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COMPARISON OF REFRACTIVE CHANGES FOLLOWING PSEUDOPHAKIC VITRECTOMY WITH OR WITHOUT GAS TAMPONADE

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Abstract: To compare refractive changes following 23-gauge (G) vitrectomy with or without gas tamponade in pseudophakic eyes. This retrospective study included patients with neodymium: yttrium-aluminum-garnet (Nd: YAG) laser capsulotomy, who underwent 23 G pars plana vitrectomy (PPV) between February 2015 and March 2019. Indications for surgery included; rhegmatogenous retinal detachment in Group 1 and epiretinal membrane or vitreous hemorrhage (VH) in Group 2. Gas tamponade 12% perflouropropane (C3F8) was used in Group 1 whereas no tamponade was used in Group 2. The minimum follow-up was 24 months for both groups. A total of 47 patients were recruited (Group 1, n=27 and Group 2, n=20). The visual acuity improvement was statistically significant in both groups (p<0.001). A statistically significant myopic shift was observed in both groups [-0.40±0.54 diopter (D) (P=0.001) in Group 1; -0.17±0.29 D (P=0.017) in Group 2]. In addition, a myopic shift greater than 1 D was observed in 2 eyes (7.4%) in Group 1. The significant hyperopic shift was detected in 3 eyes (11.1%) in Group 1 and 5 eyes (25%) in Group 2. Surgically induced astigmatism was similar between groups [0.46±0.25 D in Group 1 and 0.54±0.26 D in Group 2, (P=0.314)]. Postoperative complications included VH (n=1/27) and macular hole (n=1/27) in Group 1. The clinically significant myopic shift may occur following 23 G vitrectomy in pseudophakic eyes. Eyes with gas tamponade are more prone to myopic shift, possibly due to anterior movement of the intraocular lens. Therefore, targeting slight residual hyperopia (+0.50 D) might be suggested in patients with gas tamponade.

Keywords: Pars plana vitrectomy, Myopic shift, Induced astigmatism, Pseudophakic eyes, Gas tamponade

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1. Introduction

Pars plana vitrectomy (PPV) is a commonly employed surgical technique in posterior segment surgery. A traditional vitrectomy, which is typically indicated in retinal detachment (RD) surgery, involves the removal of all of the vitreous gel including the vitreous base. However, in limited vitrectomy, the central, and core vitreous is removed to relieve the stress on the macula (Sebag et al., 2018). On the other hand, surgical treatment of the rhegmatogenous RD typically requires the use of an intraocular tamponade agent. However, vitreoretinal pathologies such as epiretinal membrane, vitreomacular traction syndrome, and vitreous hemorrhage (VH) can usually be treated without the use of any intraocular tamponade.

In the literature, a myopic shift in refraction has been reported in pseudophakic eyes following vitrectomy (Byrne et al., 2008; Hamoudi et al., 2013). Possible explanations for refractive changes following vitrectomy include; changes in the effective lens position, the axial length, or anterior chamber depth (Suzuki et al., 2000; Byrne et al., 2008; Akinci et al., 2008). Our study aimed to compare refractive changes following 23-gauge (G) PPV with or without intraocular gas tamponade in pseudophakic eyes.

2. Material and Methods

2.1 Patient Materials

This was a retrospective, comparative case series including pseudophakic patients who underwent 23 G vitrectomy. Group 1 consisted of patients with pseudophakic rhegmatogenous RD who underwent 23 G vitrectomy and 12% perflouropropane (C3F8) gas tamponade whereas Group 2 consisted of patients with epiretinal membrane or VH who underwent 23 G vitrectomy without any tamponade between February 2015 and March 2019. Refractive data was recorded preoperatively and 12 months after vitrectomy.

2.1.1. Inclusion criteria

Patients who underwent 23 G PPV for macula-on rhegmatogenous RD, epiretinal membrane, or VH. All patients had undergone uncomplicated cataract surgery with in-the-bag acrylic foldable intraocular lens implantation and neodymium: yttrium-aluminum-garnet (Nd: YAG) laser posterior capsulotomy before vitrectomy.

2.1.2. Exclusion criteria

Patients who unable to be measured with autorefraction due to RD with macular involvement or dense vitreous hemorrhage were excluded. Furthermore, patients with a preoperative spherical refractive error > ±6 diopters or cylindrical refractive error > ±3 diopters, keratoconus, and other corneal dystrophies and pseudoexfoliation syndrome, lens dislocation, or any preoperative evidence of zonulopathy were excluded.

2.1.3. Ocular parameters

All patients underwent complete ophthalmic examination including best-corrected visual acuity in the logMAR scale, slit-lamp examination, intraocular pressure assessment, fundus examination, and autokeratorefractometry (auto kerato-refractometer KR-8800 from Topcon, Tokyo, Japan) preoperatively and at postoperative month-12. Surgically induced astigmatism values were calculated through vector analysis (Eğrilmez et al., 2003).

2.1.4. Surgical procedures

All surgeries were performed by the same surgeon (S.Y.). Retrobulbar block anesthesia (a mixture of 2 ml of lidocaine hydrochloride 2% and 2 ml of bupivacaine hydrochloride 0.5%) was used. Three port 23 G transconjunctival vitrectomy was performed using the vitrectomy system DORC (Dutch Ophthalmic Research Center, Zuidland, Netherlands) and Zeiss microscope with EIBOS 2 (Haag Streit, Mason, OH, USA) attachment for non-contact fundus viewing. In group 1, all patients underwent a near-complete vitrectomy including base shaving, laser endo-photocoagulation, and C3F8 gas tamponade. In group 2, patients with epiretinal membrane received a limited vitrectomy including; core vitrectomy, induction of a posterior vitreous detachment if not present and peeling of the epiretinal membrane and inner limiting membrane. The peripheral retina was examined with indentation to identify any retinal breaks. Neither laser endo-photocoagulation, nor gas tamponade and vitreous base shaving were performed. For patients with vitreous hemorrhage patients, a near-complete vitrectomy, including base shaving, laser endo-photocoagulation was performed except for gas tamponade. In both groups, the sclera is sutured with 8-0 polyglactin suture (Vicryl) in case of wound leakage.

2.2. Statistical Analysis

The data normal distribution was evaluated using Shapiro-Wilk test. Numerical variables were compared between the two groups under study by the Independent-Samples t-test and the Student's t-test was used to compare dependent variables in the same group. The association between categorical variables was assessed through the Chi-Square test and Fisher's exact test (Önder, 2018). The P value less than 0.05 was considered statistically significant for all analyses. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 21.0 (IBM, Corp, Armonk, NY).

3. Results

A total of 47 patients were recruited, of whom 27 were included in Group 1 and 20 were in Group 2. No statistically significant difference was detected between groups concerning age, sex, and preoperative ocular features including eye laterality, visual acuity, intraocular pressure, spherical error, cylindrical error, and spherical equivalent.

3.1. Preoperative Data

In Group 1, we detected macula on rhegmatogenous RD in 5 eyes (18.5%) with a three-piece acrylic foldable intraocular lens in 5 eyes (18.5%), and a monoblock foldable intraocular lens in 22 eyes (81.5%). In Group 2, we detected vitreous hemorrhage in 5 eyes (25%), epiretinal membrane in 15 eyes (75%) with a three-piece acrylic foldable intraocular lens in 3 eyes (15%) and monoblock acrylic foldable intraocular lens in 17 eyes (85%). The baseline characteristics and preoperative data of groups are presented in Table 1.

3.2. Postoperative Data

The postoperative visual acuity improvement was statistically significant in both groups ($p<0.001$). A mild increase in intraocular pressure (above 25 mmHg) at day-1 was observed in 4 eyes (14.8%) in Group 1 which was successfully controlled by topical anti-glaucomatous eye drops. In terms of early complication, vitreous hemorrhage was observed in one eye (3.7%) in Group 1 which was treated with vitreous lavage at the postoperative month-2. In terms of late complication, a full-thickness macular hole was observed in one eye (3.7%) in Group 1 and it was treated with inner limiting membrane peeling and gas tamponade at the postoperative month-32.

No early or late postoperative complications were observed in Group 2. Twelve months after the surgery, a significant myopic refractive shift of - 0.40±0.54 diopters (range: + 0.50 to -2.25 diopters) ($P=0.001$) and -0.17±0.29 diopters (range: + 0.25 to - 0.75 diopters) ($P=0.017$) was observed in Group 1 and Group 2 respectively. In Group 1, 21 eyes (77.8%) had a refractive change toward myopia, 3 eyes (11.1%) had no change in refraction and 3 eyes (11.1%) had a refractive change toward hyperopia. In Group 2, 12 eyes (60%) had a refractive change toward myopia, 3 eyes (15%) had no change in refraction and 5 eyes (25%) had a refractive change toward hyperopia. The mean induced astigmatism was 0.46±0.25 diopters (range: 0 to 0.98 diopters) and 0.54±0.26 (range: 0.09 to 0.92 diopters) in Group 1 and 2 respectively ($P=0.314$). No statistically significant change was observed in cylindrical error at month-12 in Group 1 ($P=0.097$) and Group 2 ($P=0.286$) compared with baseline. Postoperative data of groups are presented in Table 2.

Table 1. The baseline characteristics and preoperative data of the two groups

	Group 1	Group 2	P value
Number	27	20	
Eyes, n (%)			
Right	14 (51.9)	8 (40)	0.421[a]
Left	13 (48.1)	12 (60)	
Sex, n (%)			
Female	10 (37)	12 (60)	0.119[a]
Male	17 (63)	8 (40)	
Age (years)			
Mean±SD	63.2±8.22	68.0±9.5	0.072[ab]
IOL type, n (%)			
Monobloc Acrylic Foldable	22 (81.5)	17 (75)	0.593[abc]
Three-Pieces Acrylic Foldable	5 (18.5)	3 (15)	.
BCVA (logMAR)			
Mean±SD	0.88± .51	1.24± .69	0.059[ab]
Spheric error (D)			
Mean±SD	0.11±1.03	0.45±1.15	0.294[ab]
Cylindirical error (D)			
Mean±SD	-1.14± .82	-1.20± .77	0.798[ab]
SE (D)			
Mean±SD	- 0.46±.98	-0.15±1.19	0.335[ab]
Inter-operative period (Phaco-PPV) (months)			
Mean±SD	33.84±18.17	32.15±21.81	0.778[ab]

IOL= intraocular lens, IOP= intraocular pressure, BCVA= best-corrected visual acuity, SE= spherical equivalents, Phaco= phacoemulsification, PPV= pars plana vitrectomy, P-value is the statistical level between Group 1 and Group 2. The P value less than 0.05 was considered significant, logMAR= the logarithm of minimal angle of resolution, SD= Standard deviation, D= dioptry, [a]Chi-Square Test. [ab]Independant-Samples t-test. [abc]Fischer's Exact Test.

Table 2. The postoperative data of the two groups

	Group 1	Group 2	P value
BCVA at month 12 (logMAR)			
Mean±SD	0.24±0.26	0.49±0.30	0.007[a]
Spheric error at month 12 (D)			
Mean±SD	-0.23±0.97	0.33±1.24	0.091[a]
Cylindirical error at month (D)			
Mean±SD	-1.25±0.86	-1.29±0.84	0.882[a]
SE at month (D)			
Mean±SD	-0.87±0.93	-0.32±1.26	0.099[a]
Induced astigmatism at month 12 (D)			
Mean±SD	0.46±0.25	0.54±0.26	0.309[a]
Refractive shift at month 12 (D), n (%)			
Between ≤ 0.50 and >0 .25	2 (7.4)	Ø	
Between ≤ 0.25 and >0	1 (3.7)	5 (25)	
Unchanged	3 (11.1)	3 (15)	
Between <0 and ≥-0.25	7 (25.9)	4 (20)	0.188[ab]
Between <-0.25 and ≥-0.50	8 (29.6)	7 (35)	
Between <-0.50 and ≥-1.0	4 (14.8)	1 (5)	
>-1.0	2 (7.4)	Ø	

IOL= intraocular lens, VH= vitreous hemorrhage, MD= full-thickness macular hole, BCVA= best-corrected visual acuity, SE= spherical equivalents, P-value is the statistical level between Group 1 and Group 2. The P-value less than 0.05 was considered significant, logMAR= the logarithm of minimal angle of resolution, SD= standard deviation, D= dioptry, [a]Independant-Samples t-test. [ab]Chi-Square Test (Test was used with combined subgroups according to miyopic shift.).

4. Discussion

In many countries, cataract surgery has become an elective surgical procedure that patients undergo to become spectacle-free (Alio et al., 2017). Advances in technical equipment, surgical procedures, and lens design have improved outcomes. However, reports declared that a postoperative spherical equivalent of ≤ 1.0 diopters can be achieved in 72%-95% of patients, and a spherical equivalent ≤ 0.5 diopters can be achieved in only 45%-80% of the patients (Hamoudi et al., 2013; Rementeria-Capelo et al., 2020). After cataract surgery, a vitrectomy may be required for rhegmatogenous RD, epiretinal membrane, macular hole, or vitreous hemorrhage (Jahn et al., 2001; Patterson et al., 2001; Qureshi and Steel, 2020). Machamer et al. (1971) first introduced the trans pars plana vitrectomy technique in 1971. Also, 23 G, 25 G, and 27 G instrumentation were introduced with advances in technology since 1971 (Fujii et al., 2002; Eckardt, 2005; Oshima et al., 2010). Many reports have described the development of nuclear cataract and refractive changes following lens-sparing vitrectomy (Ikeda et al., 2014; Okamoto et al., 2014; Muto et al., 2017). Also, some reports have found changes in refraction toward myopia in pseudophakic eyes who underwent 20 G and 23 G vitrectomy for various vitreoretinal pathologies (Suzuki et al., 2000; Akinci et al., 2008). Reports declared a change in postoperative spherical equivalent between - 0.15 diopters and - 0.84 diopters in pseudophakic eyes following 20 G vitrectomy (Campo et al., 1999; Sharma et al., 2005). These studies also included patients with or without tamponade. Furthermore, Nd: YAG laser posterior capsulotomy may also induce significant changes in effective lens position (Oztas et al., 2015; Monteiro et al., 2018). Therefore, we specifically excluded patients who did not receive Nd: YAG laser posterior capsulotomy.

Hamoudi et al. (2013) reported a refractive change of - 0.26 diopters following 23 G vitrectomy without using tamponade for pseudophakic eyes with epiretinal membrane. In this study, we compared the refractive results of 23 G vitrectomy surgery with or without the use of C3F8 gas tamponade in pseudophakic eyes. We found a refractive change of - 0.40 diopters in the gas tamponade group and - 0.17 diopters in the group without tamponade. In both groups, a significant refractive shift toward myopia was observed. Moreover, the myopic shift was more prominent in the tamponade group and we found a shift ≥ -1.0 diopters in four patients in Group 1. Byrne et al. (2008) reported postoperative month-4 refraction following vitrectomy and Hamoudi et al. (2013) reported postoperative refraction between 2-months and 31-months. In the current study refraction at 12-months was included to assess standardized long-term results. On the other hand, one can suggest that neurosensory retinal detachment at the posterior pole can cause a hyperopic shift due to axial shortening of the eyeball. Therefore we have excluded patients with a macula-off retinal detachment to avoid confounding.

Citrik et al. (2009) reported changes in corneal parameters one month following 23 G vitrectomy while a return to preoperative values occurred within 3 months after surgery. Hamoudi et al. (2017) also reported a statistically significant corneal thickening at postoperative month-3, however, these values again returned to baseline levels at 12 months following vitrectomy. We found no significant change in cylindrical error at month-12 compared to baseline. The vitreous body has a slightly higher index of refraction than that of the aqueous. The replacement of the vitreous gel with aqueous following vitrectomy may play a role in the refractive shift toward myopia. However, no refractive changes or a hyperopic shift was also observed in 22.2% of patients in Group 1 and 40% of patients in Group 2. Hyperopic shift following vitrectomy might be related to a more posteriorly positioned intraocular lens due to the loss of vitreous support in some patients. The use of C3F8 gas tamponade resulted in a higher number of patients with the myopic shift in this study. So we hypothesize that the gas tamponade may change with a more anterior intraocular lens position. 11.1% of patients in Group 1 and 15% of patients in Group 2 experienced no change in refraction. Twelve months following the vitrectomy, most of the patients needed to change spectacles. The use of expanding gas tamponade in vitrectomy is a risk factor for intraocular pressure elevation in the early postoperative period (Hasegawa et al., 2014). We found an intraocular pressure (above 25 mmHg) elevation at day-1 in 4 eyes (14.8%) in Group 1 which was successfully treated with topical anti-glaucomatous eye drops. Vitreous hemorrhage which often resolves spontaneously in a few weeks may occur following vitrectomy (Eckardt, 2005; Parolini et al., 2010). We also observed vitreous hemorrhage following vitrectomy in a patient in Group 1 who was taking daily oral antiplatelet agents. The hemorrhage did not clear spontaneously during 2 months of follow-up and required vitreous lavage. Also, we detected MH in one patient in Group 1. The prevalence of MH development following rhegmatogenous retinal detachment repair varies from 0.5% to 2% (Shibata et al., 2012). The MH was closed completely following inner limiting membrane peeling and gas tamponade at month-32. Limitations of our study included a retrospective nature and a limited number of patients. However, to the best of our knowledge, this is the first study comparing refractive results of 23 G vitrectomy with or without perflouropropane gas tamponade.

5. Conclusion

A significant refractive change might occur following vitrectomy in pseudophakic eyes. Eyes with gas tamponade seem to be more prone to myopic shift however, both myopic and hyperopic shift may occur depending on the features of the eye, intraocular lens, and surgery.

Author Contributions

SY; initiated the research idea, developed, organized, analyzed and interpreted the data and wrote the manuscript. AMY; wrote the manuscript. MEA; edited the manuscript. RA; supervised the research.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval/Informed Consent

This study was approved by the ethics committee of the Medicine Faculty of the Uludag University (Approval number: 2020/23; Decision: 1). The study was performed following the aid of the ethical standards down in the 1964 Declaration of Helsinki and its later amendments.

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