



Comparison of Phaco Energy and Complications for Conventional Phacoemulsification and 25-gauge Phacovitrectomy Surgery

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Authors' contributions

This work was carried out in collaboration between all authors. Author AGKA designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MC managed the literature searches and author CI carried out statistical evaluation studies. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To compare cumulative dissipated energy (CED), intraoperative and postoperative complications in eyes underwent conventional phacoemulsification and 25-Gauge phacovitrectomy surgery.

Study Design: Retrospective, comparative case series in ophthalmology clinic of Ulucanlar Eye Education and Research Hospital.

Methodology: A total of 140 eyes underwent conventional phacoemulsification and 25-Gauge phacovitrectomy surgeries were evaluated. CDE intraoperative, early and late postoperative surgical outcomes were compared.

Results: No one had any intraoperative complication in either group. But the mean CDE was statistically significantly higher in combine group (15.07 ± 8.04) than that in phaco group (11.60 ± 7.98). Even these difference postoperative clinical outcomes were not statistically significant in each group.

Conclusion: The single session combined phacovitrectomy surgery is safe and effective technique in cases that presents with both cataract and retinal disease.

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1. INTRODUCTION

Combined phacoemulsification and vitreoretinal surgery offers several advantages including adequate visualization of the posterior segment which is mainly essential for macular surgery, adequate access to the vitreous base in eyes with retinal detachment, avoiding the need for another surgery, more rapid visual recovery after one surgery [1-5].

In the recent years with the help of advancement in technology, phacovitrectomy surgery can be performed by small scleral incision such as 23-25-Gauge even smaller and sutureless [4-7]. The development of new technologies in combine phacovitrectomy procedure provides achieving the best possible visual outcome with optimal safety and minimum invasiveness. In addition, the aim of new techniques is reducing phacoemulsification energy while increasing efficiency. Emulsification of the nucleus with the minimal phaco power is desirable. Because the increased power intensity which is the source of heat can result in anterior segment tissue damage such as excessive endothelial cell loose, wound burn and iris trauma [8-11].

Different phaco machines using different measurements to assess the energy delivered during phacoemulsification such as total phaco time, phaco power, effective phacotime, and phaco percentage. Cumulative dissipated energy (CDE) is a created to monitor of total energy delivered during phacoemulsification, which was used to show the efficiency of the procedures [11-13].

We designed a study to compare the CDE, intraoperative complications and postoperative clinical performances between eyes underwent torsional phacoemulsification and combined torsional phaco and 25-Gauge vitrectomy surgeries during a single session.

2. MATERIALS AND METHODS

In this study 140 eyes of 140 patients underwent cataract extraction and combined phacovitrectomy surgeries were evaluated. The presenting study was a retrospective study and was in accordance with the Declaration of Helsinki. After informing the patients about the nature of the surgery, provided written informed

consent was obtained before operation from each of them.

All patients underwent a complete ophthalmic examination including visual acuity and IOP measurement, anterior segment evaluation with biomicroscopy, posterior segment examinations by +90 D lens on biomicroscopy. Patient with only cataract and cataract combined with retinal disease were included. Two groups were defined according to presence of retinal and/or macular disease. The indications for vitrectomy were vitreous hemorrhage, proliferative diabetic retinopathy, both fractional and rhegmatogenous retinal detachment, epiretinal membrane and macular hole. Eyes with previous trauma, presence of corneal diseases that affect anterior segment visualization, lens subluxation, inflammation, had undergone intra-ocular surgery and uncontrolled glaucoma was not included in this study.

Cataract hardness was classified based on Lens Opacities Classification System III (LOCS III) following a slit lamp examination under full mydriasis. The LOCS III grading score was assigned a numeric scale which reflects the degree of nuclear opacity (NO) and nuclear color (NC). To prevent inter-observer bias, only one ophthalmologist (AGKA) classified each eyes in current study.

Each combined surgery performed with posterior subtenon anesthesia while phacoemulsification's performed under the sub conjunctiva anesthesia. None of them had retro bulbar or general anesthesia. Surgical approach consisted of scleral incisions by insertion of 25-Gauge trocar (Alcon 23G, Alcon Laboratories Inc.) in the infero-temporal, supero-temporal and supero-nasal quadrants. Each 23G trocars were inserted in an oblique single step fashion with sliding the conjunctiva 3.0 mm from the limbus. The infusion cannula was inserted into the infero-temporal quadrant and superior incisions were used for surgical manipulations. Following the implantation of each trocar, 2.8 mm self-sealing clear corneal incision was made on the on superior part of cornea while two side port incisions were made by MRV blades. All surgeries were performed by the same experienced surgeon (AGKA). Phacoemulsifications were performed with torsional ultrasonography (US) mode in all cases

with the same divide and conquer technique by same phacovitrectomy devices (Constellation Alcon Laboratories Inc.). The same energy and fluid settings were used to compare the intraoperative performance in each group. After nuclear extraction by phacoemulsification whole cortex materials were removed, anterior chamber were filled with viscoelastic substance Viscoat (sodium hyaluronate 3.0%, chondroitin sulfate 4.0%) was used to reform and stabilize the anterior chamber and protect the corneal endothelium and vitreoretinal surgeries were performed before the IOL implantation. Anterior chamber refilled by same viscoelastic substance when decreasing of anterior chamber during the vitreoretinal surgery. Three types of tamponading agents were used in the study: C3F6 gas, SF6 gas, and silicone oil. The type of tamponade was chosen according to retinal disease which did not influence the initially performed phacosurgeries parameter. IOL implantations were performed following the compilation of vitreoretinal surgery and the tamponade agent infusion. A single-piece foldable IOL was implanted in each patient. After removing of viscoelastic substance from anterior chamber and from behind the IOL at the end of the surgery for endophthalmitis prophylaxis, antibiotic was injected into the anterior chamber. Corneal wound closures by stromal hydration with a balanced salt solution (BSS) were done after than withdrawal of the scleral cannulas were performed. Gentle pressing with cotton tip applicator was applied on the each scleral tunnel incision site without extra intervention. To enhance sealing of conjunctiva-scleral incision, displaced conjunctiva was returned to its original position. Each patient evaluated all patients used topical prednisolone acetate 1.0% and moxifloxacin 0.5% 6 times daily for 2 weeks. Each patient evaluated at week 1, months 1 and month 3 by the same observer (AGKA). Patients in combine phacovitrectomy group continue visiting the retina clinic for their retinal pathology.

The surgical parameter that we compared in this study; Cumulative Dissipated Energy which is total U/S energy in foot pedal position 3, could be calculated manually by the following formula as: (phaco time × average phaco power) + (torsional time × 0.4 × average torsional amplitude). The factor 0.4 represents an approximate reduction of heat dissipated as compared to conventional phaco [14].

The intraoperative parameters total ultrasound (US) time, torsional time were automatically

calculated by phaco machine and the results of cumulative dissipated energy (CDE) displayed on device monitor. Therefore we preferred the record automatically calculated CDE values for comparative evaluation. CDE values of each group compared.

Each patient examined by biomicroscopy postoperatively and evaluated parameters were corneal clearance, anterior chamber inflammation, IOL decentralization, IOP spike or hypotony and any unexpected postoperative outcomes. The main outcome measure in this study was the CDE difference according to surgery type. Secondary outcomes were the both intraoperative and postoperative complication related to surgical manipulation in combine phacovitrectomy and phaco surgery.

Statistical analyses of data were performed using with the Statistical Package for the Social Sciences software (v 16.0; SPSS Inc., Chicago, IL, USA). Significance was taken at P value ≤ 0.05 . Kolmogorov-Smirnov/Shapiro-Wilks test used to assess normality of variables. The evaluating variable (CDE) values were not normally distributed in each group. Therefore descriptive statistics were expressed as median, minimum-maximum, for non-normally distributed variable. The CDE was compared between two groups by Mann-Whitney U test.

3. RESULTS

The study was performed on 140 eyes of 140 patients, including 112 patients (80%) underwent only phacoemulsification and 28 patients had combine phacovitrectomy surgery (20%). The number of patient who underwent combine surgery was significantly less than the other group. The mean age was 67.46 years (range of 47 to 78) in combine group and 66.58 years (range of 49 to 86) in the Phaco group. The difference was not statistically significant. Fourteen patients were male and 14 (50%) patients were female in combine surgery group while 64 (57.14%) patients were male and 48 (42.85%) patients were female in phacoemulsification group. The demographic data of patients are given in Table 1. The statistically significant differences in percentage of age and sex distribution were not observed between groups.

Soft cataracts with only posterior capsule opacification observed in one eye in combine phaco vitrectomy group and in two eyes in phaco

group. The CDE values of these patients were 0 in each eye. Rest of the patients had Grade 2-Grade 4 nuclear hardness. The number of patient in combine group was not sufficient to evaluate each nuclear hardness subgroup. Therefore we compared the CDE different in different surgical manipulations rather without considering of nuclear hardness.

The mean CDE was 12.29±8.08 (0.01-44.72) in whole group and it was 11.60±7.8 (0.01-44.72) in eyes underwent only phacosurgery while the mean CDE was 15.07±8.04 (0.01-29.72) in combine phacovitrectomy group. The mean CDE was statistically significantly higher in phacovitrectomy group comparing to phacoemulsification group.

Disruption posterior capsule integrity during the procedure was not observed in any eyes. IOL centration was defined as equally distanced IOL optic edges from the edge of the capsulorhexis both intraoperatively and postoperative follow up. The IOL was centered in the capsular bag in all cases during the follow-up period except one patient with silicon oil tamponade who had ocular trauma and needed IOL reposition one week after surgery and remain stable after this intervention. No patient suffered intraoperative complications such as, iris trauma, pupillary rupture, descemet's membrane detachment or postoperatively complications, such as synechiae, fibrin formation, and endophthalmitis. Corneal edema due to BSS injection for corneal wound closure was disappeared and spontaneous corneal clearance was observed in each eye at 1st week visit. No one had any other corneal changes both preoperative and postoperative period observed by biomicroscopic examination. No one needed retrobulbar anesthesia or general anesthesia because of pain or excessive irritation during the surgery.

In combine surgery group sutures were used to close sclerotomy side only in patient had

received silicon oil tamponade. In this group even most of patient had undergone transconjunctival sutureless vitrectomy, no one had leakage from the scleral incision sides so post-operative hypotonia or choroid detachment did not observed.

4. DISCUSSION

Cataract surgery in a vitrectomized eye has risks of potential complications such as posterior capsule rupture and nucleus drop, because absence of vitreous support which causes instability of both the zonules and posterior capsule. Adherent posterior subcapsular plaques may develop due to intravitreal silicon tamponade that needs to extra intraoperative manipulation such as excessive polishing or posterior capsular capsulectomy. Perfect visualization is essential for vitrectomy surgery mainly in macular surgery such as epiretinal membrane peeling, macular hole surgery and treatment in retinal detachment with peripheral holes. Combine phaco vitrectomy surgery in single session has ideal option for eyes with retinal disease and inadequate visualization due to lens opasification [3-5, 9,15-17].

The development of new techniques in both cataract and vitreoretinal surgery have focused on reducing incision sizes not only on cornea but also on the sclera such as 25-gauge or smaller, increasing efficiency while decreasing phacoemulsification energy. Because, ultrasound (US) energy delivering during phacoemulsification can carry the risk of tissue damage and endothelial cell loss, especially in prolong surgical intervention. The power intensity is a source of heat and generation of free radicals which can result in localized high pressure and temperature elevation accompanying with tissue damage. Therefore, application of the as minimal phaco power as necessary for emulsification of the nucleus is desirable [12,18,19].

Table 1. Demographic data of the patients in three groups

		Conventional phacoemulsification group n=112	25-gauge phacovitrectomy group n=28	p value
Age	Mean	66.58±7.81	67.46 ±8.11	0.55.
	Range	49-86	47-78	
Gender	Female	64	14	0.41.
	Male	48	14	

In torsional system phaco tip moves at 32 kHz which means resonant frequency is 80% of that in standard conventional longitudinal phaco of 40–45 kHz. Theoretically torsional system reduces efficiency in phacosurgery. But the phaco tip moves only forward and backward in the conventional US mode while torsional mode technology produces side to side rotary oscillations of the phaco tip and shear material from the lens with both directions of tip movement even with slower needle movement than conventional US. By this technology the torsional phacoemulsification provided a lower level of US time and energy, and more effective emulsification than the conventional methods [12,18]. Therefore we prefer to perform all surgeries by torsional phaco mode.

CDE is an important parameter that shows the efficiency of the emulsification procedures which is specifically designed for monitor the energy delivered during phacoemulsification in Alcon Infiniti® Vision System (Alcon Labs, Hünenberg, Switzerland) CDE changes according to different factors such as phaco mode, phaco technique, hand-piece designs, cataract density etc. Many authors suggested a better efficiency and less CDE with the torsional mode rather than the conventional mode [18]. Similarly, Liu et al. [20] reported that mean UST and CDE were significantly lower in the torsional group than in the conventional US group for each nucleus density grade. While Kim et al. [18] stated that the CDE (2.40 ± 0.64) in the torsional group was significantly lower than that in conventional group (5.30 ± 1.65) in eyes with moderate cataract but they did not observe significant difference between the two groups in treating hard cataracts.

CDE was also related the **phaco tip** configuration and its angle. Demircan et al. [10] found that CDE were significantly lower in the 45 degree balanced **tip** group (4.04 ± 3.42) than in the 45 degree Kelman **tip** group (6.38 ± 5.26) each of them for all type of nuclear density. Tjia et al. also concluded that the balanced phaco tips, which were specifically designed for torsional US, have a significant increased emulsification effect and a greatly reduced shaft action comparing to Kelman mini-tips. We preferred to perform all surgeries by balanced tip similarly other authors.

According to Park et al. [11] intraoperative measurements significantly less CDE expose with the phaco-chop technique than with the

divide-and-conquer and stop-and-chop techniques in the grade 4 cataract density group. But Davison et al. [21] stated that phaco-chop technique needs more mechanical energy to break nucleus and requires a longer period of nuclear fragments manipulation than divide-and-conquer technique. The longer the manipulation in the anterior chamber causes the higher the tissue disruption. That's why we performed each operation by divide-and-conquer technique. The different phaco technique why we preferred may cause the higher CED of our patient comparing to other reports.

We could not find any study that compare the CDE in eyes underwent combine phacovitrectomy surgery with 25-gauge and phacosurgery performed with combine phacovitrectomy device, Constellation Alcon which is identical to Infiniti for vitreoretinal surgery. Therefore we could not compare our results with any other study. We evaluated all type of cataract similar to Demircan et.al [10] in each group. Our result presented a significantly lower CDE in phaco group comparing to combine phacovitrectomy group. Insufficient retinal visualization due to retinal pathologies such as vitreous hemorrhage and retinal detachment may cause longer emulsification time and energy. Based on our observations even these two procedures performed in different part of the ocular segment the more complicated eyes had higher CED.

Less CDE translates to less energy used during in phacoemulsification that is considered less trauma in anterior chamber, corneal endothelial loss and better for cornea recovery. Fakhry et al. [12] reported that higher CDE found to be associated with a significant corneal endothelial cells (CEC) loss. But they also reported that CDE is even a meaningful intraoperative parameter, it did not significant reflect postoperative damage regarding the corneal endothelium loss. Because according to their study CEC loss also highly correlated with aspiration time and BSS volume.

Fakhry and El Shazly [12] reported that increase in CCT was significantly less in the torsional group comparing to conventional mode during the early postoperative period, but no difference observed at 1 month, Kim et al. [18] performed a phacoemulsification in moderate and hard cataracts and observe in similar results. According to different studies corneal thickness returned nearly to baseline, 1 month after

surgery, while endothelial loss persisted, CCT compensated by the remaining endothelial cells. Even we did not measure CCT and performed the endothelial cell count we did not observe corneal edema even earlier period of at 1 week visit, and no wound changes were occurred at any time of follow-up period in each group.

Timing of IOL implantation is still controversial in combine phacovitrectomy surgery. Some surgeons preferred to implant IOL before the vitreoretinal surgery while others performed it after the posterior segment surgery. To enhance the peripheral retinal evaluation and prevention of image distortion secondary optic edge shifting effect, we prefer to performed IOL implantations following the compilation of vitreoretinal surgery.

As far as we know current study is the first study that compares the CDE used in combine phaco and 25-Gauge vitreoetinal surgery and phacoemulsification surgery operated by same surgeon.

LOCS III is routinely used subjective system in most clinics to quantify cataract density. This system has some limitations because its assessment is based on a slit-lamp evaluation by ophthalmologists, therefore the final value influenced by the training level of the evaluator [22-23]. To prevent inter observer bias each eyes evaluated by the same experienced observer. But current study is still some limitation that, CDE did not evaluate according nuclear density level because combine surgery group had a small sample size. Further studies are necessary to evaluate CDE in each cataract density and in different retinal pathology in combine phacovitrectomy surgery.

5. CONCLUSION

In conclusion, combine phacovitrectomy surgery needed more emulsification energy in term of CDE but our findings have meaningful clinical relevance which revealed that one stage combine phacovitrectomy is as efficient and safe as phaco surgery in eyes with combine cataract and retinal disease.

ETHICAL APPROVAL

The presenting study was a retrospective study and was in accordance with the Declaration of Helsinki. The protection of privacy and other human rights were declared to each patient. After

informing the patients about the nature of the surgery, provided written informed consent was obtained before operation from each of them.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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