SERBIAN ARCHIVES OF MEDICINE Est.1872

Address: 1 Kraljice Natalije Street, Belgrade 11000, Serbia
☎ +381 11 4092 776, Fax: +381 11 3348 653
E-mail: office@srpskiarhiv.rs, Web address: www.srpskiarhiv.rs

Paper Accepted* **ISSN Online 2406-0895**

Original Article / Оригинални рад

Marija Radenković[1†], Gordana Stanković-Babić[1,2], Jasmina Đorđević-Jocić[1,2], Maja Živković[1,2], Marija Trenkić-Božinović[1,2], Maja Petrović[1], Nevena Zlatanović[2], Mariola Stojanović[3]

Ocular biometric changes after trabeculectomy

Биометријске промене ока након трабекулектомије

[1]Clinical Center, Clinic for eye diseases, Niš, Serbia;
[2]University of Niš, Faculty of Medicine, Niš, Serbia;
[3]Institute of Public Health, Department of Biostatistics in Health, Niš, Serbia

Received: December 18, 2017
Revised: August 30, 2018
Accepted: September 28, 2018
Online First: October 11, 2018
DOI: https://doi.org/10.2298/SARH171218060R

†**Correspondence to:**
Marija RADENKOVIĆ
Bulevar Nemanjića 67/41, 18000 Niš, Serbia
Email: **marad@verat.net**

Ocular biometric changes after trabeculectomy

Биометријске промене ока након трабекулектомије

SUMMARY

Introduction/Objective Trabeculectomy is conventional filtration procedure in surgical glaucoma treatment. Even after successful trabeculectomy, patient's visual acuity can be reduced. Studies (1991) showed that changes in visual acuity occur due to changes of corneal curvature and anterior chamber depth. Anterior chamber depth change for 1 mm results in about 2 diopters change in refractive sphere. Simultaneous with anterior segment changes, anti-glaucoma surgery effect can also be manifested in posterior segment of the eye: choroidal thickness, axial length and the ocular perfusion. Axial length reduction after trabeculectomy was supposed according to biometry, more pronounced if intraocular pressure is higher preoperatively, or in the first postoperative week with spontaneous recovery to preoperative values one year after surgery. Study at the Clinic for eye diseases in Niš in 60 patients with glaucoma was conducted to determine the difference in pre/post-operative values of biometry.

Methods This was a retrospective-prospective biometric analysis of patients with open-angle glaucoma.

Results Anterior chamber depth was significantly different during the observed period, for 1.1 mm in first week ($p<0.0001$) in the whole group and glaucoma type. The mean axial length varies considerably during the observed period, shorter for 0.39 mm in first week ($p<0.05$).

Conclusion By analyzing biometric parameters, a postoperative difference of biometry with spontaneous recovery was determined. There is a difference in postoperative visual acuity of patients compared to preoperative, with spontaneous recovery at the end of follow-up.

Keywords: glaucoma; trabeculectomy; ocular biometry; anterior chamber depth; axial length

САЖЕТАК

Увод/Циљ Трабекулектомија је конвенционална филтрациона процедура у хируршком лечењу глаукома. Чак и након успешно изведене трабекулектомије, пацијентима може бити редукована оштрина вида. Студије из 1991. показују да промене оштрине вида настају услед промене закривљености рожњаче и дубине предње коморе. Промена дубине предње коморе за 1 *mm* резултује за око 2 диоптрије промене у рефрактивној сфери. Истовремено са променама на предњем сегменту, ефекат антиглаукомних операција се може манифестовати и на задњем сегменту ока: дебљини хороидеје, дужини ока и окуларној перфузији. Биометријом се потврдјује смањење дужине ока након трабекулектомије, израженије код преоперативно виших вредности очног притиска и у првој постоперативној недељи са спонтаним враћањем на преоперативне вредности годину дана након интервенције. Студија ради утврдјивања разлике пре/постоперативних вредности биометрије спроведена је на Клиници за очне болести у Нишу у 60 оперисаних пацијената са глаукомом отвореног угла.

Методе Ово је била ретроспективно-проспективна биометријска анализа оперисаних глаукомних пацијената.

Резултати Дубина предње очне коморе се значајно разликује током посматраног периода праћења, за 1,1 *mm* у првој недељи ($p < 0{,}0001$) у целокупној групи и по типовима глаукома. Просечна вредност дужине ока се значајно разликује током посматраног периода праћења, краћа је за 0,39 *mm* у првој постоперативној недељи ($p < 0{,}05$).

Закључак Анализом биометријских параметара утврђена је постоперативна разлика у вредностима биометрије са спонтаним опоравком. Постоји разлика постоперативне оштрине вида пацијената у односу на преоперативну са спонтаним опоравком на крају праћења.

Кључне речи: глауком; трабекулектомија; биометрија; дубина предње коморе; дужина ока

INTRODUCTION

Trabeculectomy was developed in 1968 (Cairns) and still remains the most frequent filtration procedure in surgical glaucoma treatment that bypasses the aqueous outflow by creating a corneo-scleral fistula that leads in forming subconjunctival bleb. By using potential wound modulators (5-

fluorouracil, Mitomycin C) prolonged hypotensive effect could be achieved and year success rate for trabeculectomy increased to 70-80%. One of the greatest disappointments of glaucoma filtering surgery is suboptimal postoperative visual acuity. Even after successful procedure it can be reduced for several lines at Snellen chart. The primary reason for poor postoperative visual acuity after filtering surgery could be: astigmatism, hypotony, inflammation or hyphema. Trabeculectomy leads to a large decrease in intraocular pressure (IOP) especially in early postoperative period. Potential complications are: hypotony, choroidal effusion, hemorrhage, hypotonous maculopathy, corneal decompensation, cataract [1]. After treating all medical reasons, refractive factors could remain (corneal curvature and ocular biometric changes), that are dynamic and changeable in postoperative period.

Biometry, according to early definition, is the method of applying mathematics and measurement to biology. The term was originally used by Whewell initially in the 1800s [2]. Ultrasound biometry is the measurement of various eye dimensions, its components and their interrelationships. Ultrasound (echography, B-scan) uses high frequency sound waves (10MHz) to produce images of the internal eye structures. Ultrasound biometry (A-scan) utilizes an ultrasound device for eye measurement: axial length (Lax, AL), anterior chamber depth (ACD), crystalline lens thickness, diagnosing and measuring masses in the eyes. As an invasive procedure, it requires direct ultrasound probe contact with the cornea by trained examiner to avoid errors due to excessive compression on cornea [3]. Axial length is the distance from anterior corneal surface to the retinal pigment epithelium. It can be done using optical or ultrasound methods, which can further be done by direct contact or immersion [4].

Ocular biometric changes after trabeculectomy with refractive implications are in axial length (Lax, AL) and anterior chamber depth (ACD). Lax decreases due to improvement of ocular blood flow and increased choroidal thickness (CT) as dynamic parameter that is influenced by oscillations in IOP. Large decrease in IOP after trabeculectomy during the early postoperative period, may lead to significant CT changes and thickening as a consequence of improved ocular perfusion. Until recently, no imaging modality could get accurate in vivo CT measurements. Enhanced depth imaging-optical coherence tomography (EDI-OCT) uses low signal strength to achieve greater depth than spectral domain OCT (SD-OCT) [5, 6].

Another factor affecting postoperative visual acuity is anterior chamber depth (ACD). This was due to refraction shift secondary to depth changes, 1 mm change in ACD results in approximately 2 diopter change in refractive sphere (DSph). Visual acuity starts to return to pre-operative by the third post-operative week and usually recovers fully within 6 weeks. This alteration is caused by iris-lens plane movement partially. If cycloplegic drug was not applied postoperatively, anterior chamber tends to shallow in the post-operative period and maximal shallowing occurs by the fifth day with spontaneous reformation by 2 weeks [7, 8, 9].

It is stated that trabeculectomy can cause ACD changes and even small axial length (Lax, AL) change could lead to unsatisfactory visual acuity and significant error in IOL power calculation and refractive prediction in cataract surgery [6]. The aim of this work is to determine presumed difference between pre/postoperative biometrics findings in glaucoma patients.

METHODS

This retrospective-prospective clinical investigation included 60 phakic eyes, of 60 operated patients with Open Angle Glaucoma (OAG) in two types: 42 Primary Open Angle Glaucoma (POAG) patients and 18 Exfoliative Glaucoma (XFG) patients, to determine postoperative changes of biometry at day 7/30/60 after standard trabeculectomy without antimetabolities. Investigation was performed from march 2015. to march 2016. at Clinic for eye diseases Clinical Center Niš, according to the principles of the Declaration of Helsinki, and written consent was obtained from all the participants at medical history. Each patient underwent pre/postoperative measurements of same parameters: visual acuity (Snellen chart), slit lamp examination, Goldman aplanation tonometry, A-scan ultrasonographic biometry (ACD, Lax) (Tomey Ultrasonic A/B scanner and biometer UD6000).

Although there are two modalities of A-scan ultrasound biometry available, contact and immersion, in this investigation contact A-scan biometry measurements were obtained because it is faster and simple to perform. After topical anesthesia of ocular surface (tetracaine hydrochloride 0.5%) ultrasound probe was placed on the vertex of cornea carefully, to avoid corneal indentation and off-axis measurements. All measurements were obtained by one ophthalmologist in aim to minimize inter-observer variability of results.

A special crystal embedded in a probe oscillates to generate a high-frequency ultrasound wave that penetrates the eye. These results are in one-dimensional time-amplitude representation of echoes received along the beam path. The height of the spikes is indicative of the strength for the specific eye tissue. The distance between the echo spikes recorded on the oscilloscope screen provides an indirect measurement of tissue such as anterior chamber depth or axial length of the eye and displayed in millimeters on the screen.

Obtained results were analyzed by statistical analysis and application of software SPSS 18 statistical package.

RESULTS

Effect of trabeculectomy, in surgically treated OAG patients is shown through IOP values and visual acuity changes in Table1 and 2. The mean IOP value shows a significant difference (Friedman Test Chi-Square; $p<0.0001$) in subjects compared to preoperative values. The average preoperative IOP of 32.5 ± 8.64 mmHg decreases in the next two months to a value 15.93 ± 3.46 mmHg at the end of a two-month monitoring interval. Similar values and fluctuations of IOP were in both groups of operated glaucoma patients (POAG, XFG) with discrete higher values in POAG group, from 33.38 ± 9.08 mmHg preoperatively to16.36 ± 3.51 mmHg two months later in comparison to XFG group of respondents with 30.44 ± 7.35 mmHg before surgical intervention, lowered to 14.94 ± 3.23 mmHg two months after operation (Table 1).

The visual acuity shows statistically significant difference in operated glaucoma patients in two month interval (Friedman Test Chi-Square; $p<0.0001$). From 0.4 ± 0.35 decreases for 2 lines on Snellen chart in 7^{th} postoperative day (0.22 ± 0.22), then improves for 1 line (30^{th} postoperative day) and returns almost to the preoperative visual acuity in next two months (0.37 ± 0.32). Similar visual acuity was in both glaucoma groups of patients (Table 2).

Among OAG group: 28 (46.67%) female respondents are 72.2 ± 7.92 years old and the total number of men is 32 (53.33%) with average age 65.4 ± 11.56 years. Female are significantly older ($t = 2.626$; $p = 0.011$). (Table 3).

Of all patients 42 (70%) suffer from POAG with the average age of 66.7 ± 11.1 years and the remaining 18(30%) are patients with XFG type of glaucoma with an average age of 73.1 ± 7.5 years. Patients with XFG type are significantly older ($t = 2.195$; $p<0.05$). The average age in whole operated group of patients is 68.58 ± 10.5 years. (Table 4).

Following graph presents age structure of respondents by gender in both glaucoma types (POAG and XFG) (Figure 1). Female in XFG group are the oldest, 77 years on average. Male respondents in XFG group are younger (70.55 years) than female. In POAG group female are older (70.62 years) than male (62.71 years) too.

Upcoming results illustrate implications of anterior segment anti-glaucoma surgical approach to biometric parameters of the eye.

Anterior chamber depth (ACD) varies considerably during a two-month period (Friedman Test Chi-Square; $p<0.0001$) in whole group and according to glaucoma type (POAG; XFG). From an average preoperative value of 2.79 ± 0.65 mm, its value increases mostly at 7^{th} day (3.89 ± 1.42 mm), then decreases at 30^{th} day (3.59 ± 1.25 mm) and further reduces at the end of following period to (3.08

± 1.02 mm), near to preoperative values. Similar values of ACD were in both glaucoma types during two month time interval (Table 5).

The mean axial length (AL, Lax) varies considerably during the observed monitoring period (Greenhouse-Geisser; p<0.05). From average preoperative value of 23.41 ± 1.26 mm in whole group, its value decreases for small amount but significant at 7th day (23.02 ± 1.27 mm) and 30th day (23.09 ± 1.16) mm and then increases at the end of second month, approximately to preoperative values (23.36 ± 1.89 mm). Lax become shorter for 0.39 mm one week after operation. Similar measurements and shortening were in both glaucoma types. In POAG it become shorter for 0.42 mm one week later and in XFG is shorter 0.36 mm first week after operation (Table 6).

The dynamic relationship between change in IOP and the state of sclera and choroid, manifested and showed as Lax parameter is presented through time and confirmed by Lax sequential measurements in postoperative period. IOP was obviously lowered after operation providing estimation of the magnitude of Lax decrease with IOP lowering (Figure 2).

DISCUSSION

Trabeculectomy is commonly performed in patients with open angle glaucoma when medical therapy fails to control IOP. This procedure appears to be the best surgical method for preventing progressive optic disc damage [5]. Results of Early Manifest Glaucoma Trial (EMGT) indicate that IOP reduction of 25% from baseline reduces disease progression risk by 50%. For each mmHg IOP reduction, progression risk decreases for 10%. It is accepted that normal IOP was estimated based on the measurement in more than thousand people as the mean IOP ± 2(3) mean deviation. Normal IOP in healthy adult population is 15-16 mmHg ± 3 mmHg, in the interval 10-21 mmHg [10]. In this investigation mean preoperative IOP (32.5 ± 8.64 mmHg) was most decreased on the 7th postoperative day (14.72 ± 4.68 mmHg), and then slightly elevates in next two months, to value of 15.93 ± 3.46 mmHg at the end of monitoring. This fluctuation was within European Glaucoma Society Guidelines recommendations. Observing average reduction of 16.57 ± 5.18 mmHg from baseline, we achieved reduction of 50.98% (p <0.0001). Equal efficiency was achieved in both glaucoma types (POAG, XFG).

Based on International Glaucoma Association recommendation for results based on average statistical estimates of surgical success, trabeculectomy outcome was classified as: failure (target IOP not achieved), complete failure (loss of light perception), complete success (IOP achieved without therapy) and qualified success (IOP achieved with topical therapy). Analyzing IOP in operated patients, as an indicator of surgical efficacy, we concluded complete success in our group for 2 months without topical anti-glaucoma medication.

Detailed assessment of the effect of the surgical procedure requires monitoring over a longer period, at least one year after surgery in aim of prognostic conclusions according to Scandinavian Trabeculectomy Study (POAG, XFG). They reported total success of 82% one year after surgery, 70% after 2 years, 64% in 3 and 52% in 4 years of follow-up with a better treatment rate of POAG than XFG [11]. The first published national experience of surgical success in POAG in Britain was carried out in 2000 under patronage of the National Health Service and Public Health Department, presented 92% success rate in one-year follow-up [12].

However, in spite the fact that IOP is the only parameter in evaluation of antiglaucoma surgery effectiveness, do not forget the influence of glaucoma surgery on the refractive outcome and visual acuity due to changes in the anterior and posterior eye segment. Actual ophthalmic trends introduce the term refractive glaucoma surgery. As in cataract surgery, patients expectations and demands have been increased in terms of achieving a good refractive outcome, faster postoperative recovery, less complications, without quality of life compromising. In the past, surgeons focused mainly on effective IOP control. Today, patients rarely accept blurred vision due to astigmatism, hypotony or discomfort caused by filtration bleb. Modern glaucoma surgeons deal with the modification of surgical techniques to achieve more diffuse pads, minimal astigmatism and wound healing modulation with faster recovery.

In this investigation, best corrected pre/postoperative visual acuity was tested at Snellen chart during time (7, 30, 60 days). World Glaucoma Association (WGA) recommends that two methods can be used in the estimation of visual acuity: Snellen and ETDRS charts, that we respected because Snellen chart is used in our routine clinical practice [13].

The average preoperative visual acuity in both glaucoma types was approximately 4 lines at Snellen chart. At 7th postoperative day, there was a significant visual acuity decrease in both glaucoma types to 0.2 at Snellen chart ($p<0.0001$). On the 30th day visual acuity was improved for 1 line (0.3 Snellen) and in 60 days in both groups returned to approximate preoperative acuity of 0.37 (4 lines at Snellen chart). To prevent hypotonia, inflammation, shallow anterior chamber and other complications, topical midriatic (cycloplegic) solution Homatropini 2% was administered 2 weeks after surgery. This could be a reason in explaining visual acuity reduction in first postoperative week due to wide pupill and cycloplegia. There were no complications of bleeding or choroidal effusion that could affect visual acuity.

By analyzing demographic characteristic in OAG, fairly uniform relationship between gender (46.67% female *vs*. 53.33% male) and years of life was observed. XFG is a rare type of glaucoma, more common in elderly, that corresponds with results in our group. POAG is presented with 70% on average 66.67 years, and 30% are patients with XFG on average age 73.06 years. World studies report that XFG prevalence shows geographic, racial, ethnic variations. Australia, Sweden, Finland, Norway, Russia, Greece, Turkey, Iran, Saudi Arabia, Tunisia reported an XFG incidence of 13-21% over 60 years. Lower rate than 6% in patients over 70 years is recorded in Germany, Britain, Japan, Austria, Switzerland, Denmark. The prevalence increases with age from 2.8/100000 at 50 years to 205.7/100000 in 79 years [14, 15, 16]. Respondents age has a positive correlation with glaucoma type (XFG). In our results, significantly older XFG was observed, 77 years female and 70.55 male *vs*. 70.62 female and 62.71 males in POAG. In Serbia, half of all glaucoma is above 65 years, while the other half is a working age population between 40 and 65 years of life [10]. According to the results of multicenter clinical study in Russia, blindness occurs at 75 years, therefore scientists point out the importance of surgical therapy on time, inspite of transient change of visual acuity.

First literature review of reduced visual acuity after trabeculectomy was found in the 1960s in Watson work, as consequence of iris position change. According to his observations it lasts for 6 weeks. Detailed analysis by Cunlife implies reduction of uncorrected and best-corrected visual acuity 3 weeks after surgery in subjects without cycloplegic [7]. Although surgery benefits in glaucoma control, studies have indicated that it affects corneal curvature, ocular biometry and leads to visual acuity deterioration [17, 18]. Cunlife study showed 94% of eyes worsen uncorrected acuity 1 week following surgery. This was due to a “myopic shift” in refraction, secondary to anterior chamber depth changes which became shallow because they did not receive cycloplegic, so ciliary body rotated forward, accommodated and moved to myopic refraction. Only 1 mm change in anterior chamber depth results in 2 diopter change in refractive sphere. Visual acuity starts to return to pre-operative levels in variable period, so to determine changes in our patients, we continued research of obtained parameters (ACD, Lax).

ACD is important factor in visual acuity change in early postoperative period because it decreases on 5th day with spontaneous reforming until the 2nd week, if the cycloplegic drops was not applied. Raitta tried to reform anterior chamber by viscoelastic Na-hyaluronate in aim to prevent shallowing, because the rotation and movement of ciliary body are progressing with the spasm, which increases "myopic shift" [7]. Our postoperative protocol includes homatropini solution for 2 weeks after surgery to avoid athalamia. This is in aim of achieving better surgical outcome, preservation of filtration bleb integrity which could be bad especially in presence of irido-corneal contact [7, 19]. Shallower AC preoperatively is common finding in XFG, indicates zonular instability and increased incidence of postoperative complications.

Our biometric parameters analysis showed that average ACD varies during the monitoring period, from preoperative 2.79 ± 0.65 mm, its value increases the most at 7th day(3.89 ± 1.42 mm) then decreases to 30th (3.59 ± 1.25 mm) and 60th day (3.08 ± 1.02 mm) almost to preoperative level ($p<0.0001$). Deepening of anterior chamber was due to cycloplegic application (about 15days) according to protocol thus providing stable chamber at the end of follow-up.

The most systematic review of all relevant articles in biometric changes published in Pub Med in 1989-2016 was analyzed by Alvani who selected 25 comparable studies including 690 individuals that met similar inclusion criteria. All studies revealed ACD reduction immediately after surgery, which gradually deepened and reached its preoperative levels on day 14 in 87-91% of participants. ACD reduction was not significant after that period in majority of cases. ACD change of small amount in short period independently from measuring method: A-scan, ultrasound biometry, pachymetry or optical biometry, was also noticed by Husain (2013) and Chen (2014) [6, 20, 21, 22].

Other ocular biometric change after trabeculectomy is axial length (AL, Lax) decrease due to improvement of ocular blood flow [5]. As choroidal thickness is dynamic parameter influenced by IOP oscillations, large IOP decrease might lead to significant CT/Lax changes. Alvani analyzed 8 studies that evaluated Lax, all of them reported significant Lax reduction postoperatively at all follow up points for 0.1-0.9 mm that became stable after 3 months. These studies were different in terms of follow up period, intra-operative antimetabolites application, method of Lax measurement [6, 16, 20, 23]. Nemeth and Horoczi noticed Lax reduction 4 days after trabeculectomy for the first time [24]. Cashwell and Martin examined records of 62 patient and measured Lax before and after surgery by ultrasound biometry, then reported mean Lax reduction of 0.423 ± 0.61 mm that lasts for 22.5 months [25]. Studies of this topic differ in measurement method and antimetabolites application. High percent of patients with antimetabolite had lower IOP and frequently experienced greater amounts of biometric changes [23–26]. Kook for first time reported significant Lax reduction after trabeculectomy with mitomycin C (MMC), for 0.83 ± 1.00 mm at the follow up period of 3 months [26, 27]. Notice that different Lax measurement methods explain disparity between studies results. Ultrasonic methods led to more pronounced Lax reduction than noncontact techniques [20].

Our study was performed without MMC and showed that preoperative value of 23.41 ± 1.26 mm Lax decreases at day 7th (23.02 ± 1.27 mm) and 30th (23.09 ± 1.16 mm), then raised to 60th, almost to preoperative (23.36 ± 1.89 mm) ($p = 0.043$; $p <0.05$). This Lax reduction for 0.39 ± 1.27 mm is very similar to Cashwell and Martin results. Most studies confirmed Lax changes causes and showed: high preoperative IOP, low postoperative IOP, young age, antimetabolite application, myopic refraction, surgical complications (choroidal detachment, hypotony maculopathy) were significantly associated with prolonged Lax reduction.[23, 27]

The direct relationship between IOP reduction, choroidal thickness increase and Lax reduction has been demonstrated in several studies. In Husain study, each 1 mmHg decrease in IOP led to a 0.01 mm Lax reduction in POAG. Patients with OAG are more sensitive to Lax changes and experience more axial fluctuations during the first 3 months after trabeculectomy compared to patients with angle closure glaucoma [6, 28]. Some authors suggest that Lax reduction can be predicted after 3 months by formula: Lax reduction (mm) = -199+0.006 x IOP reduction+0.008 x final IOP [23,29]. Our scatter plot illustrates simultaneous change of Lax and IOP and showed significant correlation in IOP and Lax decrease through time ($r=0.255$; $p=0.049$; $p<0.05$) with implication to visual acuity.

Trabeculectomy, non-penetrating surgery and drainage devices usually cause Lax, ACD or keratometry changes that last more than one year, but significant enough to affect visual acuity, IOL power calculation accuracy and refractive outcomes after combined or cataract surgery. After trabeculectomy every 0.1 mm change in Lax leads to an average 0.25 D change in IOL power in emetropic eye. This error was to 0.18 D in a very long eye (30 mm) and increases to 0.3 8 D in very short eye (20 mm). Other parameter, ACD change of 0.12 mm would result in a change of 0.06 D in refractive error for posterior chamber IOL [5, 6, 28–31].

CONCLUSION

Trabeculectomy is the most common surgical procedure for glaucoma management which may significantly influence ocular biometry and may last more than one year. ACD and Lax change can be significant enough to affect visual acuity, the accuracy of IOL power calculation and refractive outcomes after combined or future cataract surgery. Our biometric parameters analysis showed significant postoperative difference in ACD (for 1.1 mm during time interval) and Lax decrease (0.39 ± 1.27 mm at 7th day) with spontaneous recovery 2 months after operation. There was a difference in the postoperative visual acuity compared to the preoperative (worsening for 2 lines at Snellen chart) with spontaneous recovery at the end of follow up. As our continuous effort is to develop new procedures and improve actual, to avoid problems associated with glaucoma filtering surgery, we must strive to improve our surgical outcome, modify surgical technique, develop strategies to optimize visual acuity and accuracy of IOL power calculation in order to achieve the best results for our patients.

ACKNOWLEDGMENT

These results were presented in Marija Radenković's master thesis and parts of the results were also presented at the XVIII Congress of Serbian Ophthalmologists held in Aranđelovac, Serbia, on September 21–24, 2017.

REFERENCES

1. Sarkisian S. Optimizing Techniques for Filtering Surgery to Improve Visual Outcomes. Glaucoma Today. Summer 2011.
2. Lee W.W. Ultrasound vs.Optical Biometry. Available at: http://www.ophthalmologyweb.com. May 16, 2011.
3. Shahzad H.S.F., Patel A, O'Brien C, DelMonte D. Biometry for Intra-Ocular Lens (IOL) power calculation. Available at: http://eyewiki.aao.org/.October 4, 2017.
4. Sahin A, Hamrah P. Clinically relevant biometry. Curr Opin Ophthalmol. 2012; 23:47–53. doi: 10.1097/ICU.0b013e32834cd63e.
5. Kara N, Baz O, Altan C, Satana B, Kurt T, Demirok A. Changes in choroidal thickness, axial length, and ocular perfusion pressure accompanying successful glaucoma filtration surgery. Eye. 2013; 27:940–5. doi:10.1038/eye.2013.116.
6. Alvani A, Pakravan M, Esfandiari H, Safi S, Yaseri M, Pakravan P. Ocular Biometric Changes after Trabeculectomy. J Ophthalmic Vis.Res. 2016; 11(3):296–303. PMCID:PMC5000533; PMID:27621788; DOI:10.4103/2008-322X.188399.
7. Cunliffe IA, Dapling RB, West J, Longstaff S. A prospective study examining the changes in factors that affect visual acuity following trabeculectomy. Eye. 1992; 6:618–22. PMID:1289140; DOI:10.1038/eye.1992.133.
8. Stewart WC, Shields MB. Management of anterior chamber depth after trabeculectomy. Am J Ophthalmology. July 1988; 106(1):41–4. PMID:3394767
9. Goins K, Smith T, Kinker R, Lewis J. Axial anterior chamber depth after trabeculectomy. Ophthalmologica. 1990; 200:177–80. PMID:2367079
10. Cvetković D. Epidemiologija IOP-a i glaukoma. Toco Bel.Maj 2008.
11. Ehrnrooth P, Lehto I, Puska P, Laatikainen L. Long-term outcome of trabeculectomy in terms of intraocular pressure. Acta Ophthalmologica Scandinavica. June 2002; 80(3):267–71. PMID:12059864.
12. Edmunds B, Thompson JR, Salmon JF, Wormald RP. The National Survey of Trabeculectomy. II. Variations in operative technique and outcome.Eye. 2001; 15:441–4. PMID:11767016 DOI:10.1038/eye.2001.152.
13. Shaarawy T, Grehn F,Sherwood M. WGA guidelines on design and reporting of glaucoma surgical trials. Kugler publications. Hague.Amsterdam. Netherlands.2009.
14. Ringvold A. Epidemiology of exfoliation syndrome and exfoliative glaucoma.Exfoliation Syndrome and Exfoliative Glaucoma. 2nd edit. Publicomm.May 2012.
15. Andrikopoulos GK, Alexopoulos DK, Gartaganis SP. Pseudoexfoliation syndrome and cardiovascular diseases. World Journal of Cardiology. 2014; 6(8):847–54. doi: 10.4330/wjc.v6.i8.847.
16. Cook C, Foster P. Epidemiology of glaucoma: what's new? Can J Ophthalmol. 2012 Jun; 47(3):223–6. doi: 10.1016/j.jcjo.2012.02.003.
17. Claridge KG, Galbraith JK, Karmel V, Bates A. The effect of trabeculectomy on refraction, keratometry and corneal topography. Eye. 1995; (9):292–8. PMID:7556735; DOI:10.1038/eye.1995.57
18. Hugkulstone CE. Changes in keratometry following trabeculectomy. British Journal of Ophthalmology. 1991; 75:217–8. doi: 10.1136/bjo.75.4.217
19. Stewart WC, Shields B. Management of Anterior Chamber Depth After Trabeculectomy. American Journal of Ophthalmology. July 1988; 106(1):41–4. doi:10.1016/S0002-9394(14)76385-8.
20. Husain R, Li W, Gazzard G, Foster PJ, Chew PT, Oen FT, et al. Longitudinal changes in anterior chamber depth and axial length in Asian subjects after trabeculectomy surgery. Br J Ophthalmol. 2013; 97:852–6. doi: 10.1136/bjophthalmol-2012-302442
21. Alvani A, Pakravan M, Esfandiari H, Yaseri M, Yazdani S, Ghahari E. Biometric Changes After Trabeculectomy with Contact and Non-contact Biometry. Optom Vis Sci. 2016; 93(2):136-40. doi: 10.1097/OPX.0000000000000781.
22. Man X, Chan NC, Baig N, Kwong YY, Leung DY, Li FC, et al. Anatomical effects of clear lens extraction by phacoemulsification versus trabeculectomy on anterior chamber

drainage angle in primary angle-closure glaucoma (PACG) patients. Graefes Arch Clin Exp Ophthalmol. 2015; 253:773–8. doi: 10.1007/s00417-015-2936-z.

23. Francis BA, Wang M, Lei H, Du LT, Minckler DS, Green RL, et al.Changes in axial length following trabeculectomy and glaucoma drainage device surgery. Br J Ophthalmol. 2005; 89:17–20. PMID: 15615739. DOI:10.1136/bjo.2004.043950
24. Nemeth J, Horoczi Z. Changes in the ocular dimensions after trabeculectomy. In Ophthalmol 1992; 16:355–7. PMID: 1428570
25. Cashwell LF, Martin CA. Axial length decrease accompanying successful glaucoma filtration surgery. Ophthalmology. 1999; 106:2307–11. PMID:10599662 DOI:10.1016/S0161-6420(99)90531-6
26. Pakravan M, Alvani A, Yazdani S, Esfandiari H, Yaseri M. Intraocular lens power changes after mitomycin trabeculectomy. Eur J Ophthalmol. 2015; 25:478-82. DOI:10.5301/ejo.5000604
27. Kook MS, Kim HB, Lee SU. Short-term effect of mitomycin-C augmented trabeculectomy on axial length and corneal astigmatism. J Cataract Refract Surg. 2001; 27:518–23. DOI: 10.1016/S0886-3350(00)00646-5
28. Pakravan M, Alvani A, Esfandiari H, Ghahari E, Yaseri M. Post-trabeculectomy ocular biometric changes. Clin Exp Optom. 2017 Mar;100(2):128-132. doi: 10.1111/cxo.12477. Epub 2016 Sep 29.
29. Saeedi O, Pillar A, Jefferys J, Arora K, Friedman D, Quigley H.Change in choroidal thickness and axial length with change in intraocular pressure after trabeculectomy.Br J Ophthalmol.2014 Jul;98(7):976-9. doi:10.1136/bjophthalmol-2013-304433.
30. Tan HY, Wu SC.Refractive error with optimum intraocular lens power calculation after glaucoma filtering surgery. J Cataract Refract Surg. 2004 Dec; 30(12):2595-7. PMID:15617930 DOI:10.1016/j.jcrs.2004.05.016
31. Üretmen Ö, Ateş H, Andaç K, Deli B. Axial Length Changes Accompanying Successful Nonpenetrating Glaucoma Filtration Surgery Ophthalmologica. 2003; 217:199–203. DOI:10.1159/000068977

Table 1. Intraocular pressure values (mmHg) in operated open angle glaucoma patients in time intervals

IOP	IOP values in glaucoma type			
	Glaucoma type	Number of patients	Average IOP	Mean dev.
IOP 0	POAG	42	33.38	9.08
	XFG	18	30.44	7.35
	Total	60	32.50	8.64
IOP 7	POAG	42	14.90	4.39
	XFG	18	14.28	5.40
	Total	60	14.72	4.68
IOP 30	POAG	42	15.90	4.07
	XFG	18	16.44	4.85
	Total	60	16.07	4.28
IOP 60	POAG	42	16.36	3.51
	XFG	18	14.94	3.23
	Total	60	15.93	3.46

IOP – intraocular pressure; OAG – open angle glaucoma; POAG – primary open angle glaucoma; XFG – exfoliative glaucoma

Table 2. Visual Acuity in glaucoma type (primary open angle glaucoma, exfoliative glaucoma) in time intervals

Visual Acuity	Visual Acuity in glaucoma type			
	Glaucoma type	Number of patients	Average Visual Acuity	Mean dev.
VA 0	POAG	42	0.41	0.35
	XFG	18	0.37	0.36
	Total	60	0.40	0.35
VA 7	POAG	42	0.22	0.22
	XFG	18	0.22	0.23
	Total	60	0.22	0.22
VA 30	POAG	42	0.28	0.25
	XFG	18	0.29	0.30
	Total	60	0.28	0.26
VA 60	POAG	42	0.37	0,32
	XFG	18	0.36	0.33
	Total	60	0.37	0.32

POAG – primary open angle glaucoma; XFG – exfoliative glaucoma; VA – visual acuity

Table 3. Gender structure

Gender	Age (years)			
	Number of patients	% of patients	Average age	Mean dev.
Female	28	46.67	72.2	7.92
Male	32	53.33	65.4	11.56
Total	60	100	68.6	10.52

Table 4. Glaucoma type according to gender and age

Gender	Glaucoma type		
	POAG	**XFG**	**Total**
Female **%**	**21** **75%**	**7** **25.00%**	**28** **100%**
Male **%**	**21** **65.63%**	**11** **34.38%**	**32** **100%**
Total **%**	**42** **70%**	**18** **30.00%**	**60** **100%**
Age (years) **Mean dev.**	**66.67** **11.11**	**73.06** **7.49**	**68.58** **10.52**

POAG – primary open angle glaucoma; XFG – exfoliative glaucoma

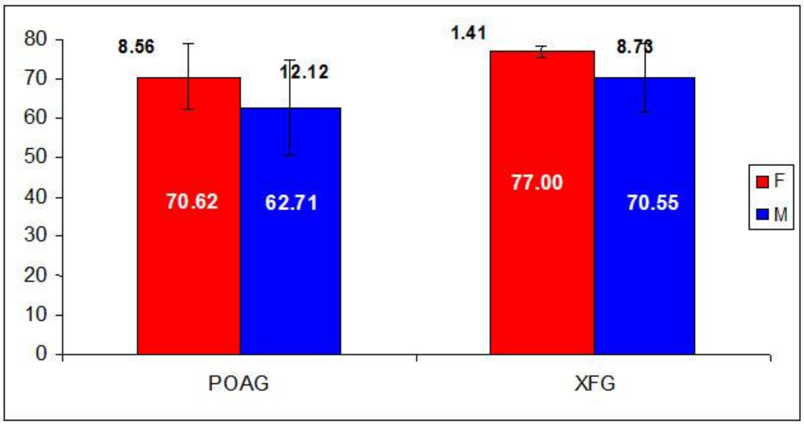

Figure 1. Age structure of respondents by gender in both glaucoma types (POAG – primary open angle glaucoma; XFG – exfoliative glaucoma)

Table 5. Time distribution of anterior chamber depth

ACD (mm)	Anterior Chamber Depth in glaucoma type			
	Glaucoma type	Number of patients	Average ACD	Mean dev.
ACD 0	POAG	42	2.73	0.56
	XFG	18	2.94	0.81
	Total	60	2.79	0.65
ACD 7	POAG	42	3.85	1.45
	XFG	18	3.99	1.37
	Total	60	3.89	1.42
ACD 30	POAG	42	3.59	1.06
	XFG	18	3.59	1.64
	Total	60	3.59	1.25
ACD 60	POAG	42	3.00	0.84
	XFG	18	3.28	1.37
	Total	60	3.08	1.02

ACD – anterior chamber depth; POAG – primary open angle glaucoma; XFG – exfoliative glaucoma

Table 6. Time distribution of axial length change

Lax (mm)	Lax values in glaucoma type			
	Glaucoma type	Number of patients	Average Lax	Mean dev.
Lax 0	POAG	42	23.49	1.40
	XFG	18	23.24	0.85
	Total	60	23.41	1.26
Lax 7	POAG	42	23.07	1.37
	XFG	18	22.88	1.03
	Total	60	23.02	1.27
Lax 30	POAG	42	23.14	1.26
	XFG	18	22.98	0.90
	Total	60	23.09	1.16
Lax 60	POAG	42	23.22	1.25
	XFG	18	23.69	2.90
	Total	60	23.36	1.89

Lax – axial length change

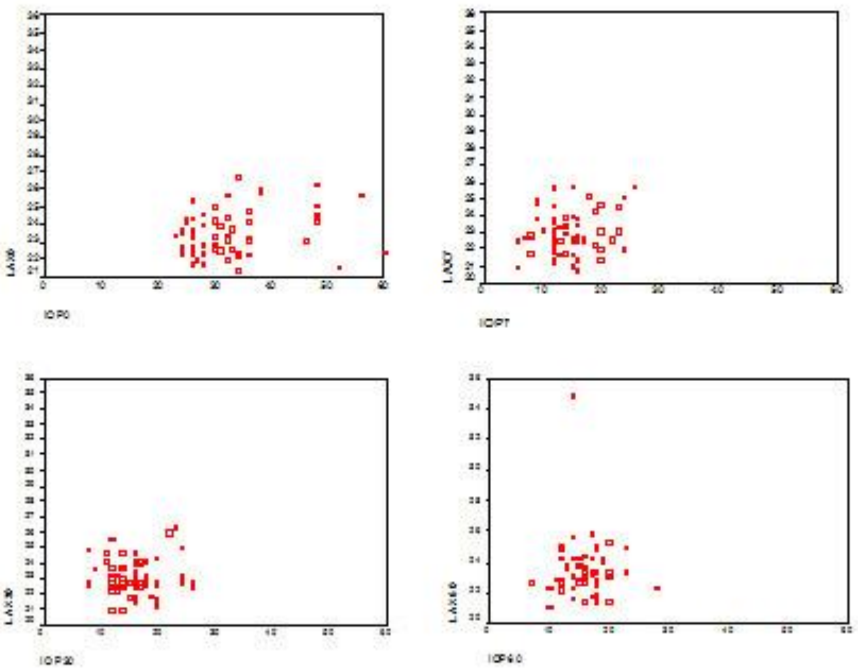

Figure 2. Intraocular pressure (IOP) and axial length change (Lax) relationship over time