Clinical Study

Surgical and Functional Results of Hybrid 25-27-Gauge Vitrectomy Combined with Coaxial 2.2 mm Small Incision Cataract Surgery

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1. Introduction

Small incision phacoemulsification and microincision cataract surgery (MICS) involving sub-2 mm clear corneal incisions are safe and effective standard surgical procedures [1–4]. The potential benefits of MICS relate to reduced wound leakage, good anterior chamber stability, and safety, minimizing surgically induced astigmatism, reducing higher-order corneal aberrations and promoting rapid postoperative wound healing [5, 6]. For treating vitreoretinal pathologies, transconjunctival sutureless microincision vitrectomy surgery (MIVS) using small-gauge (23-, 25-, or 27-gauge) instrumentation offers the potential for less inflammation, reduced operating time, and often faster visual rehabilitation after surgery compared with conventional 20-gauge vitrectomy [7–9]. Moreover, 25- and 27-gauge vitrectomy instrument system for MIVS effectively produces self-sealing sclerotomies that may alleviate concerns over wound sealing-related complications in selected vitreoretinal cases [10]. “Hybrid” is used to underline the mixed character of different seized infusion and working ports. Treating cataract and vitreoretinal pathologies in a combined one-step microincision phaco vitrectomy procedure is an efficient well-tolerated technique that is becoming increasingly common [11–14]. Combined phaco vitrectomy eliminates the need for a second operation, allows improved access to the retinal periphery during phacoemulsification, and offers potential for better vitrectomy outcomes [13, 15, 16].

The aim of this present interventional case series study was to retrospectively investigate and review surgical indications, intraoperative and postoperative complications, and visual acuity outcomes in eyes undergoing combined coaxial
2.2 mm small incision cataract surgery with intraocular lens (IOL) implantation and hybrid 25-27-gauge MIVS for the treatment of vitreoretinal disease and concurrent age-related cataract.

2. Materials and Methods

The authors report a single-center, retrospective, consecutive surgical case series that underwent small incision cataract surgery with IOL implantation combined with transconjunctival sutureless hybrid 25-27-gauge vitrectomy. All medical records and surgical charts of 102 patients (116 eyes) who underwent combined small-gauge phacovitrectomy surgery performed at Helios Klinikum Pforzheim, Pforzheim, Germany, between January and December 2014 were reviewed. Cases operated using 23-gauge vitrectomy or microincision coaxial phacoemulsification, where postoperative follow-up was less than 2 months, were excluded. Overall, 55 patients (55 eyes) were identified who had undergone coaxial small incision cataract surgery and IOL implantation combined with hybrid 25-27-gauge MIVS, who were all included in this study.

All patients in this series had preoperative lens opacification, which was graded mild or moderate in 36 of 55 eyes (65.5%). Demographic data and preoperative patient characteristics are presented in Table 1; surgical indication and cataract grade are shown in Table 2. Postoperative follow-up ranged between 2 months and 18 months (mean 6 months; standard deviation [SD] ± 4.05). All patients were examined and assessed between 1 week and 4 weeks following the first postoperative day.

Combined phacovitrectomy procedures were carried out in single-session operations performed by the same surgeon, Fabian Hohn. Surgeries were completed throughout using a single phacovitrectomy console and the EVA ophthalmic surgical system (DORC International, Zuidland, Netherlands), together with a 25-gauge two-dimensional cutting (TDC) vitrectomy probe. The EVA surgical system is designed for use in anterior and posterior segment procedures that require infusion, vitreous cutting, aspiration, illumination, irrigation, lens emulsification and fragmentation, cautery, and diathermy as well as photoacoagulation.

Preoperative data collected included patient demographics, visual acuity, intraocular pressure (IOP) measured in millimeters of mercury (mmHg) by Goldmann applanation tonometry, and diagnostic indication for combined phacovitrectomy surgery. Intraoperative data collected included suture placement if required, corneal incision and sclerotomy wound stability, and other complications observed during surgery. Postoperative visual acuity, IOP, degree of ocular inflammation, and IOL-related complications were analyzed.

2.1. Surgical Methods and Techniques. Following consultation and informed consent, patients underwent combined phacovitrectomy surgery under general anesthesia. Coaxial small incision cataract surgery was performed through a 2.2 mm corneal incision. A 27-gauge valved trocar (DORC) was preplaced in the inferior temporal quadrant 4 mm from the limbus, then a 2.2 mm clear corneal incision for cataract surgery was made at the 10-o’clock position, using a 2.2 mm ophthalmic phaco knife (MANI, Tochigi, Japan). For the side instrument, a 1.2 mm limbal incision was made at the 2-o’clock position left of the main incision using the same phaco knife. Following creation of clear corneal incision, viscoelastic material was injected into the anterior chamber.

5 mm continuous curvilinear capsulorhexis was performed with microcapsulorhexis forceps suitable for 2.2 mm incision. After hydrodissection and rotation, a stop-and-chop phacoemulsification technique was utilized for nucleus removal. The cortex was removed and the capsular bag was filled with viscoelastic material. A hydrophilic, acrylic monofocal aspheric IOL, TECNIS iTec (Abbott Medical Optics AMO, Illinois, USA), was placed in the capsular bag by docking onto the inner lip of the main clear corneal incision. The corneal wound was hydrated with balanced salt solution following removal of viscoelastic material. The valve of the preplaced trocar was removed by surgical forceps, and the high-flow infusion line of the EVA surgical system was then connected. The eye was pressurized, allowing for controlled placement of two 25-gauge vitrectomy trocars in the superior quadrants 3.5 mm from the limbus. A 27-gauge twin light chandelier was placed at 11 and 1 o’clock position (Figure 1).

Vitreous surgery was performed using a 25-gauge TDC vitreous cutter controlled using the EVA vacuum vitrectomy unit. The vacuum level was placed at maximum 600 mmHg, and the vitreous cutter rate set at 8,000 cuts per minute.

Table 1: Demographic data and preoperative clinical features.

| Variable | Data |
|----------|------|
| Number of patients (eyes) | 55 (55) |
| Gender (male : female) | 23 : 32 |
| Age (mean ± SD) | 70.0 ± 10.33 years |
| Laterality (OD : OS) | 26 : 29 |
| Preoperative logMAR BCVA (mean ± SD) | 0.52 ± 0.6 |

SD, standard deviation; OD, right eye; OS, left eye; logMAR, logarithm of the minimum angle of resolution; BCVA, best-corrected visual acuity.

Table 2: Vitreoretinal indication and cataract grade.

| Variable | Patients, n (%) |
|----------|----------------|
| Diagnosis |                 |
| Rheumatogenous retinal detachment | 2 (3.6) |
| Epiretinal membrane | 26 (47.3) |
| Macular hole stage 4 | 11 (20) |
| Vitreous hemorrhage | 3 (5.5) |
| Vitremacular traction | 6 (10.9) |
| Proliferative diabetic retinopathy | 5 (9.1) |
| Subretinal hemorrhage | 2 (3.6) |
| Cataract grade |                 |
| Mild nuclear sclerosis ± cortical spoking | 22 (40) |
| Moderate | 14 (25.5) |
| Dense brunescent | 12 (21.9) |
| Dense posterior subcapsular | 3 (5.5) |
| Degree and type of cataract not recorded | 4 (7.3) |
postoperative follow-up was 6 months (range: 2–18 months).

Gauge vitrectomy surgery. The average patient age was 70

phacoemulsification, IOL implantation, and hybrid 25-27-

of 55 patients (55 eyes) underwent combined small incision

3. Results

3.1. Study Population and Baseline Characteristics. A total

of 55 patients (55 eyes) underwent combined small incision

phacoemulsification, IOL implantation, and hybrid 25-27-

gauge vitrectomy surgery. The average patient age was 70

years, with 23 male and 32 female subjects. The mean

postoperative follow-up was 6 months (range: 2–18 months).

The most common indication for vitrectomy surgery

was epiretinal membrane (26 eyes, 47.3%), followed by

macular hole stage 4 (11 eyes, 20%), vitreomacular traction

(6 eyes, 10.9%), and proliferative diabetic retinopathy (5

eyes, 9.1%). Internal tamponade was performed with 20% sulfur hexafluoride (SF6) or air; the decision and selection

regarding tamponade procedure were based on assessment of

preoperative and intraoperative clinical characteristics.

3.2. Primary Intraoperative and Postoperative Outcome Mea-

sures. Intraoperative and postoperative findings are shown in Table 3. None of the eyes in the case series required a

corneal suture to seal the corneal tunnel, no sclerotomy

sutures were needed, and all cases were completed without

conversion to larger-gauge vitrectomy (23- or 20-gauge). A

retinal break occurred in 3 eyes (5.5%). None of these 3 eyes

had an iatrogenic retinal break, and the break was classified as a preexisting retinal break. All breaks were successfully

managed with endolaser treatment using a curved 25-gauge

dioloscope probe (DORC).

The preoperative IOP (mean ± SD) was 15.2 ± 2.84 mmHg,

and the postoperative IOP was 14.29 ± 6.96 mmHg. There

were no cases of postoperative hypotony (IOP < 7 mmHg).

One eye (1.8%) experienced elevated IOP greater than

30 mmHg on Day 1 after surgery, requiring topical hypoten-
sive medications, and normalized IOP was achieved at the

next examination.

Fibrin reaction in the anterior chamber was observed in

3 eyes (5.5%) the day after surgery, which was resolved

following topical steroid treatment. During follow-up, there

were no cases of IOL decentration or capture, while PCO

developed in 7 eyes (12.7%). There were no cases of postoper-

ative endophthalmitis or choroidal detachment.

3.3. Secondary Outcome Measures. The preoperative logMAR

visual acuity (mean ± SD) in the current case series was 0.52 ±

0.6. At the final follow-up visit, logMAR visual acuity (mean

± SD) was 0.22 ± 0.46, which was a statistically significant

improvement (P < 0.0001) from baseline, and represents

| Variable                          | Patients, n (%) |
|-----------------------------------|-----------------|
| Intraoperative findings           |                 |
| Retinal break                     | 3 (5.5)         |
| Posterior capsule tear            | 0 (0)           |
| Corneal suture                    | 0 (0)           |
| Scleral suture                    | 0 (0)           |
| Conversion to larger-gauge vitrectomy | 0 (0)     |
| Postoperative findings            |                 |
| Fibrin in the anterior chamber    | 3 (5.5)         |
| Hypotony (<7 mmHg)                | 0 (0)           |
| Elevated intraocular pressure (>30 mmHg) | 1 (1.8) |
| Retinal or choroidal detachment   | 0 (0)           |
| Endophthalmitis                   | 0 (0)           |
| Posterior capsule opacification   | 7 (12.7)        |
| Intrachoroidal lens capture or decentration | 0 (0) |

The preoperative logMAR visual acuity (mean ± SD) in the current case series was 0.52 ± 0.6. At the final follow-up visit, logMAR visual acuity (mean ± SD) was 0.22 ± 0.46, which was a statistically significant improvement (P < 0.0001) from baseline, and represents

![Figure 1: Hybrid 25-27-gauge vitrectomy setting following coaxial 2.2 mm small incision cataract surgery.](image)
an average improvement in visual acuity of 0.30 logMAR. Overall, at last postoperative follow-up visit, visual acuity had improved in 49 eyes (89.1%), was unchanged in 3 eyes (5.5%), and worsened in 3 eyes (5.5%). Monitored visual loss occurred as a result of progressive diabetic macular edema in one case and a conversion into exsudative age-related macular degeneration in two patients.

4. Discussion

In a series of 85 eyes, Canan et al. [17] found that phaco-vitreectomy using combined 20-gauge vitrectomy and 2.8 mm phacoemulsification with a standard phaco-chop technique was safe and effective for proliferative diabetic retinopathy. Developments in small incision cataract surgery together with enhancements in smaller-gauge vitrectomy instrumentation systems provide additional opportunities for securing effective and safe outcomes in combined phaco-vitreectomy for complex vitreoretinal diseases with simultaneous cataract [8, 14, 18–20]. Phaco-vitreectomy with either conventional 20-gauge vitrectomy or MIVS reduces surgical trauma for patients with vitreoretinal disease and cataract, while high-speed small-gauge vitrectomy cutters improve vitrectomy surgery by generating less vitreous traction and more efficient vitreous removal [21]. Moreover, studies confirm that phaco-vitreectomy improves visualization during the vitrectomy procedure in cases where there is a clinically significant lens opacity and speeds visual rehabilitation after surgery [22, 23].

The present clinical study was designed specifically to evaluate the potential intraoperative and postoperative complications and visual results of a hybrid 25-27-gauge microincisional sutureless vitrectomy in combination with coaxial small incision cataract surgery, and the primary and secondary outcomes have been reported above.

None of the 55 eyes in our case series required suture of the corneal wound or sclerotomy site at the end of the surgery, and there were no serious complications related to corneal wound leakage. A similar retrospective study which evaluated combined 1.8 mm microincision cataract surgery and 23-gauge vitrectomy found corneal suturing was required in 6 of 50 eyes (12%), with a sclerotomy suture in 4 eyes (8%) [15]. One possible explanation for the incidence of suturing could be the pressure force created during the insertion of a 23-gauge trocar instrument. For our case series, 25- and 27-gauge trocars that were used require less insertion force than larger-sized trocars because they have a smaller diameter. Another contributing factor explaining suturing procedures could be related to preplacement of the infusion trocar prior to creating a 2.2 mm tunnel incision. A series of 60 patients treated with combined 23-gauge phaco-vitreectomy found that vitrectomy ports were self-sealing in all eyes except 4 (6.7%) [24]. From another case series, Jalil et al. [16] reported that 4 of 43 cases (9.3%) required suturing of one or more ports during 23-gauge phaco-vitreectomy. The fact that in our series no eyes required scleral suturing suggests that in 95% of cases, sclerotomies immediately self-seal following trocar removal, leading to faster visual rehabilitation and minimal ocular inflammation [24].

Intraoperative complications commonly associated with pars plana vitrectomy (PPV) procedures are iatrogenic retinal breaks, lens touch, and iatrogenic retinal tears [25]. There were 3 cases (5.5%) of intraoperative retinal break observed in our case series, although none of these eyes developed retinal detachment postoperatively. Higher incidences of retinal break during vitrectomy have been reported in the literature. Analysis of 2,471 primary PPV operations between 2001 and 2010 found that intraoperative iatrogenic retinal breaks developed in 10.09% of eyes overall, with an incidence of 32.45% in eyes with tractional retinal detachment and 16.3% of eyes with macular hole [26]. Risk factors include phakia and absence of a preoperative PVD [26, 27]. Intraoperative iatrogenic peripheral retinal breaks occurred in 15.2% (98 of 645 eyes) of cases involving 20-gauge PPV, approximately 4 in 10 breaks related to traction at sclerotomy entry site, in a large interventional case series study by Ramkisson et al. [28]. Induction of PVD during vitrectomy is associated with a significantly higher incidence of retinal breaks [29, 30]. The frequency of retinal breaks related to the PPV operation was 6.9% in patients with epiretinal membrane and 14.6% in patients with macular hole, in a retrospective, comparative study by Chung et al. [29]. An intraoperative retinal break in 9 of 50 eyes (18%) undergoing MICS and 23-gauge vitrectomy for posterior segment disease was reported by Czajka et al. [15]. Prospective study data show that entry site retinal breaks are uncommon in patients undergoing small-gauge (23-, 25-gauge) vitrectomy, while a 2-year observational study involving a large series undergoing 20-gauge or 23-gauge vitrectomy found a significantly lower incidence of anterior iatrogenic retinal breaks in patients treated with the smaller-gauge surgery (7.8% versus 16.7% for 20-gauge vitrectomy) [31, 32].

No case of capsule tear was observed during phaco-vitrectomy surgery. Treumer et al. [33] reported posterior capsule tears in 7 of 111 eyes (6.3%) treated with combined PPV, phacoemulsification, and IOL implantation compared with 4 of 50 eyes (8%) in eyes that underwent sequential PPV and cataract surgery. An evaluation of 114 eyes undergoing combined 23-gauge phaco-vitrectomy between January 2006 and March 2009 found that capsular tears were more frequent in eyes with a prior history of radiation or vitrectomy [14]. Similar to the study presented here, a case series of 52 eyes that underwent combined MICS and PPV, mostly 23-gauge, reported posterior capsule rupture in 2 patients (3.8%) [16].

There were no occurrences of postoperative hypotony in the present study. In a smaller series of 30 eyes, Moon et al. [34] found a low risk of postoperative hypotony following combined 23-gauge sutureless vitrectomy and clear corneal phacoemulsification for rhegmatogenous retinal detachment repair. Only one eye (0.7%) experienced severe postoperative hypotony (<6 mmHg) despite the absence of suturing of sclerotomy sites, in an interventional cases series of 108 patients (136 eyes) with proliferative diabetic retinopathy who underwent combined 23-gauge phaco-vitrectomy [35]. A study evaluating 23-gauge phaco-vitrectomy using microincision phacoemulsification reported that hypotony (IOP < 9 mmHg) occurred in 18% (9/50) of eyes [15]. Oshima et al. [10] found that all sclerotomies were self-sealed without
hypotony (IOP ≤ 7 mmHg) from Day 1 postoperatively in
an experimental study evaluating a new 27-gauge instrument
system for transconjunctival MIVS. No eyes in our series
developed choroidal detachment postoperatively.

It was decided not to administer antibiotics to the anterior
chamber at the end of the phacovitrectomy case; Delyfer et al. [36] reported that intracameral injection of high doses of
cefuroxime at the end of uneventful cataract surgery induced
anterior and posterior inflammation, with extensive macular
edema associated with a large serous retinal detachment.
There is nonetheless evidence of benefit that may justify the
use of intracameral cefuroxime to reduce the rate of acute
endophthalmitis after cataract surgery [37, 38].

Formation of posterior synchia of the iris is a postop-
erative complication of combined phacoemulsification and
PPV. Oh et al. [39] identified postoperative synchia in 6.1%
of 263 eyes treated with 23-gauge phacovitrectomy, which
is a relatively low incidence when compared with other
studies, with reported frequencies as high as 30% observed
after phacovitrectomy in patients with proliferative diabetic
retinopathy [40]. In our case series, 3 patients (5.5%) were
identified with postoperative anterior chamber fibrin depo-
sition, a known risk factor of posterior synchia, although
no patient developed postoperative iris synchia in the present
case series.

With regard to other postoperative anterior segment
complications, the rate of posterior capsule opacification over
the follow-up period was 12.7% (7 eyes), which is at the
lower end of the range reported from similar investigations.
Posterior capsule opacification is a common postoperative
anterior segment complication associated with combined
phacoemulsification, with incidence rates of up to 51% reported
in the literature [41]. Wensheng et al. [42] observed a PCO
rate of 21.5% in 186 eyes of 149 patients who underwent
combined phacoemulsification and vitrectomy for coexist-
ing cataract and vitreoretinal diseases. Studies indicate a
lower PCO rate in eyes undergoing transconjunctival 23-
gauge phacovitrectomy compared with eyes treated using 20-
gauge phacovitrectomy [43, 44]. Contributing factors for the
development of PCO are increased surgical manipulation
and inflammation, rhegmatogenous retinal detachment, gas
tamponade, intraoperative/postoperative complications, and
postoperative posturing [44]. Minimal fluid-air exchange
during combined small-gauge phacoemulsification may be ben-
eficial in reducing the possibility of postoperative hypotony
and IOL-related complications [45].

There were no cases of intraocular lens capture or
decentration following combined phacovitrectomy surgery.
A case series evaluation of sub-2 mm MICS combined with
23- or 20-gauge vitrectomy using an IOL with a 4-point
fixation design similarly reported no cases of IOL decentra-
tion [16]. Compared with 25-gauge phacovitrectomy, more
frequent IOL decentration has been observed with 20-gauge
vitrectomy combined with phacofragmentation [46]. Better
centration has been recorded with a 4-point haptic design
IOL compared with an intraocular lens incorporating a 2-
point haptic design [47]. In a comparative study, Leiderman et
al. [48] revealed that single-piece acrylic IOLs are associated
with a low rate of surgical complications after combined
phacovitrectomy.

Visual results that were recorded in our study popula-
tion are generally consistent with published outcomes from
other clinical studies, demonstrating that good functional
outcomes are achievable with combined hybrid MIVS and
phacoemulsification using 2.2 mm microincision corneal
wounds. Combining phacoemulsification, IOL implantation
and vitrectomy offer clearer visualization during surgery
compared with sequential procedures, and often time
decreases visual rehabilitation time in cases with early or
visually significant cataracts [22, 49]. Good success rates
have been reported, with 95% of patients achieving a 2-line
or greater improvement in visual acuity within 6 weeks of
combined phacovitrectomy surgery in one institution in the
United States [23].

To summarize, surgical and visual outcomes demonstrate
that a single-session approach is safe, feasible, and effective
for the treatment of vitreoretinal pathology and coexisting
cataract, with minimal incremental surgical risk. Additional
clinical studies evaluating multicenter practice outcomes
utilizing combined phacovitrectomy will help guide practi-
tioners as they transition toward more efficient minimally
invasive combination approaches for a variety of vitreoretinal
pathologies with and without visually significant cataract.

Conflict of Interests

Mitrofanis Pavlidis is a consultant to DORC International and
declares a proprietary financial interest. None of the other
authors have any conflict of interests to disclose.

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