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Research Article

Rehabilitation of Patients with Posttraumatic Aniridia and Secondary Glaucoma

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Abstract

Secondary glaucoma is one of the main problems of rehabilitation of patients with traumatic damage of iris.

Purpose: To analyse remote results of rehabilitation of patients with posttraumatic aniridia and glaucoma.

Materials and Methods: The study included 310 patients (310 eyes) with post-traumatic aniridia post implantation of an artificial iris-lens diaphragm (ILD) MIOL-Iris© (Reper NN, Nizhny Novgorod) in the period from 2002 to 2022. 61 patients (22.8%) had secondary glaucoma before ILD implantation, of which 35 patients (11.3%) underwent various modifications of glaucoma surgeries (GS). In 26 patients (8.6%), intraocular pressure (IOP) was compensated by medication before ILD implantation.

Results: By 3rd month post ILD implantation, IOP was increased over time in some patients. 8 patients (22.9%) out of 35 with previous GS have exhibited decompensation. In glaucoma patients treated before ILD implantation, IOP decompensation occurred in 21 (80.8%) of 26 cases. 21 patients (6.8%) out of 310 had de novo glaucoma post ILD implantation. The IOP compensation post ILD implantation was mainly followed by the Ahmed valve implantation performed in 35 cases (70%) out of 50, deep sclerectomy (DSE) performed in 5 cases (10%), non-penetrating deep sclerectomy (NDSE) – in 4 cases (8%), micro-pulse laser cyclophotocoagulation (MicroLCPC) – in 5 cases (10%), endoscopic cyclophotocoagulation (ECPC) – in 1 case (2%).

Conclusion: ILD implantation in patients with posttraumatic aniridia and secondary glaucoma should be performed under IOP compensation without hypotensive therapy not earlier than 6-12 months post GS. The most optimal types of GS in this group of patients are implantation of the Ahmed valve and MicroLCPC.

Keywords: Posttraumatic Aniridia; Secondary Glaucoma; Iris-Lens Diaphragm

Abbreviation

ILD: Artificial Iris-Lens Diaphragm; GS: Glaucoma Surgeries; IOP: Intraocular Pressure; DSE: Deep Sclerectomy; NDSE: non-Penetrating Deep Sclerectomy; MicroLCPC: Micro-Pulse Laser Cyclophotocoagulation; ECPC: Endoscopic Cyclophotocoagulation; TR: Trabecular Reticulum; IOF ¬: Intraocular Fluid; ACA: Anterior Chamber Angle; PKP: Penetrating Keratoplasty; PKG: Postkeratoplastic Glaucoma; ORA: Ocular Response Analyser; NFL: Retinal Nerve Fibre Layer

Introduction

Traumatic eye injuries still remain one of the most frequent causes of visual disability among the able-bodied population. Eyeball injuries are often followed by variously severe iris defects. They occur in 68.3% of penetrating wounds, with contusion injuries – in 49.8% [1]. Rare cases (0.07%) deal with the pronounced changes up to complete aniridia in combination with posttraumatic cataract or aphakia, severe vitreoretinal complications, abnormality of the ocular surface and secondary glaucoma [1-3].

One of the complications of eye injury leading to irreversible blindness is secondary (posttraumatic) glaucoma developing in 9.2-61.4% of cases. Among its causes are: the formation of anterior and posterior synechiae as a result of posttraumatic iridocyclitis, recession of the anterior chamber angle (ACA), obturation of the trabecular reticulum (TR) by phantom cells and haemolysis products, toxic effects of iron on the trabecular reticulum [4], damage to the lens and iris.

Glaucoma in posttraumatic aniridia can develop both immediately post injury and in the long-term period, which indicates the need for constant monitoring of intraocular pressure (IOP) in this group of patients [1-3]. Several authors state that the pathogenesis is based on the loss of all or most of the iris, as a result whereof it loses its pumping function, which in turn leads to the trabecula collapse and organic transformation of the Schlemm canal [1].

Zolotarev A.V. *et al*. an experimental study of the outflow pathways of intraocular fluid (IOF) in isolated cadaveric eyes under complete aniridia showed that an ordinary eye ink coming through the trabecular reticulum into the Schlemm canal, stains the eye walls and penetrates the intermuscular slits, i.e., partially goes along the uveoscleral pathway (Figure 1 a-b) [5]. If there is no iris, the ink does not penetrate the intermuscular spaces, leaving only through the Schlemm canal (Figure 1 c-d). This allowed to assume that the lack of iris pumping function caused the intermuscular slit collapse and the improper function of uveoscleral outflow of IOF. If we add thereto the collapse of walls and organic transformation of the Schlemm canal, sclerosis and obliteration of the outflow pathways, we are going to have a high percentage of secondary glaucomas with complete aniridia, which directly depends on the preservation of the anatomical structures of the anterior eye segment [6].

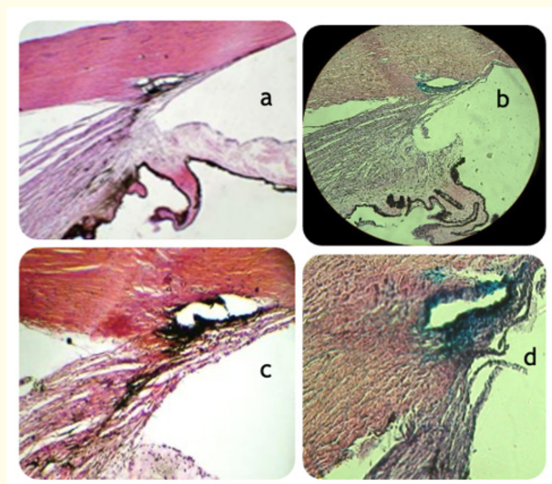

Figure 1: State of intraocular fluid outflow ways on isolated cadaver eyes in normal and in complete aniridia.
a, b – in normal eyes
c, d – in case of iris membrane absence.
Arrows on a and c show ink staining of Schlemm canal walls. On b ink (intraocular fluid) outflow uveoscleral way is shown by arrow. On d absence of ink outflow in uveoscleral way is shown by arrow. Staining according to Van-Gizon. Magnification a, b – 10x18x4, c, d – 10x18x10.

According to N. P. Sobolev's study, fibroblastic processes of the iridociliary zone can last up to 9 years post injury, which may explain the absence of a stable hypotensive effect during secondary glaucoma surgery [7]. The blood-aqueous barrier breach was observed by us to have been detected in association with the iris traumatic damage, which is confirmed by laser tindalemetry. The protein flow in the anterior chamber remains elevated in 70-80% of patients with traumatic iris injury, increases significantly immediately after injury, and stabilizes only by 6-8 months after surgery. Some patients will never have such an indicator as normal due to fibroblastic processes of the iridociliary zone.

Various approaches to IOP compensation in this group of patients are proposed. The scarring changes in the anterior segment of the eye, goniosynechiae, adhesion in ACA, etc., provide for the fistulizing surgeries: sinustrabeculectomy, filtering iridectomy using allodrainages, implantation of valve devices [2,3,8].

In order to reconstruct the anterior segment of the injured eye with aniridia and aphakia, an artificial iris-lens diaphragm (ILD) is implanted [1-3,9-13]. In Russia, ILD developed by Cheboksary Branch of the Intersectoral Scientific and Technical Complex S. Fyodorov Eye Microsurgery and Reper NN (N. Novgorod) is widely used and has several models depending on the eyeball anatomical structure preservation, the area of the iris defect and the need for simultaneous optical correction in specific clinical cases. ILD implantation may be both intracapsularly post cataract extraction with the intact capsule, on the capsule with full or partial capsule preservation, and in the area of the ciliary sulcus with transscleral suture fixation [13,12].

It is important to consider that patients with posttraumatic aniridia may have serious corneal damage, which often requires to perform penetrating keratoplasty (PKP). Postkeratoplastic glaucoma (PKG) is one of the serious problems affecting the survival of the graft. The frequency of PKG has been reported to range from 9 to 35%, and this is the second most common cause of a graft failure [14]. Another aggravating factor is the difficult adequate assessment of the intraocular pressure in the eyes with a corneal transplant. Therefore, postkeratoplastic glaucoma additionally challenges the achievement of the target IOP level in these patients [15].

Purpose

To analyse the long-term results of rehabilitation of patients with posttraumatic aniridia and glaucoma.

Materials and Methods

In the period from 2002 to 2022, we analysed the results of 310 ILD implantations with posttraumatic aniridia, which were implanted with MIOL-Iris© (Reper NN, Nizhny Novgorod). Model A was implanted in 63 patients, C – in 133, D – in 56, F – in 45, S – in 13 patients. In 205 cases (66.1%), the ILD was sutured in a transscleral way, in 60 cases (19.4%) it was implanted on the remains of the capsular bag, in 45 (14.5%) ones – in the capsular bag. The choice and the type of fixation of ILD model was determined in dependence on the capsular bag preservation. In 83 cases (26.8%), ILD was implanted simultaneously with PKP. The nature of the injury was diverse, it included combinations of severe contusions with rupture of keratotomic scars of the cornea – 118 patients (38%), the sclera rupture – 28 (9%), penetrating wounds – 164 (53%).

The volume of damage to the iris varied from complete aniridia in 197 cases (63.5%) to partial aniridia in 93 (30%) and posttraumatic mydriasis in 20 (6.5%). There were 244 (78.7%) men and 66 (21.3%) women. The average age of patients at the time of surgical treatment in our clinic was 42.3 ± 15.75 years old (from 11 to 82 years old).

All patients underwent special studies: refracto-keratometry, the visual acuity test with and without correction, ultrasound study (B-scan), assessment of the optic nerve lability, IOP measurement. Maklakov tonometry was performed using a weight of 10 g; contactless tonometry was performed using an automatic pneumotonometer NidekNT-530 (Japan), NidekNT-2000 (Japan), TomeyFT-1000 (Japan) or Reichert 7 (USA). The study of the cornea biomechanical properties was performed in patients with visual impaired hydrodynamics using the Ocular Response Analyser (ORA) from Reichert Inc. (USA), and in the presence of rough corneal scars; the study was performed using an iCare tonometer in the area of the intact cornea. The eye inflammatory reaction was assessed objectively with laser tindalemetry using FS-2000 from Kowa (Japan) (FCM).

The biomicroscopy and ophthalmoscopy put a focus on the assessment of the ILD position, the depth of the anterior chamber, signs of inflammation, and the optic disk. In addition, all patients underwent gonioscopy or OCT of the anterior segment to assess the anterior chamber angle and control the absence of the ILD contact to the reactive structures of the eye.

An increase in IOP involved the expansion of the list of studies, and an extra trend perimetry was performed and if possible, tonography, optical coherence tomography of the optic disc and the retinal nerve fibre layer (NFL).

The injury to ILD implantation average time was 62 months (5.2 years, 0.25 to 45 years).

The follow-up ranged from 1 month to 20 years, with an average of 6 years. It was mandatory to pay visits for control examinations 1, 3, 6, 12 months post-surgery and, thereafter, if possible, once a year. Every visit was associated with the compulsory collection of medical histories: if there were any complaints, changes in between-visit treatment, as well as the clarifications with respect to the medications applied and the frequency of their administration were made.

Statistical data are presented as M±σ, Me{Q25; Q75}; where M is the mean, σ is the root mean square deviation, Me is the median, Q25 is the lower quartile (25%), Q75 is the upper quartile (75%).

Results and Discussion

Uncorrected visual acuity before ILD implantation was 0.013 ± 0.015, 0.01{0.005; 0.01}, visual acuity with maximum correction was equal to 0.204 ± 0.234, 0.2{0.1; 0.3}. A large variation in the visual functions was due to the difference in the initial condition of patients, the injury severity, ophthalmological status and pre-surgery comorbidity.

Before ILD implantation, the mean IOP corresponded (according to Maklakov) to 21.53 ± 4.3; 20.8{19; 23} mm Hg, pneumotonometry 16.7 ± 5.23; 16.1{13.5; 19} mm Hg.

The means according to Ocular Response Analyzer (ORA) from Reichert Inc. (USA) were IOPcc 20.16 ± 7.32; 19.4{14.9; 23.6} mm Hg, IOPg 16.78 ± 7.68; 17.2{11.8; 20.2} mm Hg, CRF 8.79 ± 2.9, 8.6{7; 10.2}, CH 8.69 ± 1.5; 8.2{6.4; 9.5}.

61 patients (22.8%) had secondary glaucoma before ILD implantation, of which 35 patients (11.3%) underwent various modifications of GS. In 30 patients with secondary glaucoma, IOP was compensated after one GS, in 3 – after 2 operations, in 1 – after 3, in 1 – after 4. Totally, 35 patients with secondary glaucoma underwent 43 GS: DSE with allodrainage – 3 operations, DSE – 4, NDSE – 9, NDSE with allodrainage – 3, implantation of the Ahmed valve – 16, LCPC – 1, MicroLCPC – 5; in 2 cases, the type of GA could not be reliably determined. Of note, those patients who underwent the implantation of the Ahmed valve, LCPC and MicroLCPC, had achieved the IOP compensation by the time of ILD implantation without additional hypotensive intervention. In 26 patients (8.6%), IOP was compensated using medications.

The probable increase in IOP was revealed to be significantly higher – 49 cases (80.3%) out of 61 in the complete absence of the iris, with partial aniridia – 7 (11.5%), with mydriasis more than 8 mm – 5 cases (8.2%).

Before the start of glaucoma treatment, the average IOP in patients was 28.2 ± 3.66 mm Hg (from 25 to 34 mm Hg). The number of antihypertensive agent instillations corresponded to 3 drops per day averagely.

After GS, the main stage of ILD implantation was performed not earlier than 8-12 months, provided that the indicators of laser tindalemetry and hydrodynamics of the eye were stabilized.

The protein flow in the anterior chamber in all patients before surgery was 14.76 ± 13.63 12{5.6; 18} f/ms. The indicators of this study in 61 patients with glaucoma were slightly higher and corresponded to 19.5 ± 14.6 13.2{6.1; 17.2} f/ms. Normal values of this indicator (no more than 6 f/ms) were only in 73 of 310 patients (23.5%). Despite the excess of protein flow in ¾ of patients, clinical manifestations of inflammation were absent in all patients with aniridia. This confirms the fact of a significant blood-aqueous barrier breach after the eye injury, which cannot be detected during standard ophthalmological examinations.

By 3rd month post ILD implantation, IOP was increased over time in some patients (Table 1, 2). 8 patients (22.9%) out of 35 with previous GS have exhibited decompensation. In glaucoma patients medically treated previously, IOP decompensation occurred in 21 (80.8%) of 26 cases. 21 patients (6.8%) out of 310 had de novo glaucoma post ILD implantation. A clear dependence of the secondary glaucoma frequency on the area of the iris defect was revealed. Thus, after ILD implantation, IOP decompensation occurred in 50 cases and its highest probable occurrence was in patients who take drip hypotensive regimen without prior GS. Depending on the ILD fixation method, decompensation of IOP prevailed when implanted on the lens capsule – in 24 cases (48%) out of 50, in the ciliary sulcus with transscleral suture fixation – in 21 (42%), and with intracapsular fixation – in 5 (10%). From the presented data, it can be seen that decompensation of IOP is much more common during implantation on the lens capsule. This may be explained by the anatomical features of the anterior segment, as observed in the injured eye – the formation of fibrous films fixed to the free edge of the ciliary processes, fibrosis of the ciliary processes in the area of the iris root [3,7]. These changes can lead to a slight decentration of ILD and contact of haptics with reactive structures of the eye, their mechanical effect on the already damaged ciliary zone leads to chronic irritation, impaired permeability of the blood-aqueous barrier and, as a consequence, dysfunction of the trabecular reticulum (Figure 2).

Table 1: ORA indices dynamics, M±σ, Me{Q 25; Q75}, n – number of patients.

All patients	Before surgery n = 310	1 month post implantation n = 267	3 months post implantation n = 221	6 months post implantation n = 200	12 months post implantation n = 162
IOPcc, mm Hg	20,.16 ± 7.32 19.4{14.9; 23.6}	20.77 ± 6.9 19.6{15.5; 24.5}	21.87 ± 7.8 21.6{17.1; 26.1}	21.93 ± 8.8 21.8{15.3; 26.1}	20.57 ± 6.8 20.1{17.1; 23.7}
IOPg, mm Hg	16.78 ± 7.68 17.2{11.8; 20.2}	17 ± 7.4 17.1{11.4; 19.2}	19.6 ± 8 19.3 {15.2; 22.85}	20.18 ± 8.6 20.4{12.5; 25.5}	17.6 ± 7.8 17.8{15.2; 22.85}
CRF	8.79 ± 2.9 8.6{7; 10.2}	8.57 ± 2.3 8.4{6.9; 10.5}	9.22 ± 2.4 9.2{7.6; 11}	9.48 ± 3.2 9.8{6.7; 11.9}	9.1 ± 2.3 9.4{7.2; 11}
CH	8.69 ± 1.5 8.2{6.4; 9.5}	7.6 ± 1.8 7.8{6.1; 8.7}	7.58 ± 2.3 7.3{6.2; 10}	7.79 ± 2 7.6{6.4; 8.6}	7.5 ± 2.1 7.5{6.3; 9.3}

Table 2: IOP dynamics, M±σ, Me{Q 25; Q75}, n – number of patients.

All patients	Before surgery n = 310	After ILD implantation						
		1 month n = 267	3 months n = 221	6 months n = 200	12 months n = 162	2-3 years n = 112	14 years n = 33	15-20 years n = 16
Pneumotonometry mm Hg	16.7 ± 5.23 16.1{13.5; 19}	16.76 ±3.8 17.3{15; 19}	17.2 ±6.7 18.2{14; 21}	17.75 ± 6.9 18.4{13; 20}	16.5 ± 4.2 16.1{14; 19}	16.5 ± 4.2 16.1{14; 19}	17.3 ± 1.84 17.4{16; 18}	17.5 ± 2.43 18.1{16; 19}
IOP (according to Maklakov) mm Hg	21.53 ± 4.3 20.8{19; 23}	19.2 ±3.29 21.2{18; 23}	19.87 ±4.02 21.3{17; 23}	20.01 ± 4.32 21.6{18; 23}	19.72 ± 4.4 19.5{17; 22}	20.6 ± 5.2 20.4{17; 22}	21.7 ± 2.25 20.8{20; 23}	20.57 ± 2.76 20.5{19; 22}

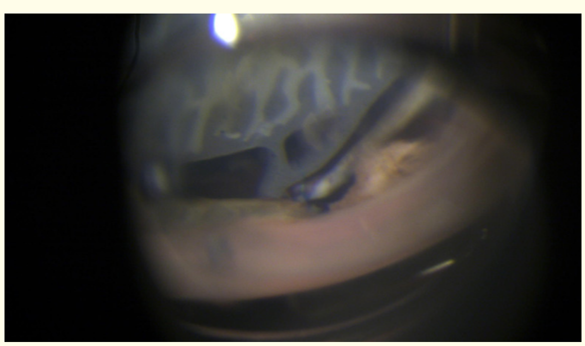

Figure 2: Position of haptics after ILD implantation (gonioscopy view).

In order to compensate IOP, the ILD implantation was mainly followed by the Ahmed valve implantation performed in 35 cases (70%) out of 50, DSE was performed in 5 cases (10%), NDSE – in 4 cases (8%), MicroLCPC – in 5 cases (10%), endoscopic cyclophotocoagulation (ECPC) – in 1 case (2%).

Among 83 patients (83 eyes) who underwent ILD implantation in conjunction with PKP, 24 had unstable IOP before surgery. Among them, 9 eyes of patients in whom the target IOP was achieved through drug treatment, and 15 eyes of patients in whom the target IOP was achieved through surgical treatment, 5 patients underwent Ahmed valve implantation, 5 – non-penetrating deep sclerectomy (NDSE) + allodrainage, 2 – deep sclerectomy (DSE), 2 – DSE with drainage. 1 patient underwent glaucoma surgery repeatedly: NDSE with drainage implantation, micro-pulse laser cyclophotocoagulation (LCPC). Among those patients to whom IOP was compensated before the penetrating corneal transplantation with medication, IOP decompensation and the need for a second transplant were required in 5 cases (55.5%), and among those who had previously GS – in 2 cases (26.6%).

In 59 patients who had stable IOP without antihypertensive drugs prior to penetrating keratoplasty and implantation of the iris-lens diaphragm, graft disorder associated with secondary glaucoma was observed in 3 cases (5%).

Hypotension was detected in 3 patients during the follow-up period after implantation, which is 0.97% of all cases.

The effectiveness of trabeculectomy in aniridic glaucoma has been evaluated in many studies. According to a number of authors, the fibrous proliferation occurring with aniridia may be the primary cause for the high risk of IOP decompensation after trabeculectomy. The use of cytostatics in this group of patients is limited due to their detrimental effect on limbal stem cells, while these patients often have concomitant severe corneal damage. Along with this, there are reports of the successful use of valve drains in glaucoma associated with aniridia, and it is proposed to use them at the first stage of treatment of this type of glaucoma. The study of G. Demirok included 6 patients with secondary aniridic glaucoma, whose average preoperative IOP was 33.00 ± 12.11 (from 22 to 50) mm Hg, and the volume of hypotensive therapy was 3.5 ± 1.2 drops. The average IOP 1 month after the implantation of the Ahmed valve was 16.33 ± 4.22 (from 12 to 24) mm Hg, the number of hypotensive drops was 1.5 ± 0.8 [16].

According to our data, 16 patients with secondary glaucoma associated with posttraumatic aniridia underwent implantation of the Ahmed valve. Preoperative IOP in these patients averaged 20.71 ± 3.83 mm Hg, the average number of drops used was 2.75 ± 1.75, among them in 7 persons (43.75%) IOP compensation was not achieved under the maximum hypotensive regimen. 1 month after GS, the IOP value was 18.90 ± 3.20 mm Hg, only 3 (18.75%) patients continued to take antihypertensive therapy, after 3 months only 1 patient needed additional antihypertensive drops. Decompensation of IOP after ILD implantation in patients with previous GS (the Ahmed valve) was the lowest – 1 case out of 16 operations.

In patients with IOP decompensation after ILD implantation, the most stable hydrodynamics was observed in cases of GS with implantation of the Ahmed valve and MicroLCPC.

In cases where the Ahmed valve was used, the stable hypotensive effect is probably due to the location of the main filtration site (the body of the Ahmed valve) posteriorly from the iridociliary zone, the site of the most active fibroblastic processes, in contrast to the classical conjunctival glaucoma surgery. As for the use of MicroLCPC, in this case, the success of this technique in the control of IOP can be explained by several mechanisms of hypotensive effect. It is believed that the total hypotensive effect consists of a decrease in the production of intraocular fluid by the ciliary non-pigmented epithelium, an increase in the level of uveoscleral outflow and an increase in outflow through the trabecular reticulum due to contraction of the longitudinal muscle and tension of the trabecula [17].

Also, the case report of combined surgery is of some interest: trabeculectomy with ILD implantation, where the fistula of the GS zone as the first stage of the operation is used as a tunnel for implanting an artificial iris, which, according to the authors, helps to avoid performing additional incisions and minimize surgical trauma [18]. In our opinion, the use of this technique is not justified, given the above data on aggressive fibroplastic processes in this group of patients. Pronounced scarring can lead to rapid overgrowth of the surgery area and early decompensation of IOP. In turn, the use of loose fixation of the scleral flap to prevent early scarring carries risks of vascular and retinal detachment in the early postoperative period due to the fact that these patients initially have severe organic lesions of the structures of both the anterior and posterior segments of the eye.

Conclusion

ILD implantation in patients with posttraumatic aniridia and secondary glaucoma should be performed under IOP compensation without hypotensive therapy not earlier than 6-12 months after GS provided stable hydrodynamics.

The most optimal types of GS in this group of patients are implantation of the Ahmed valve and MicroLCPC. In the rehabilitation of patients with aniridic glaucoma, it is necessary to adhere to the stages of surgical treatment.

Bibliography

1. Pozdeyeva NA and Pashtayev NP. "Artificial iris-lens diaphragm in surgical treatment of aniridia". Cheboksary; (2012).
2. Pozdeyeva N., *et al*. "Ahmed glaucoma valve in cases of posttraumatic aniridia and aphakia". In World glaucoma congress: abstract Book. Paris (2011): 240.
3. Pozdeyeva NA., *et al*. "Efficacy of valve drainage devices in secondary glaucoma in patients with artificial iridolenticular diaphragm". *Annals of Ophthalmology* 127.4 (2011): 41-45.
4. Yanoff M and Duker JS. "Ophthalmology". Fifth Edition. Philadelphia, Pennsylvania: Elsevier Inc; (2019): 1089-1094.
5. Zolotarev AV., *et al*. "Morphology and functions of uveoscleral outflow". *Russian Ophthalmological Journal* 2.1 (2009): 35-39.
6. Pozdeyeva NA. "System of medical rehabilitation of patients with aniridia: dissertation for the degree of Doctor of Medical Sciences". Moscow; (2014).
7. Sobolev NP., *et al*. "Clinical morphological characteristics of iris-ciliary zone in secondary posttraumatic aniridic glaucoma". *Fyodorov Journal of Ophthalmic Surgery* 4 (2015): 17.
8. Pozdeyeva NA and Gorbunova NYu. "Surgical treatment of glaucoma in patients with posttraumatic aniridia". 14th European Glaucoma Society Congress. The 13-15th of December: Abstract book. (2020):293.
9. Haritoglou C. "Artificial iris after severe trauma of the orbit". *Ophthalmologe* 112.7 (2012): 599-601.
10. Pozdeyeva NA., *et al*. "Vitreoretinal surgery in patients with posttraumatic aniridia". *Fyodorov Journal of Ophthalmic Surgery* 3 (2012): 42-47.
11. Pozdeyeva NA. "New model of artificial iris-lens diaphragm for correction of large iris defects (clinical and functional results of implantation)". *Annals of Ophthalmology* 6 (2013): 38-44.
12. Pozdeyeva N., *et al*. "New Model of Artificial Iris-Lens Diaphragm for Extensive Iris Defects". World Ophthalmology Congress: Abstract Book. Abu Dhabi (2012): 63.
13. Pozdeyeva NA., *et al*. "Artificial iris-lens diaphragm in reconstructive surgery for aniridia and aphakia". *Journal of Cataract and Refractive Surgery* 31.9 (2005): 1750-1759.
14. Pozdeyeva NA., *et al*. "Penetrative keratoplasty in comprehensive treatment of course scars and epithelial and endothelial corneal distrophy in patients with posttraummatic aphakia and aniridia". *Chuvashia Healthcare* 1 (2018): 83-95.
15. Yildirim N., *et al*. "Glaucoma after penetrating keratoplasty: incidence, risk factors, and management". *Journal of Ophthalmology* (2011): 951294.
16. Demirok GS., *et al*. "Short- and Long-term Results of Glaucoma Valve Implantation for Aniridia-related Glaucoma: A Case Series and Literature Review". *Turkish Journal of Ophthalmology* 49.4 (2019): 183-187.
17. Abdelmassih Y., *et al*. "Micropulse Transscleral Cyclophotocoagulation". *Journal of Current Glaucoma Practice* 15.1 (2021): 1-7.
18. Christodoulou E., *et al*. "Combined Post-Traumatic Total Aniridia and Glaucoma Management". *Case Report on Ophthalmology* 12.1 (2021): 204-207.