• Clinical Research •

Combined treatment of phacoemulsification and single-port limited pars plana vitrectomy in acute angle-closure glaucoma

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Abstract

● AIM: To evaluate the efficacy of combined treatment of phacoemulsification (PE) and micro-incisional single-port transconjunctival limited pars plana vitrectomy (PPV) in acute angle-closure glaucoma (AACG).

● METHODS: A retrospective study included 26 patients who underwent PE diagnosed with AACG. Among them, 16 patients (16 eyes) underwent PE alone, 10 patients (10 eyes) underwent combined limited vitrectomy and PE. Then we compared intraocular pressure (IOP), anterior chamber angle, anterior chamber depth, central corneal thickness and corneal endothelial cell count before and after surgery, and effective PE time during cataract surgery.

● RESULTS: Effective PE time was shorter in the combined surgery group than in the single surgery group (*P*=0.040). There was no statistically significant difference in IOP and best-corrected visual acuity between the two groups postoperatively. At 6mo postoperatively, there was no difference in the anterior chamber angle, anterior chamber depth, and central corneal thickness between two groups, but corneal endothelial cell count was higher in the combined surgery group than in the single surgery group (*P*=0.046). No complication such as vitreoretinal disease, endophthalmitis, bullous keratopathy was noted.

● CONCLUSION: Combined micro-incisional single-port transconjunctival limited PPV and PE are more effective and safer than PE alone because of less operation time and fewer complications for management of AACG.

● KEYWORDS: limited vitrectomy; phacoemulsification; acute angle-closure glaucoma

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INTRODUCTION

Acute angle-closure glaucoma (AACG) is caused by the relative pupillary block or a sudden closure of the anterior chamber angle, which result in a severe intraocular pressure (IOP) rise. Laser iridotomy is a safe and effective nonsurgical treatment to resolve the relative pupillary block and to widen the anterior chamber angle[1]. However, laser iridotomy is not always effective in controlling IOP, and in some cases it often fails to control IOP[2]. One of the causes of this result is that the lens pushes the peripheral iris forward, making the anterior chamber shallower[3]. Old patients with AACG are more likely to be associated with cataracts. In this case, phacoemulsification (PE) may result in the increase of the anterior chamber depth and the decrease of IOP. So, many studies have reported that cataract surgery in patients with AACG can lower IOP[4]. However, cataract surgery in patients with AACG has difficulties due to anatomical problems such as shallow anterior chamber, high IOP, small pupil, corneal edema, and weak zonule[5]. High-vitreous pressure in such eyes can result in capsulorhexis extension, iris prolapse, zonular dialysis or posterior capsular rupture with subsequent vitreous loss and possibly suprachoroidal haemorrhage[6]. Extreme caution is recommended when operating on eyes with shallow anterior chamber. Therefore, cataract surgery in patients with AACG results in prolonged PE ultrasound time and increased corneal endothelial damage[7-8].

If the vitreous pressure is lower before performing cataract surgery, the cataract surgery can be performed much easier and safer. In 2001, Chang[9] performed vitreous aspiration to lower the vitreous pressure using a 20-gauge vitrectomy cutter in PE for management of AACG. However, vitreous aspiration could be a good technique in vitrectomized eye, but could fail to aspirate the vitreous in non-vitrectomized eye. If vitreous was aspirated strongly, the risk of complications such as retinal detachment and vitreous hemorrhage were increased. In addition, vitreous aspiration was required a large sized needle and conjunctival peritomy was necessary to suture the sclerotomy, which may affect the poor outcome of glaucoma surgery in the future[10]. Currently, micro-incisional transconjunctival sutureless pars plana vitrectomy (PPV) is widely used in vitreoretinal surgery due to the development of the instrument. The performance of the PPV with a higher cutting rate and the smaller diameter of vitrectomy cutter has been improved so that the vitreous traction can be effectively reduced and the possibility of making on iatrogenic retinal tear can be reduced. Dada *et al*[11] in 2007 described a single-port-limited PPV without infusion cannula using a 23-gauge vitrectomy probe inserted through a sclerotomy incision 3.5 mm from the limbus in PE for management of phacomorphic glaucoma. Miura *et al*[12] in 2008 introduced a single-port-limited PPV using a 23-gauge vitrectomy cutter before performing PE for management of acute angle closure. In this study, we evaluate the effectiveness of combined limited PPV and PE compared with PE alone in patients with AACG.

SUBJECTS AND METHODS

Ethical Approval The study protocol was approved by the institutional review board (IRB) of the Chosun University Hospital and followed the Declaration of Helsinki. All participants signed an informed consent. And all participants didn't receive a stipend.

Study Design We retrospectively reviewed the medical records of 26 patients who underwent PE to manage AACG from March 2011 to October 2016. Of these, 16 patients (16 eyes) underwent PE alone, and 10 patients (10 eyes) underwent combined pars plana vitrectomy and phacoemulsification (PPV+PE). Secondary glaucoma, such as neovascular glaucoma and uveitic glaucoma, was excluded from the study. Patients with corneal disease and vitreoretinal disease that may affect visual acuity were also excluded.

Surgical Technique In patients with AACG, to lower IOP, we performed laser iridotomy. We performed cataract surgery emergently in AACG patients who have difficulty performing laser iridotomy due to severe corneal edema, and can't lower IOP after laser iridotomy and medication. Surgery was performed by one surgeon (Kim ST) who had been adopting the use of this technique for several years. Retrobulbar local anaesthetic mixture of lidocaine 1% and bupivacaine 0.5% was injected. In combined surgery group, limited PPV was performed prior to the PE to lower posterior vitreous pressure. Patient selection for PE alone or combined surgery is conducted randomly selection without specific criteria. A 25-gauge trocar was inserted at a distance of 3.5 mm from the corneal limbus. A 25-gauge vitrectomy cutter was placed at the center of the eyeball and a limited PPV was performed with 5000 cuts/min and 100 mm Hg vacuum. When the eyeball was softened by digital IOP check, the vitrectomy cutter was removed and then the trocar was removed. If leakage was not seen, suturing was not performed. And, PE was performed. Ultrasound energy and total PE time were recorded to calculate effective phacoemulsification time (EPT). The EPT during cataract surgery recorded the cumulative dissipated energy (CDE) value of Infinity® (Alcon Laboratories Inc.). Intraoperative complications were recorded.

Retrospective Chart Review Preoperative and demographic data were retrieved. Preoperative and postoperative best-corrected visual acuity, IOP, and complications were reviewed. Recorded preoperative and postoperative Snellen best-corrected visual acuity was converted to logarithmic minimal angle of resolution (logMAR) units for statistical analysis. Preoperative axial length had been measured by IOL Master® (Carl Zeiss Meditec, Dublin, CA, USA). Preoperative and postoperative anterior chamber depth, and central corneal thickness had been measured by Visante OCT® (Carl Zeiss Meditec Inc., Dublin, CA, USA). Anterior chamber angle, anterior chamber depth, central corneal thickness and corneal endothelial cell count were measured at 6mo postoperatively. Postoperative corneal endothelial cell counts were measured by non-contact specular microscope (SP-2000P®, Topcon, Tokyo, Japan). It was difficult to measure the preoperative corneal endothelial cell counts due to corneal edema. Intraoperative data such as EPT and intraoperative complications, if any, were collected. Postoperative complications such as corneal edema, hyphema, and posterior capsular rupture were also reviewed.

Statistical Analysis Statistical analysis was performed using SPSS 21.0 for windows (version 17.0 SPSS Inc., Chicago, IL, USA). Means±standard deviations (SD) were used for descriptive data. Statistical evaluation was based on an independent samples *t*-test, Mann-Whitney *U*-test and Pearson's Chi-square test. $P<0.05$ was considered significant.

RESULTS

The mean age of the patients was 68.69±7.46y in the PE single surgery group, and 67.70±9.42y in the PPV+PE combined surgery group ($P=0.769$). The mean preoperative IOP was 52.56±7.14 mm Hg in the PE, 51.40±9.56 mm Hg in the PPV+PE ($P=0.726$), and the best corrected visual acuity (logMAR) was 1.78±0.44 in the PE and 1.67±0.41 in the PPV+PE ($P=0.604$). There was no difference in axial length, anterior chamber depth, and central corneal thickness between the two groups preoperatively ($P=0.725$, 0.339, 0.425 respectively; Table 1). The mean effective PE time was 21.88±6.93s in the PE and 16.20±5.67s in the PPV+PE. PPV+PE was statistically significantly shorter than PE ($P=0.040$; Figure 1). Postoperative IOP was 11.06±2.11, 11.13±1.71, 12.44±1.75, 11.94±2.02, and 12.12±2.23 mm Hg at 1d, 1wk, 1, 3, and 6mo in the PE, 10.80±1.32, 12.01±2.16, 11.70±1.89, 12.40±1.71 and 13.30±1.70 mm Hg at 1d, 1wk, 1, 3, and 6mo in the PPV+PE. The difference in IOP between

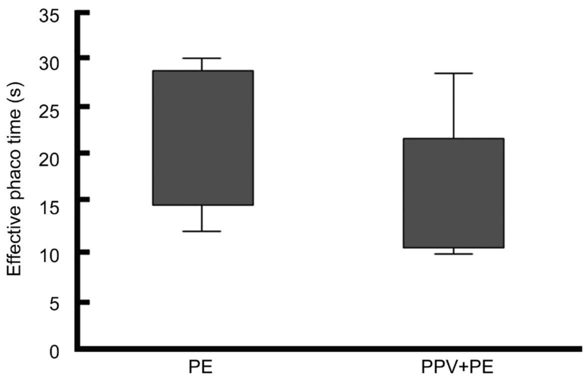

Figure 1 Effective phacoemulsification (PE) time between PE and combined pars plana vitrectomy and phacoemulsification (PPV+PE) Effective PE time was shorter in the PPV+PE than in the PE (P=0.040).

Table 1 Preoperative clinical characteristics mean±SD

Parameters	PE (n=16)	PPV+PE (n=10)	P
Age (y)	68.69±7.46	67.70±9.42	0.769
Sex (M/F)	3/13	1/9	0.566
IOP (mm Hg)	52.56±7.14	51.40±9.56	0.726
BCVA (logMAR)	1.78±0.44	1.67±0.41	0.604
Axial length (mm)	22.16±0.70	22.26±0.73	0.725
ACD (mm)	2.17±0.24	2.07±0.30	0.339
CCT (μm)	611.50±61.71	628.70±31.76	0.425

IOP: Intraocular pressure; BCVA: Best corrected visual acuity; ACD: Anterior chamber depth; CCT: Central corneal thickness; PE: Phacoemulsification; PPV: Pars plana vitrectomy.

the two groups was not statistically significant (P=0.729, P=0.262, P=0.320, P=0.553, P=0.319; Figure 2). There was no case who need anti-glaucoma medication or glaucoma surgery postoperatively. Postoperative best-corrected visual acuity (logMAR) was 0.95±0.45, 0.59±0.35, 0.23±0.12, 0.21±0.13, and 0.23±0.16 at 1d, 1wk, 1, 3, and 6mo in the PE, 0.78±0.32, 0.45±0.29, 0.24±0.15, 0.17±0.16, and 0.19±0.14 at 1d, 1wk, 1, 3 and 6mo in the PPV+PE. The difference in postoperative best-corrected visual acuity between the two groups was not statistically significant (P=0.222, P=0.311, P=0.784, P=0.472, P=0.581; Figure 3). At 6mo postoperatively, the anterior chamber angle, anterior chamber depth, and central corneal thickness were not different statistically between the two groups (P=0.689, P=0.143, P=0.697), but corneal endothelial cell count was higher in the PPV+PE than in the PE statistically (P=0.046; Table 2). There were a few intraoperative complications, 4 cases of iris injury, 2 cases of anterior capsular tear, 2 cases of posterior capsular rupture in the PE, and 1 case of iris injury and 1 case of anterior capsular tear, no case of posterior capsular rupture in the PPV+PE. Postoperative complications were included corneal edema, cyclitic membrane and hyphema in both groups. In addition, complications such as retinal detachment, endophthalmitis, and bullous keratopathy did not occur (Table 3).

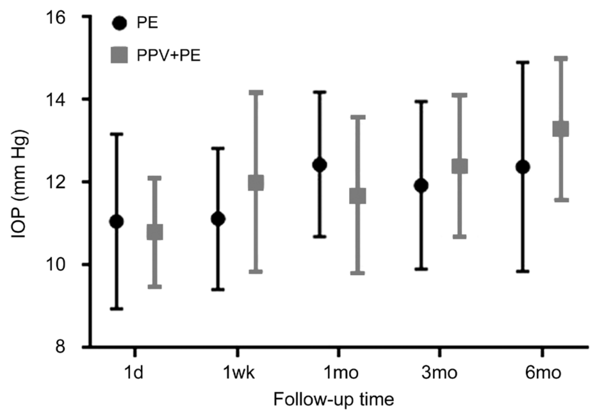

Figure 2 Postoperative intraocular pressure between phacoemulsification (PE) and combined pars plana vitrectomy and phacoemulsification (PPV+PE) There was no significant difference between two groups (by Mann-Whitney U-test).

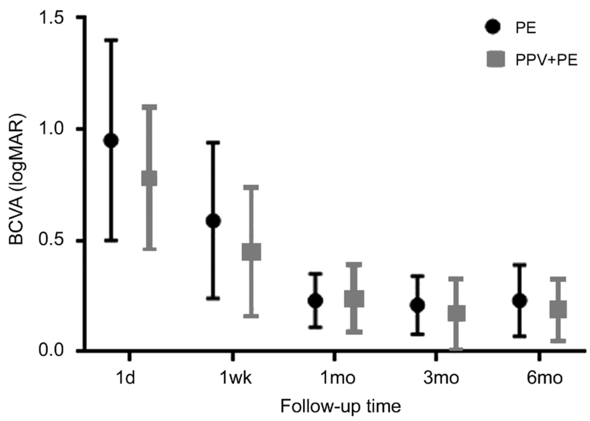

Figure 3 Postoperative best-corrected visual acuity between phacoemulsification (PE) and combined pars plana vitrectomy and phacoemulsification (PPV+PE) There was no significant difference between two groups (by Mann-Whitney U-test).

Table 2 Postoperative clinical characteristics mean±SD

Parameters	PE (n=16)	PPV+PE (n=10)	P
ACA (degree)	18.50±4.41	17.80±4.05	0.689
ACD (mm)	3.08±0.36	3.27±0.41	0.143
CCT (μm)	516.56±16.90	513.60±21.20	0.697
ECC	1912.75±457.72	2317.70±510.29	0.046

ACA: Anterior chamber angle; ACD: Anterior chamber depth; CCT: Corneal central thickness; ECC: Corneal endothelial cell count; PE: Phacoemulsification; PPV: Pars plana vitrectomy.

DISCUSSION

In the treatment of AACG, it is important to restore angle to prevent the peripheral anterior synechia[13]. Laser iridotomy is a treatment of choice for AACG. However, Aung *et al*[14] reported that long-term normal IOP range was maintained only in 41.8% of Asian eyes when laser iridotomy was performed for AACG. The reason why IOP may not well controlled after laser iridotomy is that the iris is thick and dark brown color in Asian. Therefore, when laser iridotomy is performed, there is a high possibility of closing the trabecular meshwork because

Table 3 Complication *n* (%)

Complication	PE (*n*=16)	PPV+PE (*n*=10)
Intraoperative		
Iris prolapse	4 (25)	1 (10)
Capsulorhexis extension	2 (12.5)	1 (10)
PC rupture	2 (12.5)	0
Zonulolysis	1 (6.25)	0
Dropped nuclear fragment	0	0
Postoperative		
Corneal edema	12 (75)	5 (50)
Cyclitic membrane	6 (37.5)	3 (30)
Hyphema	2 (12.5)	1 (10)
Retinal detachment	0	0
Endophthalmitis	0	0
Bullous keratopathy	0	0

PC: Posterior capsule; PE: Phacoemulsification; PPV: Pars plana vitrectomy.

of inflammatory response and dispersion of iris pigment. The second reason is that the lens becomes thicker with aging, which is likely to cause an angle-closure anatomically[15]. For this reason, there has been a report that it is possible to lower IOP by cataract surgery that can remove the factor of phacomorphic characteristic[16]. Jacobi *et al*[17] reported that high IOP was effectively controlled in 75% of patients with AACG by cataract surgery alone. It reported that 1.40±0.71 mm increase of anterior chamber depth, reduction of the IOP from 40.50±7.60 to 17.80±3.40 mm Hg, and 0.52±0.29 improvement of best-corrected visual acuity (logMAR) after cataract surgery. In our study, mean anterior chamber depth increased by 0.91±0.30 mm, mean IOP decreased from 52.56±7.14 to 12.12±2.23 mm Hg, and best-corrected visual acuity improved by 1.55±0.30 after cataract surgery. However, when cataract surgery is performed in patients with AACG, shallow anterior chamber interferes with almost every step, starting from the creation of wound incisions and capsulorhexis until the intraocular lens implantation. Working in a shallow anterior chamber increases the risks of Descemet's membrane detachment, capsulorhexis extension, iris prolapse, and zonular dialysis[18]. In our study, we had intraoperative complications such as capsulorhexis extension, posterior capsular rupture and zonular dialysis.

Corneal endothelial cell loss is a main concern due to the closer distance between PE tip and corneal endothelium. In addition, during performing cataract surgery in AACG, the ultrasound PE time may be long, and the corneal endothelial cell damage increases[19-21]. Severe corneal endothelial damage can result in corneal edema, which can lead to permanent visual loss[22]. The normal corneal endothelial cell density is 2500 cells/mm^2, and corneal edema and corneal decompensation can occur when the corneal endothelial cell density is reduced under 500 cells/mm^2[23]. It is known that corneal endothelial cell density decreases from 0.89% to 1% per year even naturally, and the rate of decrease is about 2% per year after cataract surgery[24]. Factors affecting corneal endothelial cell damage in cataract surgery include patient-related factors such as age and severity of cataract, and operative factors such as surgeon factor, viscoelastic materials, ultrasound emulsification time, and ultrasound emulsification energy[25]. The lower the anterior chamber depth is, the higher damage of the corneal endothelial cell becomes. Igarashi *et al*[26] reported corneal endothelial damage by the surgical instrument, which is related to anterior chamber depth. Lee *et al*[27] reported the corneal endothelial cell density would be less than 1900 cells/mm^2 in patients who underwent PE for the initial treatment of AACG.

Therefore, performing limited PPV to remove small volume of vitreous is considered the only possible way to successfully deepen the anterior chamber. This technique makes it easier to perform cataract surgery and reduce the incidence of complications. In addition, the risk of corneal endothelial cell damage can be reduced. In comparison with that, in our study, corneal endothelial cell density in the single surgery group was 1912 cells/mm^2 at postoperative 6mo, corneal endothelial cell density of the patients in the combined surgery group are more than in single surgery group. Although it may be more reasonable to compare corneal endothelial cell density before and after surgery, but it is difficult to measure preoperative corneal endothelial cell density because of corneal edema in glaucoma attack. Another factor affecting corneal endothelial cell damage during cataract surgery is the total amount of PE ultrasound used. If the effective PE time is shortened during cataract surgery, the amount of ultrasound energy can be reduced to minimize complications such as corneal edema and corneal endothelial cell loss[28]. Baradarb-Rafii *et al*[29] reported that total ultrasound use during cataract surgery was significantly associated with loss of corneal endothelial cell. In our study, effective ultrasound time was shorter in the combined surgery group than in the single surgery group, which means that the combined limited PPV is effective for corneal endothelial cell protection. Thus, limited PPV is an effective method to prevent problems occurring in PE alone for AACG. In addition, recent micro-incisional limited PPV may be performed without a conjunctival peritomy and suture. Therefore, even if glaucoma surgery is necessary in the future, preservation of the conjunctiva does not interfere with the success rate of the glaucoma surgery. The disadvantage of this combined surgery is the possibility of retinal tear or retinal detachment due to traction from PPV. However, micro-incisional PPV, which has been widely used recently, has been decreasing the risk because of the increased cutting rate of vitreous cutter. In case of having taken combined, it is recommended to perform fundus examination until the first month after surgery to avoid retinal tears or retinal detachment. There are some reports on partial PPV combined with cataract surgery without any serious complication for malignant glaucoma[30].

The limitations of this study are the follows. First, the number of patients is low. Second, this study is a retrospective study. Third, there can be a possibility of the selection bias. Fourth, preoperative corneal endothelial cell density could not be measured due to corneal edema. There have been many reports on the effects of laser iridotomy and PE in AACG. However, there has been no analysis on the effect of limited PPV combined with PE.

In this study, we compared the single PE, and the combined limited PPV and PE. As a result, there was no significant difference in visual acuity, IOP, anterior chamber depth, and central corneal thickness before and after surgery, but the difference of corneal endothelial cell density measured at 6mo postoperatively was statistically significant. In conclusion, we confirmed that in patients with AACG, performing the micro-incisional single-port sutureless limited PPV followed by PE is more effective than PE alone because of less surgical complications and less corneal endothelial damage.

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