrous-vascular membrane in the trabecula, and decrease of efficiency in subsequent repeated laser surgeries.

Therefore, at present, to achieve a more significant hypotensive effect when performing laser surgery on the trabecula, it is reasonable to use SLT in combination with YAG-laser and OCT data of the eye anterior segment [13,14], which makes it possible to create scar-resistant perforations in the trabecula precisely in the projection of collector channels as a combined technology - optimized YAG-laser trabeculostomy in combination with SLT [15].

Aim of the Study

The aim of the study is to develop a combined technology of optimized YAG-laser trabeculostomy and to evaluate its efficacy and safety in the treatment of primary open-angle glaucoma.

To realize this goal it was necessary, firstly, to use the advantages of SLT - active photothermolysis of pigment granules, and secondly, to use YAG-laser to perform trabeculostomy, which allows to significantly reduce the elevated IOP by improving the intraocular fluid outflow through cleaning the trabecula from pigment granules and creating anastomoses with collector channels.

Materials and Methods

Three groups of patients were included in the study:

1. Group 1, main, (prospectively): 87 patients (87 eyes) with primary open-angle glaucoma (stage I - 50 eyes, stage II - 37 eyes) before and after optimized YAG-laser trabeculostomy technique, mean age - 68.8 ± 7.7 years, (M ± σ). There were 51 males (58.6%) and 36 females (41.4%).

2. Group 2, control group, (prospectively): 78 patients (78 eyes) with primary open-angle glaucoma (stage I - 42 eyes, stage II - 36 eyes) before and after SLT, mean age was 65.5 ± 8.3 years, (M±σ). There were 43 males (55.1%) and 35 females (44.9%).

3. Group 3, control group: 60 healthy individuals (60 eyes), mean age was 61.4 ± 2.1 years, (M ± σ). There were 34 males (56.7%) and 26 females (43.3%). The difference between the groups by gender, as well as between the mean values of the patients' age in groups 1, 2 and 3 was statistically insignificant, indicating their homogeneity by these indicators.

Criteria for selection of patients in the main and 2nd control groups:

- Early and moderate stages of primary open-angle glaucoma;
- IOP reduction on the background of combined drug therapy to the values of average statistical norm, but exceeding the individual IOP value;
- Pigmentation of the anterior chamber angle I-IV degree;
- Visualization of Schlemm's canal and collector channels according to OCT data.

Exclusion criteria: Elevated IOP on the background of combined drug therapy, closed anterior chamber angle, advanced and terminal stages of glaucoma, secondary glaucoma, bullous keratopathy.

Patients underwent a comprehensive ophthalmologic examination, including visometry (Reichert Inc, USA), standard automated perimetry (Perimeter 720i, Humphrey, USA), tonography (Glautest 60, Spetsmedpribor, Russia), biomicro-ophthalmoscopy, optical coherence tomography (OCT) of the optic disc and anterior segment of the eye (DRI OCT Triton, Japan), determination of individually tolerated IOP (using age and brachial artery diastolic BP), corneal endothelial microscopy (EM-3000, Tomey, Japan) and tear immunoassay for proinflammatory interleukins 6 and 17, TNF-α (Infinite F50 Tecan, Austria).

For the application of YAG-laser trabeculostomy, a technique was developed to determine the topography of the collector channels and the Schlemm's canal. Using OCT of the eye anterior segment, the collector channels were localized relative to the Schlemm's canal. Then, the collector channel diameter, the length of the major and minor axes of the Schlemm's canal were recorded on a series of images, and the area of the sagittal slice of the Schlemm's canal was calculated using the formula for calculating the ellipse area: $S = \pi \times a/2 \times b/2$, where: S is the cross-sectional area of the Schlemm's canal, π is a mathematical constant equal to the ratio of the length of a circle to its diameter, a is the length of the major axis of the Schlemm's canal, b is the length of the minor axis of the Schlemm's canal.

The area of the operation was marked both on the full-face image and in the form of a mark placed on the patient at the limbus for the subsequent projection of a slanted light slit at the slit lamp along the course of this mark.

The technique of performing optimized YAG-laser trabeculostomy was divided into 2 stages:

1. Stage I - Selective laser trabeculoplasty according to the standard technique of M.A. Latina: Nd:YAG-laser «Tango» Laserex (Australia), wavelength 532 nm, spot diameter 400 μm, exposure 3 ns, along the lower sector of the angle of the anterior chamber of the eye in an arc of 180°, Latina lens, average energy level of one pulse 0.5 mJ;
2. Stage II - YAG-laser trabeculostomy: formation of 1 to 8 trabeculostomies in the projection of collector channels with application of 2 to 5 laser applications until the trabeculostomy is obtained (appearance of a white spot - visualization of the sclera area in the projection of the trabeculostomy).

Postoperative monitoring was performed at one day, one month, 3, 6, 12, and 24 months.

The methods of variation statistics were used in data processing with determination of the mean value, mean square deviation, Student's criterion and significance level p in case of normal distribution, which was determined by the Shapiro-Wilk criterion. For data characterizing non-normal distribution, medians - Me, [Q1; Q3] and X min-X max were determined, and Mann-Whitney U-criterion was used to compare independent samples, Kraskell-Wallis criterion was considered for comparative analysis of several independent groups, Wilcoxon criterion was used for dependent variables. Differences were evaluated as statistically significant at a significance level of $p < 0.05$. Calculations were performed in the programs STATISTICA 10.0 (StatSoft, USA) for Windows (Microsoft Corporation, USA) and Numbers 13.0 for macOS (Apple Inc., USA).

Results and Discussion

Table 1 presents mean values of morphometric parameters of Schlemm's canal and collector channels in healthy individuals (3rd control group) and in patients with early and moderate stages of primary open-angle glaucoma: 1st group (main) and 2nd control group. The difference between the values of the median of the major and minor axes of the Schlemm's canal, sagittal area of the Schlemm's canal in healthy individuals and glaucoma patients was statistically significant ($p < 0.00001$). The difference between the median values in glaucoma patients was statistically insignificant ($p > 0,05$), which indicated that the 1st and 2nd groups were homogeneous in terms of morphometric parameters of the Schlemm's canal and collector channels. Thus, in patients with glaucoma there was a significant decrease in morphometric indices of the Schlemm's canal, as well as in the diameter of collector channels in contrast to healthy individuals ($p < 0,0001$).

Indexes	Main group (87 eyes)	2nd control group (78 eyes)	3rd control group (60 eyes)	H p
Major axis of the Schlemm's canal, µm Me [Q1; Q3]	220 [198; 245]	227 [202; 265]	320 [267; 374]	$H_{1;2} = 2.3$ $p_{1;2} = 0.13$ $H_{1;3} = 58.2$ $p_{1;3} < 0.0001$ $H_{2;3} = 43.1$ $p_{2;3} < 0.0001$
Minor axis of Schlemm's canal, µm Me [Q1; Q3]	28 [21; 36]	29 [22; 37]	66 [37; 95,2]	$H_{1;2} = 0.4$ $p_{1;2} > 0.52$ $H_{1;3} = 50.3$ $p_{1;3} < 0.0001$ $H_{2;3} = 44.3$ $p_{2;3} < 0.0001$
Sagittal area of Schlemm's canal, µm² Me [Q1; Q3]	5 845 [4580; 6500]	5 880 [5475; 6130]	13 671 [12727;14560]	$H_{1;2} = 1.2$ $p_{1;2} = 0.27$ $H_{1;3} = 103.8$ $p_{1;3} < 0.0001$ $H_{2;3} = 100.2$ $p_{2;3} < 0.0001$
Collector channel diameter, µm Me [Q1; Q3]	63 [45; 80]	64,4 [45; 82]	276 [227,5; 325]	$H_{1;2} = 0.31$ $p_{1;2} = 0.58$ $H_{1;3} = 105.8$ $p_{1;3} < 0.0001$ $H_{2;3} = 101.0$ $p_{2;3} < 0.0001$

Table 1: Mean values of morphometric parameters of the Schlemm's canal and collector channels in patients of the main group with POAG stages I and II and control groups, M ± σ.

Note: H - value of the Kraskell-Wallis criterion.

Figure 1 shows the state of trabecula and collector channels before and after combined technology of optimized YAG-laser trabeculostomy. Earlyly: major axis of Schlemm's canal - 220 µm, minor axis - 38 µm, sagittal slice area of Schlemm's canal: 6,563 µm². Postoperatively: major axis of Schlemm's canal - 275 µm, minor axis - 51 µm, sagittal slice area of Schlemm's canal: 11,010 µm².

No intra- and postoperative complications were detected in patients in the main (87 eyes) and in the 2nd control (78 eyes) groups.

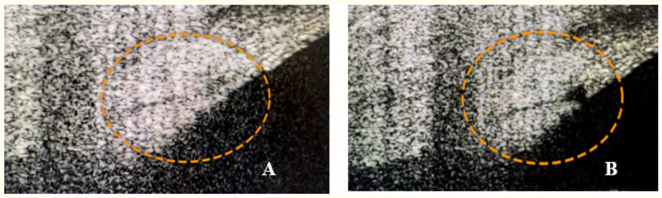

Figure 1: OCT of the trabecula (1) and collector channel (2) before (A) and after (B) combined optimized YAG-laser trabeculostomy.

The mean values of ocular hydrodynamics parameters of the 1st main group after optimized YAG-laser trabeculostomy and the 2nd control group after SLT after 1 and 6 months are presented in table 2.

After 1 and 6 months, patients in the main group showed a significant hypotensive effect of the surgery, which amounted to 29.5% and 30.7% of the early level of intraocular pressure. In patients of the 2nd control group after SLT the hypotensive effect of the operation was significantly lower and after 1 and 6 months ($p < 0.0001$) amounted to 21.5% and 18.9%, respectively.

This difference in the hypotensive effect was due to significantly better values of theintraocular fluid outflow coefficient in glaucoma patients in the 1st main group compared to patients in the 2nd control group. In 1 month after application of optimized YAG-laser trabeculostomy IOP (P_0) decreased to 12.4 ± 2.6 mm Hg. - by 30% from baseline due to improved aqueous outflow to 0.25 ± 0.06 mm^3/mm Hg. * min - by 108% from baseline. After 6 months IOP (P_0) decreased to 12.3 ± 2.5 mm Hg. - by 30.5% from baseline due to improvement of aqueous fluid outflow to 0.26 ± 0.05 mm^3/mm Hg. * min - by 117% from baseline.

Indicators	After 1 month. 2nd control group	After 1 month. 1st main group	After 6 months. 2nd control group	After 6 months. 1st main group
$P_{0,}$ mean/ mean (Xmin -Xmax), mm Hg. Me [Q1; Q3] Z p	13,2 (11-21,6) 13,15 [12;14]	12,4 (10,5-15,3) 12,2 [11,4; 13,2] 3,69 0,0002	13,8 (9,8-21,3) 13,6 [12,4; 14,7]	12,3 (10,0-14,3) 13,2 [11,6; 13,0] 6,13 0,000001
C, mean (Xmin -Xmax), mm^3/mmHg. * min Me [Q1; Q3] Z p	0,18 (0,12-0,25) 0,18[0,16; 0,2]	0,25 (0,16-0,36) 0,25 [0,22; 0,27] -8,47 < 0,001	0,19 (0,13-0,24) 0,19 [0,17; 0,21]	0,26 (0,15-0,36) 0,25 [0,23; 0,28] -9,7 < 0,001
F, mean (Xmin -Xmax), mm^3/min Me [Q1; Q3] Z p	0,6 (0,2-2,2) 0,55 [0,4; 0,7]	0,97 (0,3-2,1) 0,9 [0,8; 1,2] -7,2 < 0,001	0,8 (0,35-2,1) 0,7[0,6; 0,8]	0,63 (0,3-1,0) 0,67 [0,5; 0,78] 2,0 0,043
KB, mean/ mean (X min-Xmax), Me [Q1; Q3] Z p	74,5 (15,6-115,4) 74 [65; 82]	56,2 (34,3-89) 54 [48; 62] 7,1 < 0,001	74,5 (48-136) 73,3 [64; 83]	47,0 (30-82) 46 [41; 52] 9,8 < 0,001

Table 2: Mean values of ocular hydrodynamics parameters in patients of group 2, control, (78 eyes) after SLT and group 1, main, (87 eyes) after YAG-laser trabeculostomy 1 and 6 months after laser surgery.

In glaucoma patients (2nd control group), the intraocular fluid outflow coefficient increased after 1 and 6 months only by 28.7% and 35.7%, respectively, and was equal to 0.18 ± 0.03 mm^3/mm Hg. * min and 0.19 ± 0.03 mm^3/mm Hg. * min. The values of Becker's coefficient (P_0/C) at 1 and 6 months after surgery were significantly lower in patients in the 1st main group than in the 2nd control group ($p < 0.0001$), and the maximum values did not exceed 100.

Thus, the patients of the 1st main group had significantly better values of ocular hydrodynamics parameters 1 and 6 months after optimized YAG-laser trabeculostomy ($p < 0.001$).

Comparative analysis of the results 1 and 2 years after laser surgery also showed significantly better results in terms of ocular hydrodynamics in the patients of the 1st main group (Table 3).

At 1 year after optimized YAG-laser trabeculostomy, the mean true IOP (P_0) was 12.4 ± 2.6 mm Hg, and the mean value of the intraocular fluid outflow coefficient was 0.25 ± 0.05 mm^3/mm Hg. * min. The hypotensive effect of surgery was 30% due to a 108.3% improvement in intraocular fluid outflow. After 2 years, the mean value of true IOP (P_0) increased to 13.1 ± 2.7 mm Hg, and the hypotensive effect was 26%. The difference between the mean P_0 values after 1 and 2 years was statistically insignificant ($p > 0.05$).

Hypotensive effect after SLT in patients of the 2nd control group due to improvement of intraocular fluid outflow was maintained during 1 year, then after 2 years there was an increase of true IOP up to 14.7 ± 2.6 mm Hg due to decrease of the intraocular fluid outflow coefficient to 0.16 ± 0.04 mm^3/mm Hg. * min. Whereas 1 year after SLT the hypotensive effect was 17.2% of the early level, after 2 years the hypotensive effect was only 12.5%.

Indicators	After 12 months. 2nd control group	After 12 months. 1st main group	After 24 months. 2nd control group	After 24 months. 1st main group
$P_{0,}$ mean/mean (Xmin -Xmax), mm Hg. Me [Q1; Q3] Z p	13,9 (10,2-21,3) 13,65 [12,8; 14,6]	12,3 (9-15,5) 12,1 [11,7; 13] 6,34 < 0,001	14,7 (11-21,6) 14,5 [12,5; 16,3]	13,1 (11,0-17,3) 12,9 [12,3; 13,7] 4,32 < 0,001
C, mean (Xmin -Xmax), mm^3/mmHg. * min Me [Q1; Q3] Z p	0,18 (0,13-0,23) 0,18 [0,16; 0,2]	0,24 (0,16-0,36) 0,24 [0,22; 0,27] -9,05 < 0,001	0,18 (0,09-0,29) 0,18 [0,14; 0,2]	0,25 (0,15-0,35) 0,24 [0,22; 0,26] -8,08 < 0,001
F, mean (Xmin -Xmax), mm^3/min Me [Q1; Q3] Z p	0,75 (0,35-1,8) 0,7 [0,6; 0,9]	0,73 (0,3-1,3) 0,7 [0,6; 0,9] -0,54 0,58	0,82 (0,2-2,1) 0,75 [0,6; 1,0]	0,84 (0,3-1,4) 0,84 [0,7; 1,0] -1,45 0,14
KB, mean/ mean (X min-Xmax), Me [Q1; Q3] Z p	75,2 (48-125,3) 74 [65; 83]	48,7 (30-91) 48 [42; 53] 9,3 < 0,001	91,7 (31-212) 84,5 [69; 109]	52,0 (30-106) 51 [44; 58] 8,26 < 0,001

Table 3: Mean values of ocular hydrodynamics parameters in patients of group 2, control, (78 eyes) after SLT and group 1, main, (87 eyes) after YAG-laser trabeculostomy 1 and 2 years after laser surgery.

The values of Becker's coefficient (P_0 /C) 1 and 2 years after surgery were significantly lower in patients in the 1st main group than in the 2nd control group ($p < 0.0001$). No significant difference in watery fluid (F) secretion 1 and 2 years after surgery was found between the groups ($p > 0.05$).

Thus, within 1 year in patients of the 2nd control group there was a progressively decrease of hypotensive effect after SLT to 17.2%. After optimized YAG-laser trabeculostomy the hypotensive effect remained - 30.1%, in 2 years was 26.2% of the early level (Figure 2).

It should be noted that after optimized YAG-laser trabeculostomy a significant hypotensive effect was observed already on the first day after surgery and amounted to 30.1%. After SLT according to the standard technique, the hypotensive effect on the first day after surgery was insignificant - 5.4%, and the maximum hypotensive effect was observed only 1 month after surgery and amounted to 21.5% (Figure 2).

The intraocular fluid outflow coefficient in the patients of the main group after YAG-laser trabeculostomy increased by 117% on the next day after surgery and in contrast to the control group was significantly higher, persisting for 1 year (Figure 3).

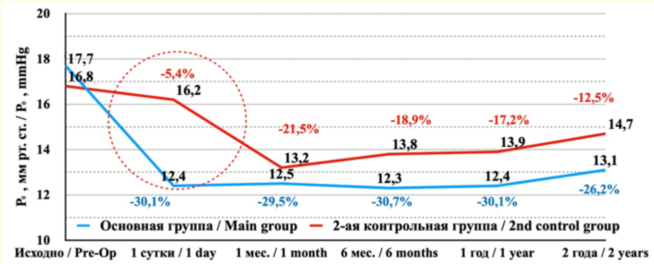

Figure 2: Dynamic in IOP (P0) values in the main (optimized YAG-laser trabeculostomy) and 2nd control (SLT) groups.

Figure 3: Dynamic in aqueous outflow coefficient (C) values in the main (optimized YAG-laser trabeculostomy) and 2nd control (SLT) groups.

Table 4 shows the frequency of use and mean values of the number of applied drugs and their instillations in patients of the 1st main and 2nd control groups before laser surgery. There were no significant baseline differences between the groups (p > 0.05).

Indicators	Group 2 Control	Group 1 Basic	t	p
Combined therapy	76,9%	80,5%	0,56	> 0,05
Monotherapy	23,1%	19,5%	0,56	> 0,05
Average number of medications	1,9± 0,7	2,1 ± 0,86	1,6	> 0,05
Average number of instillations per day	2,4 ± 1,2	2,57 ± 1,16	0,9	> 0,05

Table 4: Frequency of use and mean values of the used drugs number and their instillations in patients of the 2nd control and main groups before laser surgery, M ± σ.

Table 5 shows the frequency of use and mean values of the number of medications used and their instillations in patients of the 1st main and 2nd control groups after laser surgery after 2 years.

Indicators	Group 2 Control	Group 1 Basic	t	p
Combination therapy	56,4%	28,7%	3,7	< 0,001
Average number of medications	1,8 ± 0,84	1,1 ± 0,67	5,8	< 0,001
Average number of instillations per day	2,16 ± 1,1	1,35 ± 1,05	2,8	< 0,01

Table 5: Frequency of use and mean values of the number of drugs used and their instillations in patients of the 2nd control and main groups before laser surgery, M ± σ.

In patients of the main group after 2 years, combination therapy was used in 25 eyes only (28.7%), monotherapy - in 46 eyes (52.9%), and withdrawal of drug treatment (absolute success) occurred in 16 eyes (18.4%). The mean number of medications used was significantly lower in contrast to the 2nd control group and amounted to 1.1 ± 0.67 (p < 0.001), and the mean number of instillations in this group decreased to 1.35 ± 1.05 (p < 0.001). In contrast to the 2nd control group, when comparing the percentage of hypotensive regimen used, the main group after 2 years of observation had 27.7% significantly less use of combined agents (p < 0.001) and withdrawal of hypotensive therapy in 18.4% of cases in contrast to the control group, which was noted only in 10.3% of cases.

During 2 years of follow-up in the postoperative period, the patients of the main group showed stabilization of visual functions, the average IOP level (P_0) did not exceed the level of individually tolerated pressure (15.1 ± 1.15 mm Hg). The level of ophthalmotonus (P_0) significantly decreased from the early level for 2 years by 26.2% (p < 0.05). To achieve an individually tolerable IOP level for the period from 6 months to 2 years of follow-up, repeated SLT was performed in the main group in 8 eyes - in 9.2% of cases. In the second control group, to achieve the level of individually tolerable pressure, which was equal to 15.4 ± 1.3 mm Hg, repeated SLT was performed in 35 eyes - in 44.9% of cases.

In case of ophthalmotonus increase above the individually tolerated IOP level on maximal hypotensive drug therapy and in case of GON progression according to perimetry and OCT data of the ONH, glaucoma surgical treatment was performed in the 1st main group during 2 years of observation - in 5 eyes (5,7%), and in patients of the 2nd control group - in 12 eyes (15,4%).

Table 6 shows the mean values of interleukins 6 and 17, TNF-alpha in the patients of the main group before and after optimized YAG-laser trabeculostomy.

After 1 week and 1 month, there was a significant increase in the level of interleukin 6 and TNF-a ($p < 0.05$), which is associated with the destruction of pigment granules of the trabecular network and biological response to laser exposure. Decrease of interleukin 6 and TNF-a values was significantly observed 3 months after surgery.

Indexes	Pre-Op	After 1 week	After 1 month	After 3 months
Interleukin 6, pg/mL	49.9 ± 5.7*	100.3 ± 173.8**	354.2 ± 186.3**	54.8 ± 6.4
Interleukin 17, pg/mL	762 ± 544.2	780.1 ± 507.6	841.3 ± 498.3	820.3 ± 466.3
TNF-a , pg/mL	360 ± 298.8*	726.7 ± 235.4**	624 ± 230.5**	397 ± 298.8

Table 6: Mean values of interleukins 6 and 17, TNF-alpha in the main group of patients before and after optimized YAG-laser trabeculostomy.

The difference between the mean values marked with ** and ** is statistically significant ($p < 0.05$).

Thus, the comparative analysis of clinical and functional results of selective laser trabeculoplasty and optimized YAG-laser trabeculostomy in the treatment of patients with early and moderate stages of primary open-angle glaucoma over a two-year observation period demonstrated the advantage of the developed technology in the form of hypotensive effect of the operation: up to 30% on the next day and within 1 year, 26% - after 2 years of observation against 5.4%, 17.2% and 12.5% after selective laser trabeculoplasty, respectively ($p < 0.001$), higher values of the intraocular fluid outflow coefficient at all terms of observation ($p < 0.001$) and higher frequency of visual function stabilization - 94.3% against 84.6% after selective laser trabeculoplasty ($p < 0.05$).

Conclusion

YAG-laser and OCT data can optimize the YAG-laser trabeculostomy technique, providing an alternative non-invasive treatment for patients with early and moderate stages of primary open-angle glaucoma.

Combination technology of optimized YAG-laser trabeculostomy is effective and safe, and in comparison with SLT it has more significant and persistent hypotensive effect (30,1%), allows to perform the operation precisely in the projection of collector channels and after a day to reduce IOP to individual values.

Conflicts of Interest

None declared.

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