

**COMPARISON OF PHACO ENERGY AND COMPLICATIONS FOR
CONVENTIONAL PHACOEMULSIFICATION AND 25-GAUGE
PHACOVITRECTOMY SURGERY**

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.

Key words: cumulative dissipated energy, 25-Gauge vitrectomy, phaco energy, phacovitrectomy surgery.

24 **Introduction**

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

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

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

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

46

47 **Material and Methods**

48 In this study 140 eyes of 140 patients underwent cataract extraction and combined
49 phacovitrectomy surgeries were evaluated. The presenting study was a retrospective study
50 and was in accordance with the Declaration of Helsinki. After informing the patients about the
51 nature of the surgery, provided written informed consent was obtained before operation from
52 each of them.

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

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

67 Each combined surgery performed with posterior subtenon anesthesia while
68 phacoemulsification's performed under the sub conjunctiva anesthesia. None of them had
69 retro bulbar or general anesthesia. Surgical approach consisted of scleral incisions by
70 insertion of 25-Gauge trocar (Alcon 23G, Alcon Laboratories Inc.) in the infero-temporal,
71 supero-temporal and supero-nasal quadrants. Each 23G trocars were inserted in an oblique

72 single step fashion with sliding the conjunctiva 3.0 mm from the limbus. The infusion
73 cannula was inserted into the infero-temporal quadrant and superior incisions were used for
74 surgical manipulations. Following the implantation of each trocar, 2.8 mm self-sealing clear
75 corneal incision was made on the on superior part of cornea while two side port incisions
76 were made by MRV blades. All surgeries were performed by the same experienced surgeon
77 (AGKA). Phacoemulsifications were performed with torsional ultrasonography (US) mode in
78 all cases with the same divide and conquer technique by same phacovitrectomy devices
79 (Constellation Alcon Laboratories Inc.). The same energy and fluid settings were used to
80 compare the intraoperative performance in each group. After nuclear extraction by
81 phacoemulsification whole cortex materials were removed, anterior chamber were filled with
82 viscoelastic substance Viscoat (sodium hyaluronate 3.0%, chondroitin sulfate 4.0%) was used
83 to reform and stabilize the anterior chamber and protect the corneal endothelium and
84 vitreoretinal surgeries were performed before the IOL implantation. Anterior chamber refilled
85 by same viscoelastic substance when decreasing of anterior chamber during the vitreoretinal
86 surgery. Three types of tamponading agents were used in the study: C3F6 gas, SF6 gas, and
87 silicone oil. The type of tamponade was chosen according to retinal disease which did not
88 influence the initially performed phacosurgeries parameter. IOL implantations were
89 performed following the compilation of vitreoretinal surgery and the tamponade agent
90 infusion. A single-piece foldable IOL was implanted in each patient. After removing of
91 viscoelastic substance from anterior chamber and from behind the IOL at the end of the
92 surgery for endophthalmitis prophylaxis, antibiotic was injected into the anterior chamber.
93 Corneal wound closures by stromal hydration with a balanced salt solution (BSS) were done
94 after than withdrawal of the scleral cannulas were performed. Gentle pressing with cotton tip
95 applicator was applied on the each scleral tunnel incision site without extra intervention. To
96 enhance sealing of conjunctiva-scleral incision, displaced conjunctiva was returned to its

97 original position. Each patient evaluated all patients used topical prednisolone acetate 1.0%
98 and moxifloxacin 0.5% 6 times daily for 2 weeks. Each patient evaluated at week 1, months 1
99 and month 3 by the same observer (AGKA). Patients in combine phacovitrectomy group
100 continue visiting the retina clinic for their retinal pathology.

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

106 The intraoperative parameters total ultrasound (US) time, torsional time were
107 automatically calculated by phaco machine and the results of cumulative dissipated energy
108 (CDE) displayed on device monitor. Therefore we preferred the record automatically
109 calculated CDE values for comparative evaluation. CDE values of each group compared.

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

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

121 normally distributed variable. The CDE was compared between two groups by Mann-
122 Whitney U test.

123

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 distrubution were not observed between groups.

Soft cataracts with only posterior capsule opasification observed in one eye in combine phaco vitrectomy group and in two eyes in phaco group. The CDE values of these patient were 0 in each eye. Rest of the patients had Grade 2- Grade 4 nuclear hardnes. The number of patient in combine group was not sufficient to evaluate each nuclear hardnes subgroup. Therefore we compared the CDE different in different surgical manipulations rather without considering of nuclear hardnes.

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 or postoperative period observed by biomicroscopic examination. No one needed retrobulbar anaesthesia or general anaesthesia 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.

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 tamponate 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 opacification [3-5, 9, 15-17].

173 The development of new techniques in both cataract and vitreoretinal surgery have
174 focused on reducing incision sizes not only on cornea but also on the sclera such as 25-gauge
175 or smaller, increasing efficiency while decreasing phacoemulsification energy. Because,
176 ultrasound (US) energy delivering during phacoemulsification can carry the risk of tissue
177 damage and endothelial cell loss, especially in prolong surgical intervention. The power
178 intensity is a source of heat and generation of free radicals which can result in localized high
179 pressure and temperature elevation accompanying with tissue damage. Therefore, application
180 of the as minimal phaco power as necessary for emulsification of the nucleus is desirable [12,
181 18,19].

182 In torsional system phaco tip moves at 32 kHz which means resonant frequency is
183 80% of that in standard conventional longitudinal phaco of 40–45 kHz. Theoretically
184 torsional system reduces efficiency in phacosurgery. But the phaco tip moves only forward
185 and backward in the conventional US mode while torsional mode technology produces side
186 to side rotary oscillations of the phaco tip and shear material from the lens with both
187 directions of tip movement even with slower needle movement than conventional US. By this
188 technology the torsional phacoemulsification provided a lower level of US time and energy,
189 and more effective emulsification than the conventional methods [12,18]. Therefore we
190 prefer to perform all surgeries by torsional phacomode.

191 CDE is an important parameter that shows the efficiency of the emulsification
192 procedures which is specifically designed for monitor the energy delivered during
193 phacoemulsification in Alcon Infiniti® Vision System (Alcon Labs, Hünenberg, Switzerland)
194 CDE changes according to different factors such as phaco mode, phaco technique, handpiece
195 designs, cataract density etc. Many authors suggested a better efficiency and less CDE with
196 the torsional mode rather than the conventional mode [18]. Similarly, Liu et al [20] reported
197 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 cause 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. That means CDE is not the single determining factor for tissue damage in term of CEC).

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 vitreoretinal 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.

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.

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335 **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	

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