

# A Prospective Interventional Study to Study Changes in Intra Ocular Pressure (IOP) after Phacoemulsification in Patients with Cataract and Primary Angle Closure Suspect, Primary Angle Closure or Primary Angle Closure Glaucoma

Dr. Bhavesh Patel<sup>1</sup>, Dr. Rupam Desai<sup>2</sup>, Dr. Avni Patel<sup>3</sup>

<sup>1</sup>M. S. [Ophthalmology], Assistant Professor, Hari Jyot College Of Optometry, Rotary Eye Institute, Navsari, Gujarat, India  
<sup>1</sup>(bp393982[at]gmail.com)

<sup>2</sup>M. S. [Ophthalmology], Rotary Eye Institute, Navsari, Gujarat, India  
<sup>2</sup>(desairupam[at]gmail.com)

<sup>3</sup>MBBS, DOMS, Rotary Eye Institute, Navsari, Gujarat, India  
<sup>3</sup>(avnip222[at]gmail.com)

**Abstract:** Title: "A Prospective Interventional Study to Study Changes in Intra Ocular Pressure (IOP) after Phacoemulsification in Patients with Cataract and Primary Angle Closure Suspect, Primary Angle Closure or Primary Angle Closure Glaucoma". Material and methods: A prospective, nonrandomized, non-comparative, interventional study conducted on primary angle closure patients attending the outpatient department of Rotary eye institute, Navsari, Gujarat, India from August 2020 to August 2021 i.e., 12 months of duration. Patients were registered with their name, age, sex, occupation and postal address. Each patient included in the study underwent history taking including past history of any laser treatment or surgeries and complete ophthalmological examination including: Uncorrected distance visual acuity (UCVA), best corrected distance visual acuity (BCVA) measurement, Slit lamp biomicroscopic examination, Fundus examination using Indirect ophthalmoscope, Central corneal thickness using Pachymetry, Keratometry using autokeratometer, A scan Biometry for Axial length, Anterior chamber depth, Lens thickness, IOP measurement using Goldmann Applanation tonometer and Shaeffer's grading for further gonioscopic scoring was done from 0-16 by adding all the angle grades, Gonioscopy to detect type of glaucoma. And evaluated preoperative and postoperative changes in uncorrected and best corrected visual acuity, intraocular pressure (IOP). Results: 50 eyes were taken in this study. 54% were found to be females and 46% were found to be males among 50 patients in my study. Visual outcomes were noted after phacoemulsification surgery in these patients which showed significant improvement in UCVA as well as BCVA after surgery. In preoperative period, 8 patients had UCVA between 6/6-6/18, 22 patients had UCVA between 6/18-6/60 and 20 patients had UCVA <6/60. In post operative period, 38 patients had UCVA between 6/6-6/18, 12 patients had UCVA between 6/18-6/60 and 0 patient had UCVA <6/60. In preoperative period, 26 patients had BCVA between 6/6-6/18, 13 patients had BCVA between 6/18-6/60 and 11 patients had BCVA <6/60. In post operative period, 46 patients had BCVA between 6/6-6/18, 4 patients had BCVA between 6/18-6/60 and 0 patient had BCVA <6/60. In 50 eyes, mean baseline IOP was 26 mmHg (mean IOP). Mean IOP after 1 week of phacoemulsification was 16 mmHg, Mean IOP after 4 weeks was 14 mmHg and it was 15 mmHg after 3 months which was comparable with that of 4 weeks post operative IOP. Phacoemulsification for the treatment of primary angle-closure glaucoma along with cataract effectively reduces the intraocular pressure and improves their visual acuity level. The effective rate of the treatment is high, so the treatment improves the quality of life of patients. Therefore, this treatment can be used as a first line of management in patients with primary angle closure suspect, primary angle closure and primary angle closure glaucoma patients having cataract. Conclusion: Phacoemulsification is effective as therapy in close angle glaucoma with cataract by lowering IOP and also improving visual acuity. Phacoemulsification is a good alternative to other treatment modalities for angle closure glaucoma patients to lower IOP and disease progression.

**Keywords:** Phacoemulsification, Glaucoma, Intraocular Pressure

## 1. Introduction

Primary angle closure glaucoma (PACG) is estimated to affect 15 million people worldwide and is responsible for half of all glaucoma blindness [1]. Prevalence of Occludable angle in Asia is 10.2 % [2]. A lens induced mechanism in the development of angle closure glaucoma has been suggested. A thick crystalline lens might lead to angle closure through reduction of anterior chamber depth and narrowing of the angle [3, 4, 5]. Studies have reported IOP control and angle opening after phacoemulsification in PACG [6]. Glaucoma surgery can accelerate cataract progression, and performing both surgeries may increase the rate of postoperative complications and compromise the success of either surgery. However, cataract surgery may

independently lower intraocular pressure (IOP), which may allow for greater IOP control among patients with co-existing cataract and glaucoma [7]. Phacoemulsification has been shown to be effective in refractory cases of acute angle closure as well as in eyes with controlled attacks. In a randomized clinical trial, compared with laser peripheral iridectomy, lens extraction resulted in a wider anterior chamber angle, a deeper anterior chamber, and a lower IOP in PACS eyes [8]. As such; cataract surgery may be a safe alternative to glaucoma surgery in some patients and could shift the surgeon's approach in treatment of concurrent cataract and glaucoma. The aim of this study is to evaluate efficacy of phacoemulsification surgery on reduction in IOP in primary angle closure patients.

Volume 11 Issue 2, February 2022

[www.ijsr.net](http://www.ijsr.net)

Licensed Under Creative Commons Attribution CC BY

**2. Material and Methodology**

Patients with primary angle closure suspect, primary angle closure and primary angle closure glaucoma with cataract at Rotary eye institute, Navsari will be taken up for the study July-2020 to July 2021. 50 eyes with primary angle closure suspect, primary angle closure or primary angle closure glaucoma with cataract A prospective, nonrandomized, non-comparative, interventional study. Rotary eye institute, Navsari, Gujarat. Convenient method of sampling has been done. Inclusion criteria: Patients aged 50-70 years with IOP > 22 mmHg on 2 or more sittings with glaucoma suspect and angle closure on gonioscopy. Willing to provide written informed consent. Willing to follow up for a minimum of 3 months. Exclusion criteria: History of prior ocular surgery and laser peripheral iridectomy. History of prior ocular trauma Other ocular pathology likely to affect structure and function of angle of eye. Glaucomatous optic neuropathy in affected eye. Patients were evaluated by following proforma: All patients presenting to Rotary eye institute with suspected (shallow central or peripheral anterior chamber) or confirmed primary angle closure glaucoma. A written informed consent will be taken from the patients to include their findings and analysis for the study. Detailed history will be taken and clinical/ocular examination done. A pre-structured proforma shall be used to collect the data. The following evaluation will be done in each case: Personal data: Patient Name, father / mother name, Age, Sex, address, registration number, contact number. History including past history of any laser treatment or surgeries. Best corrected Visual acuity Distance (Snellen’s vision chart) Near (Snellen near vision chart) Detailed Anterior segment examination on slit lamp with grading of cataract by LOCS 3rd grading system Intra-ocular tension (With Rebound Tonometry / Applanation tonometry Fundus examination using indirect ophthalmoscope, +78D and +90D Lens thickness, Axial length, anterior chamber depth by A Scan/USG-B Scan (for cases where fundus not visible) Keratometry (k-vertical, k-horizontal) USG-A Scan (axial length and IOL power calculation) Central corneal thickness by konan specular microscope Angle visualization by gonioscopy and grading by Schaeffer’s grading system. After detailed explanation and written informed consent, patients enrolled under study and underwent following evaluation.

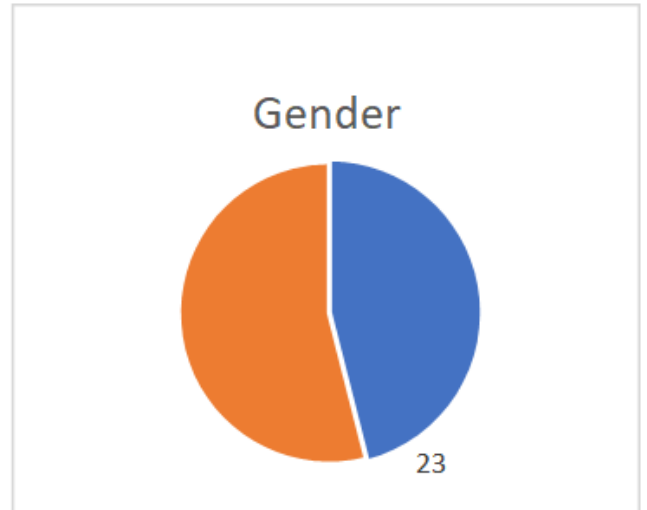
**3. Results and Observations**

A prospective non-randomized, noncomparative interventional study was carried out among 50 eyes who were diagnosed as any form of angle closure glaucoma along with cataract and underwent phacoemulsification surgery at Rotary eye institute, Navsari. They were enrolled in study as per inclusion criteria after written informed

consent. A pre tested structured questionnaire was filled and after that they underwent the procedure as per the protocol and all the data was analyzed.

**Table 1: Distribution of Patients by Gender**

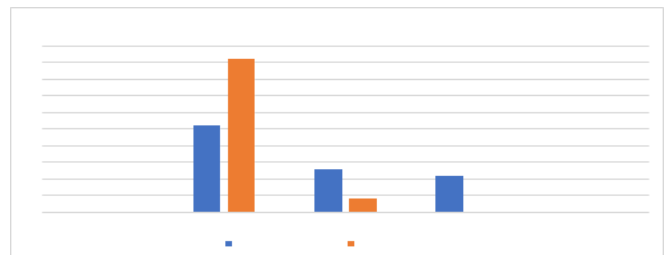
Male	23	46%
Female	27	54%
Total	50	100%



**Table 2: Visual Outcomes (BCVA)**

Preoperative BCVA Postoperative BCVA

Visual acuity	Frequency	Frequency
6/6-6/18	26	46
6/18-6/60	13	4
<6/60	11	0
Total	50	50



This graph shows that in preoperative period, 26 (52%) patients had BCVA between 6/6-6/18, 13 (26%) patients had BCVA between 6/18-6/60 and 1 (2%) 1 patients had BCVA <6/60. In post operative period, 46 (92%) patients had BCVA between 6/6-6/18, 4 (8%) patients had BCVA between 6/18-6/60 and 0 (0%) patient had BCVA <6/60.

**Table 4: The Mean Values of Different Parameters in Angle Closure Patients in Our Study**

	Mean	Std. Deviation
Age	64.98	9.28
Axial length	23.05	.86
Lens thickness	4.47	.61
KV (keratometry vertical meridian)	43.47	1.45
KH (keratometry horizontal meridian)	44.38	1.61
Preop ACD	2.81	.39

Variable s	Prep IOP		Post op IOP 1 Week		Post op IOP 4 week		Post op IOP 3 months		F (4272.520, 3829.980)	$\eta^2$
	M	SD	M	SD	M	SD	M	SD		
	25.5	8.71	16.3	5.67	14.1	3.18	14.6	3.53	1424.173	0.00
	6	6	6	4	8	0	2	3		0

Table shows mean, standards deviation and *F*-value for changes of IOP following phacoemulsification surgery on consecutive follow ups. Results indicated significant mean differences in changes of IOP across three time period  $F(4272.52, 3829.98) = 1424.173$ ,  $MSE = 147$ ,  $p = <0.05$ ,  $\eta^2 = .000$  with large effect size. The findings revealed that higher level of IOP reduction after one week of phacoemulsification surgery ( $M = 16.3$ ,  $SD = 5.67$ ) subsequently reduced after 4 weeks of phacoemulsification surgery ( $M = 14.18$ ,  $SD = 3.18$ ) and third month after phacoemulsification surgery ( $M = 14.62$ ,  $SD = 3.53$ ). The paired wise comparison indicated that there is significant difference in all pairs of scores after one week, 4 weeks and 3 month after phacoemulsification surgery.

#### 4. Discussion

The phacoemulsification surgery alone in patients with any form of angle closure glaucoma with cataract can cause significant reduction of IOP. The study performed at Rotary eye institute, Navsari, included 50 eyes of patients with primary angle closure suspect, primary angle closure or primary angle closure glaucoma with cataract who underwent phacoemulsification surgery, observed and data analysed for interpretation. Thasarat S Vajaranant 1, Sushma Nayak, Jacob T Wilensky, Charlotte E Joslin: [73] Shows that Women not only outlive men, but also outnumber men in glaucomacases worldwide. Women are at higher risks for angle closure glaucoma, but there is no clear gender predilection for open angle glaucoma. Of interest, there is some evidence suggesting that female sex hormones might be protective of the optic nerve. In addition, it is hypothesized that decreased estrogen exposure is associated with increased risk for open angle glaucoma, yet population-based studies present inconsistent results. Presently, there is insufficient evidence to support hormonal replacement therapy use in glaucoma prevention. In addition, it appears that women carry a larger burden of glaucoma blindness due to longevity and disadvantages in socioeconomic/health beliefs. IN OUR STUDY, majority of participants are female (54%) and rest 46% male. Majority of male and female are in the age group of 45-70 years. Ariel Yuhan Ong et al. underwent 9 randomised controlled trials with 914 eyes and concluded that lens extraction has an advantage over LPI in treating chronic PACG with clear crystalline lenses over three years of follow-up. Min Kyung Song et al. underwent retrospective observational study including 77 eyes from patients with PACS, PAC and PACG who underwent lens extraction and were followed up for >2 years after surgery and concluded that lens extraction achieved significant IOP reduction. In our study, phacoemulsification surgery in patients of acute angle closure suspect, angle closure and angle closure glaucoma with cataract had controlled IOP after surgery. According to Romkens et al Compared with LPI, LE resulted in a wider anterior chamber angle, a deeper anterior chamber, and a lower IOP in PACS eyes. In our

study, the mean ACD was 2.81mm in preoperative patients which was deepening in the postoperative period after phacoemulsification surgery. Eray Atalay, Monisha E Nongpiur, Mani Bhaskaran, Shamira A pereira, Tina T Wong, Desmond Quek, Tin Aung noted in a retrospective case series including 85 patients (85 eyes, 52 PACS, 33 PAC) that overall, IOP decreased by 19.9% from the preoperative mean of 16.1 mm Hg  $\pm$  3.1 (SD) to 12.9  $\pm$  2.7 mm Hg. The IOP change between the PACS group ( $-3.3 \pm 2.8$  mm Hg; -20.6%) and the PAC group ( $-3.2 \pm 4.7$  mm Hg; -19.6%) was similar ( $P > .05$ ). In multiple linear regression analyses, a higher preoperative IOP ( $\beta = 0.68$ ,  $P < .001$ ) and fewer clock hours of peripheral anterior synechiae (PAS) ( $\beta = -0.30$ ,  $P = .03$ ) predicted a greater absolute change in and percentage of reduction in IOP, respectively. The mean IOP reduction 6 months after phacoemulsification was 20%. In our study, In 50 eyes mean baseline IOP was 26 mmHg (mean IOP), Mean IOP after 1 week of phacoemulsification was 16 mmHg, Mean IOP after 4 weeks was 14 mmHg and it was 15 mmHg after 3 months which was comparable with that of 4 weeks post operative IOP. Dennis S C Lam, Dexter Y L Leung, Clement C Y Tham, Felix C H Li, Yolanda Y Y Kwong, Thomas Y H Chiu, Dorothy S P Fan Prospective randomized controlled trial with 62 subjects randomized to receive either early phacoemulsification or LPI after aborting APAC by medications in which early phacoemulsification appeared to be more effective in preventing IOP rise than LPI in patients after abortion of APAC. Phacoemulsification is now considered as one of the first line of treatment for patients with all types of angle closure glaucoma along with cataract. Early phacoemulsification with intraocular lens implantation results in a reduced intraocular pressure and number of glaucoma medications after an acute angle closure glaucoma crisis in patients with coexisting cataract.

#### 5. Conclusion

Angle closure glaucoma, when associated with concurrent cataract can be treated effectively with phacoemulsification surgery alone and IOP control can be achieved with phacoemulsification surgery alone as well in these patients. 50 eyes were taken in this study. 54% were found to be females and 46% were found to be males among 50 patients in my study. Visual outcomes were noted after phacoemulsification surgery in these patients which showed significant improvement in UCVA as well as BCVA after surgery. In preoperative period, 8 patients had UCVA between 6/6-6/18, 22 patients had UCVA between 6/18-6/60 and 20 patients had UCVA <6/60. In post operative period, 38 patients had UCVA between 6/6-6/18, 12 patients had UCVA between 6/18-6/60 and 0 patient had UCVA <6/60. In preoperative period, 26 patients had BCVA between 6/6-6/18, 13 patients had BCVA between 6/18-6/60 and 11 patients had BCVA <6/60. In post operative period, 46 patients had BCVA between 6/6-6/18,

4 patients had BCVA between 6/18-6/60 and 0 patient had BCVA <6/60. In 50 eyes, mean baseline IOP was 26 mmHg (mean IOP). Mean IOP after 1 week of phacoemulsification was 16 mmHg, Mean IOP after 4 weeks was 14 mmHg and it was 15 mmHg after 3 months which was comparable with that of 4 weeks post operative IOP. Phacoemulsification for the treatment of primary angle-closure glaucoma along with cataract effectively reduces the intraocular pressure and improves their visual acuity level. The effective rate of the treatment is high, so the treatment improves the quality of life of patients. Therefore, this treatment can be used as a first line of management in patients with primary angle closure suspect, primary angle closure and primary angle closure glaucoma patients having cataract.

## References

- [1] Quigley H. A., Broman A. T. The number of people with glaucoma worldwide in 2010 and 2020. *Br J Ophthalmol.*2006; 90: 262–267
- [2] Aung T., Ang L. P., Chan S.-P., Chew P. T. Acute primary angle closure: long-term intraocular pressure outcome in Asian eyes. *Am J Ophthalmol.*2001; 131: 7–12.
- [3] George R., Paul P., Baskaran M. Ocular biometry in occludable angles and angle closure glaucoma: a population based survey. *Br J Ophthalmol.*2003; 87: 399–402.
- [4] Nongpiur M. E., He M., Amerasinghe N. Lens vault, thickness, and position in Chinese subjects with angle closure. *Ophthalmology.*2011; 118: 474–479
- [5] Mansouri M., Ramezani F., Moghimi S. Anterior segment optical coherence tomography parameters in phacomorphic angle closure and mature cataracts risk factors for phacomorphic angle closure. *Invest Ophthalmol Vis Sci.*2014; 55: 7403–7409.
- [6] Selvan H, Angmo D, Tomar AS, Yadav S, Sharma A, Dada T. Changes in Intraocular Pressure and Angle Status After Phacoemulsification in Primary Angle Closure Hypertension. *J Glaucoma.*2019 Feb; 28 (2): 105-110. doi: 10.1097/IJG.0000000000001137. PMID: 30689605.
- [7] Zhang ML, Hirunyachote P, Jampel H.combined surgery versus cataract surgery alone for eyes with cataract and glaucoma. *Cochrane Database Syst Rev.*2015 Jul 14; 7 (7): CD008671. doi: 10.1002/14651858. CD008671. pub3. PMID: 26171900; PMCID: PMC4730948.
- [8] Yan C, Han Y, Yu Y, Wang W, Lyu D, Tang Y, Yao K. Effects of lens extraction versus laser peripheral iridotomy on anterior segment morphology in primary angle closure suspect. *Graefes Arch Clin Exp Ophthalmol.*2019 Jul; 257 (7): 1473-1480. doi: 10.1007/s00417-019-04353-8. Epub 2019 May 11. PMID: 31079203.
- [9] Casson, R. J., Chidlow, G., Wood, J. P., Crowston, J. G. and Goldberg, I. (2012), Definition of glaucoma: clinical and experimental concepts. *Clinical & Experimental Ophthalmology*, 40: 341-349. <https://doi.org/10.1111/j.1442-9071.2012.02773.x>
- [10] Foster P. J., R. Buhrmann, et al. The definition and classification of glaucoma in prevalence surveys. *Br J Ophthalmol* 2002; 86: 238-242.
- [11] Sihota R. and H. C. Agarwal. Profile of the subtypes of angle closure glaucoma in a tertiary hospital in north India. *Indian J Ophthalmol* 1998; 46 (1): 25-29
- [12] Quigley H., N. Congdon, et al. Glaucoma in China (and worldwide): 179 changes in established thinking will decrease preventable blindness. *Br J Ophthalmol* 2001; 85: 1271-1272.
- [13] Hung P. T. and L. H. Chou. Provocation and mechanism of angle-closure glaucoma after iridectomy. *Arch Ophthalmol* 1979; 97 (10): 1862-1864.
- [14] Wang N., H. Wu, et al. Primary angle closure glaucoma in Chinese and Western populations. *Chin Med J (Engl)* 2002; 115 (11): 1706-1715.
- [15] Leydhecker W, Akiyama K & Neumann HG (1958): Der intraocular
- [16] Shiose Y. Intraocular pressure: new perspectives. *Surv Ophthalmol* 1990;
- [17] Brubaker RF. Flow of aqueous humor in humans [The Friedenwald Lecture]. *Invest Ophthalmol Vis Sci* 1991; 32: 3145-3166
- [18] Toris CB, Yablonski ME, Wang YL & Camras CB. Aqueous humor dynamics in the aging human eye. *Am J Ophthalmol* 1999; 127: 407-412
- [19] Kniestedt C, Punjabi O, Lin S & Stamper RL. Tonometry through the ages. *Surv Ophthalmol* 2008; 53: 56
- [20] Goldmann H. Applanation tonometry. New York. Josiah Macy, Jr. Foundation 1957: 8-591.
- [21] Whitacre MM, Stein RA & Hassanein K. The effect of corneal thickness on applanation tonometry. *Am J Ophthalmol* 1993; 115: 592-596
- [22] Doughty MJ & Jonuscheit S. The orbscan acoustic (correction) factor for central corneal thickness measures of normal human corneas. *Eye Contact Lens* 2010; 36: 106-115.
- [23] Mosby; 1997
- [24] Trantas A: Moyens d'explorer par l'ophtalmoscope—et partranslucidite—L. A. partie anterieure du fond oculaire, le cercleculaire y compris. *Arch Ophthalmol Paris* 1900; 20: 314
- [25] Dellaporta A: Historical notes on gonioscopy. *Surv Ophthalmol*1975; 20 (2): 137-49
- [26] Salzmann M: Die Ophthalmoskopie der Kammerbucht. *ZAugenheilk* 1914; 31: 1
- [27] Koeppel L: Die Mikroskopie des lebenden Kammerwinkels I'mfokalen Lichte der Gullstrandschen Nerstlampe. *Albrecht vonGraefe's Arch Ophthalmol* 1919; 101: 48
- [28] Koeppel L: Das stereoskopische Bild des lebendenKammerwinkels an der Gullstrandschen Spaltlampe beimGlaucom. *Deutsche Ophthalmol Gesell* 1920, p 87
- [29] Troncoso, M: Treatise on Gonioscopy. F A Davis, Philadelphia, 1947
- [30] Barkan O, Boyle SF, Maisler S: On the genesis of glaucoma: an improved method based on slit lamp microscopy of the angle of the anterior chamber. *Am J. Ophthalmol* 19: 209-215, 193637: 504-519, 1936
- [31] Barkan O: A new focal illuminator. *Am J Ophthalmol* 24: 439, 1941
- [32] Hoskins HD Jr: Interpretive gonioscopy in glaucoma.

- Invest Ophthalmol 11 (2): 97-102, 197
- [33] Schirmer KE: Gonioscopy and artefacts. *Br J Ophthalmol* 1): 50-3, 1967
- [34] Weinreb NR, Friedman DS eds: *Angle Closure and Angle Closure Glaucoma*. Kugler Publications, The Hague, The Netherlands, 2006
- [35] Shaffer RN: *Stereoscopic Manual of Gonioscopy*. Mosby, 1962.
- [36] Shaffer RN: Primary glaucomas. *Gonioscopy, ophthalmoscopy and perimetry*. *Trans Am Acad Ophthalmol Otolaryngol* 64: 112-27, 1960
- [37] Faulkner WJ, Varley GA. *Corneal Diagnostic Techniques*. In: Krachmer JH, Mannis MJ, Holland EJ. *Fundamentals of Cornea and External Disease*. St. Louis: 1992
- [38] Rapuano C, Fishbaugh J, Strike D. Nine point corneal thickness measurements and keratometry readings in normal corneas using ultrasound pachymetry. *Insight: The Journal of the American Society of Ophthalmic Registered Nurses*. December 1993; 18 (4): 16-22 7p.
- [39] Thornton SP, Gardner SK, Waring GO. *Surgical Instruments used in Refractive Keratotomy*. In: *Refractive Keratotomy for myopia and astigmatism*. St. Louis: Mosby; 1992
- [40] Norrby S. Sources of error in intraocular lens power calculation. *J Cataract Refract Surg*. 2008; 34: 368–376
- [41] Hrebцова J., Skorkovska S., Vasku A. comparison of contact and immersion techniques of ultrasound biometry in terms of target postoperative refraction. *Cesk Slov Oftalmol*. 2009; 65: 143–146
- [42] R J., F M. The contact and immersion ultrasound methods compared using the ray tracing method. *Optica Applicata*. 2010; XL: 77–92.
- [43] Hoffmann P. C., Hutz W. W., Eckhardt H. B., Heuring A. H. Intraocular lens calculation and ultrasound biometry: immersion and contact procedures. *Klin Monbl Augenheilkd*. 1998; 213: 161–165
- [44] Olsen T. Calculation of intraocular lens power: a review. *Acta Ophthalmol Scand*. 2007; 85: 472–485
- [45] Packer M., Fine I. H., Hoffman R. S., Coffman P. G., Brown L. K. Immersion A-scan compared with partial coherence interferometry: outcomes analysis. *J Cataract Refract Surg*. 2002; 28: 239–242.
- [46] Hill W., Angeles R., Otani T. Evaluation of a new IOL Master algorithm to measure axial length. *J Cataract Refract Surg*. 2008; 34: 920–924.
- [47] Haigis W., Lege B., Miller N., Schneider B. comparison of immersion ultrasound biometry and partial coherence interferometry for intraocular lens calculation according to Haigis. *Graefes Arch Clin Exp Ophthalmol*. 2000; 238: 765–773.
- [48] Rajan M. S., Keilhorn I., Bell J. A. Partial coherence laser interferometry vs conventional ultrasound biometry in intraocular lens power calculations. *Eye (Lond)* 2002; 16: 552–556
- [49] Gale R. P., Saldana M., Johnston R. L., Zuberbuhler B., McKibbin M. Benchmark standards for refractive outcomes after NHS cataract surgery. *Eye (Lond)* 2009; 23: 149–152.
- [50] Fontes BM, Castro E. Intraocular lens power calculation by measuring axial length with partial optical coherence and ultrasonic biometry. *Arq Bras Oftalmol*; 74: 166–170.
- [51] Mylonas G, Sacu S, Buehl W, Ritter M, Georgopoulos M, Schmidt-Erfurth U. Performance of three biometry devices in patients with different grades of age-related cataract. *Acta Ophthalmol*; 89: e237–41
- [52] Aristodemou P., Knox Cartwright N. E., Sparrow J. M., Johnston R. L. Intraocular lens formula constant optimization and partial coherence interferometry biometry: refractive outcomes in 8108 eyes after cataract surgery. *J Cataract Refract Surg*. 2011; 37: 50–62.
- [53] *Basic and Clinical Science Course, Section 3: American Academy of Ophthalmology 2011-2012*; 211–223.
- [54] Olsen T. Sources of error in intraocular lens power calculation. *J Cataract Refract Surg*. 1992; 18: 125–129
- [55] Haigis W, Lege B, Miller N, et al. comparison of immersion ultrasound biometry and partial coherence interferometry for intraocular lens calculation according to Haigis. *Graefes Arch Clin exp Ophthalmol* 2000; 238: 765-73.
- [56] Kiss B, Findl O, Menapace R, et al. Biometry of cataractous eyes using partial coherence interferometry: clinical feasibility study of a commercial prototype 1. *J Cataract Refract Surg* 2002; 28: 224-9.
- [57] George R, Paul PG, Baskaran M, et al. Ocular biometry in occludable angles and angle closure glaucoma: a population based survey. *Br J Ophthalmol*. 2003; 87 (4): 399-402. doi: 10.1136/bjo.87.4.399.
- [58] Moghimi S, Vahedian Z, Zandvakil N, et al. Role of lens vault in subtypes of angle closure in Iranian subjects. *Eye (Lond)*. 2014; 28 (3): 337-343. doi: 10.1038/eye.2013.296
- [59] Ong AY, Ng SM, Vedula SS, Friedman DS. Lens extraction for chronic angle-closure glaucoma. *Cochrane Database Syst Rev*. 2021 Mar 24; 3 (3): CD005555. doi: 10.1002/14651858. CD005555. pub3. PMID: 33759192; PMCID: PMC8094223.
- [60] Song MK, Sung KR, Shin JW, Jo YH, Won HJ. Glaucomatous Progression After Lens Extraction in Primary Angle Closure Disease Spectrum. *J Glaucoma*. 2020 Aug; 29 (8): 711-717. doi: 10.1097/IJG.0000000000001537. PMID: 32366776.
- [61] Sengupta M, Tayab S, Sarma P, Sangma CA, Paul S, Borgohain M. Early Phacoemulsification After Acute Angle Closure in Patients With Coexisting Cataract. *J Glaucoma*. 2019 Jun; 28 (6): e107-e108. doi: 10.1097/IJG.0000000000001243. PMID: 30882768.
- [62] Römken HCS, Beckers HJM, Schouten JSAG, Nuijts RMMA, Berendschot TTJM, Breusegem CM, Webers CAB. Early Phacoemulsification After Acute Angle Closure in Patients With Coexisting Cataract. *J Glaucoma*. 2018 Aug; 27 (8): 711-716. doi: 10.1097/IJG.0000000000000998. PMID: 30005031.
- [63] Day AC, Cooper D, Burr J, Foster PJ, Friedman DS, Gazzard G, Che-Hamzah J, Aung T, Ramsay CR, Azuara-Blanco A. Clear lens extraction for the management of primary angle closure glaucoma: surgical technique and refractive outcomes in the EAGLE cohort. *Br J Ophthalmol*. 2018 Dec; 102 (12): 1658-1662. doi: 10.1136/bjophthalmol-2017-311447. Epub 2018 Feb 16. PMID: 29453222.

- [64] Traverso CE, Cutolo CA. The Effects of Phacoemulsification and Intraocular Lens Implantation on Anatomical and Functional Parameters in Patients with Primary Angle Closure: A Prospective Study. (An American Ophthalmological Society Thesis). *Trans Am Ophthalmol Soc.* 2017 Nov 9; 115: T7. PMID: 29167629; PMCID: PMC5683799.
- [65] Atalay E, Nongpiur ME, Baskaran M, Perera SA, Wong TT, Quek D, Aung T. Intraocular pressure change after phacoemulsification in angle-closure eyes without medical therapy. *J Cataract Refract Surg.* 2017 Jun; 43 (6): 767-773. doi: 10.1016/j.jcrs.2017.03.031. PMID: 28732610.
- [66] Trikha S, Perera SA, Husain R, Aung T. The role of lens extraction in the current management of primary angle-closure glaucoma. *Curr Opin Ophthalmol.* 2015 Mar; 26 (2): 128-34. doi: 10.1097/ICU.000000000000128. PMID: 25565368.
- [67] Brown RH, Zhong L, Whitman AL, Lynch MG, Kilgo PD, Hovis KL. Reduced intraocular pressure after cataract surgery in patients with narrow angles and chronic angle-closure glaucoma. *J Cataract Refract Surg.* 2014 Oct; 40 (10): 1610-4. doi: 10.1016/j.jcrs.2014.01.038. Epub 2014 Aug 16. PMID: 25134991
- [68] Hayashiet al. (*J Cataract Refract Surg* 2001; 27: 1779-86)
- [69] Lam DS, Leung DY, Tham CC, Li FC, Kwong YY, Chiu TY, Fan DS. Randomized trial of early phacoemulsification versus peripheral iridotomy to prevent intraocular pressure rise after acute primary angle closure. *Ophthalmology.* 2008 Jul; 115 (7): 1134-40. doi: 10.1016/j.ophtha.2007.10.033. Epub 2007 Dec 27. PMID: 18164064.
- [70] Husain R, Gazzard G, Aung T, Chen Y, Padmanabhan V, Oen FT, Seah SK, Hoh ST. Initial management of acute primary angle closure: a randomized trial comparing phacoemulsification with laser peripheral iridotomy. *Ophthalmology.* 2012 Nov; 119 (11): 2274-81. doi: 10.1016/j.ophtha.2012.06.015. Epub 2012 Aug 11. PMID: 22885123.
- [71] Melese E, Peterson JR, Feldman RM, Baker LA, Bell NP, Chuang AZ, Blieden LS. Comparing Laser Peripheral Iridotomy to Cataract Extraction in Narrow Angle Eyes Using Anterior Segment Optical Coherence Tomography. *PLoS One.* 2016 Sep 8; 11 (9): e0162283. doi: 10.1371/journal.pone.0162283. PMID: 27606482; PMCID: PMC5015922.
- [72] Hansapinyo L, Choy BNK, Lai JSM, Tham CC. Phacoemulsification Versus Phacotrabeculectomy in Primary Angle-closure Glaucoma With Cataract: Long-Term Clinical Outcomes. *J Glaucoma.* 2020 Jan; 29 (1): 15-23. doi: 10.1097/IJG.0000000000001397. PMID: 31702714.
- [73] Tham CC, Kwong YY, Leung DY, Lam SW, Li FC, Chiu TY, Chan JC, Lam DS, Lai JS. Phacoemulsification vs phacotrabeculectomy in chronic angle-closure glaucoma with cataract: complications [corrected]. *Arch Ophthalmol.* 2010 Mar; 128 (3): 303-11. doi: 10.1001/archophthalmol.2010.12. Erratum in: *Arch Ophthalmol.* 2010 Sep; 128 (9): 1128. PMID: 20212200. <https://pubmed.ncbi.nlm.nih.gov/20051857/114>Tan AM, Loon SC, Chew PT.