

Comparison of two popular nuclear disassembly techniques for cataract surgeons in training: divide and conquer versus stop and chop

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Abstract

Purpose To compare two common phacoemulsification techniques in the learning curve phase, and their effect on ultrasound energy dissipation.

Methods One hundred and ten consecutive patients scheduled for cataract surgery with the same surgeon in training were prospectively enrolled. Study was divided in two parts. In the first one, 60 patients were stratified for cataract grade [nuclear opalescence (NO) grade 2–4] and divided in two groups receiving surgery with the divide-and-conquer technique (Group-1) and with the stop-and-chop technique (Group-2). In the second part, 50 patients were stratified according to cataract grade (NO2–6), and the surgeon had to choose one of the two techniques according to personal preference. The primary outcome was the cumulative dissipated energy (CDE).

Results Significant differences of CDE were observed between the NO3 and NO4 cataracts in

Group-1. In Group-2, this difference was not significant, suggesting that with more advanced cataracts, the stop-and-chop technique allows less ultrasound use. In the second part of the study, the stop and chop was most frequently used for more advanced cataracts. When considering harder cataracts (NO5–NO6), patients receiving surgery with the divide-and-conquer technique had higher CDE values compared to stop and chop.

Conclusions Both divide-and-conquer and stop-and-chop techniques are efficient in the learning curve. Stop and chop dissipates less energy in harder nuclei. Once surgeons reach sufficient experience with both techniques, they should switch to a stop-and-chop technique, allowing lower levels of ultrasound energy.

Keywords Cataract surgery · Phacoemulsification · Stop and chop · Divide and conquer · Surgical training, cumulative dissipated energy

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Introduction

Modern cataract surgery has improved significantly with the reduction in incision size and ultrasound energy, and an increased efficiency of phacoemulsification [1]. Advances in phacoemulsification surgical techniques have allowed reduced energy utilization. The phaco-chop technique was developed to utilize lower ultrasound energy compared to the stop-and-

chop technique in dense cataracts; nonetheless, reports indicate that the resulting endothelial loss is similar with both techniques [2]. A recent study by Park et al. [3] indicated that intraoperative phacoemulsification parameters, such as ultrasound time, are decreased when using a phaco-chop technique compared to both the divide-and-conquer and stop-and-chop techniques. The study highlights that differences are statistically and clinically significant in the case of more advanced cataracts. Furthermore, the study confirms that the phaco-chop technique can decrease postoperative corneal endothelial cell loss compared with the stop-and-chop and divide-and-conquer techniques in hard cataracts.

Lens disassembly and removal is a critical step in the cataract surgery teaching process, and one of the hardest to learn [4]. Although several studies tackled various aspects of cataract surgery training, there is a paucity of studies comparing different lens disassembly and removal techniques in this delicate stage of surgical career. At the best of our knowledge, the study by Gross and colleagues [5] is the only one in the current literature to compare two different phacoemulsification techniques, specifically divide-and-conquer and a pop-and-chop (a supracapsular chopping technique). Divide-and-conquer and, with less extent, stop-and-chop are the most common techniques used to train the novice surgeon, and other techniques follow by far [6]. However, we are not aware of any study in the current literature directly comparing these two popular approaches in the learning curve.

In this study, we aimed to compare two different techniques (i.e., divide-and-conquer and stop-and-chop) performed by a novice surgeon. In addition, we explored the preferences of the surgeon in training in a “real-life” scenario.

Materials and methods

Patients

This prospective study was conducted in a single surgical center (Desio Hospital, Monza e Brianza, Italy) from September 2016 to July 2017. Consecutive patients were enrolled in the study. The institutional board requested informed consent to be obtained from all patients; guidelines of the Declaration of Helsinki were followed. Exclusion criteria were patient’s

characteristics predictive of increased complexity (e.g., pseudoexfoliation, axial length below 22 or above 26.5 mm, poor mydriasis, lack of patient’s cooperation, uveitis), age < 18, and inability to release the informed consent.

Phaco-machine settings

Phacoemulsification was performed with the Centurion Vision System with Intrepid Balanced Mini-tip (Alcon Laboratories, Inc., Fort Worth, TX, USA), and ultrasound settings were personalized for each of the two techniques used. The following sculpt settings were used for both techniques: intraocular pressure of 55 mmHg, vacuum of 60 mm Hg, flow rate of 23 cc/min, and torsional ultrasound of 80%. For the divide-and-conquer technique, quadrant removal was performed with the following parameters: intraocular pressure of 60 mm Hg, vacuum range between 300 and 575 mmHg, flow rate of 30 cc/min, and torsional ultrasound of 80%. For the stop-and-chop technique, chopping was performed using the following parameters: intraocular pressure of 60 mmHg, vacuum of 500 mmHg, flow rate of 30 cc/min, and torsional ultrasound of 80%.

Surgical technique

Cases were performed by a single surgeon (K.A.K.) with a previous experience of 60 phacoemulsification operations. Cases were performed on either local or topical + intracameral anesthesia. A corneal paracentesis with a 30° straight knife was made, and anterior chamber was filled with a dispersive viscoelastic (Viscoat). A temporal clear corneal incision was made with a 2.2-mm beveled blade. A 5–5.5 mm capsulorhexis was made with Utrata forceps, and hydrodissection was accomplished with balanced salt solution ejected from a Kellan cannula. In the divide-and-conquer technique, the surgeon sculpted four trenches to crack the nucleus bimanually into four segments. The four quadrants were emulsified and removed in the pupillary plane. In the stop-and-chop technique, the phacoemulsification probe was used to create a central groove of approximately 90% of the nuclear thickness. After groove formation, the chopper was inserted into the depth of the crater and a horizontal movement was used to crack the nucleus in half. The phacoemulsification tip was impaled in one

heminucleus, and the chopper was used to create 2 smaller fragments, which were emulsified and aspirated. The process was repeated for the second heminucleus. Subsequent steps were identical for both techniques. After cortical material removal with a coaxial aspiration/irrigation system, the anterior chamber and the capsular bag were filled with a cohesive viscoelastic (Provisc), and the intraocular lens (Tecnis iTEC) was injected in the bag. Viscoelastic material was removed with the coaxial aspiration/irrigation system, corneal incisions were sealed with hydrosutures, and cefuroxime 1 mg/0.1 ml was injected in the anterior chamber. After checking for leakage and elevated intraocular pressure, the drape was removed and patient was instilled a drop of 0.1% dexamethasone/0.3% netilmicin (Netildex).

Study design

In the first part of the study, 60 patients were stratified for cataract grade and divided in two groups receiving surgery with the divide-and-conquer technique (Group 1) and with the stop-and-chop technique (Group 2). Every other subject was allocated to each group (alternating allocation). In the second part of the study, 50 patients were selected and stratified according to cataract grade. In this second group, the surgeon had the choice of using one of the two techniques according to personal preference and judgment based on the specific case. Essentially, the first part of the study had the objective to compare the two techniques in standard cases, while the second part of the study simulated a “real-life” situation, where the surgeon may modify surgical technique based on cataract grade and intraoperative conditions.

Study outcomes and statistical analysis

The primary study outcome was the cumulative dissipated energy (CDE, measured in percent-seconds), which is the total ultrasound energy released at the incision site in pedal position 3. In the case of longitudinal ultrasound, CDE values are obtained as average ultrasound power \times total ultrasound time (data on file, Alcon Laboratories, 2015). For the torsional ultrasound, the CDE formula is modified using a coefficient of 0.4 (torsional amplitude \times torsional time \times coefficient of 0.4). The coefficient of 0.4 is utilized since torsional phacoemulsification

differs from longitudinal phacoemulsification in two main ways: Frequency of the phacoemulsification tip in torsional mode (32 kHz) is 80% of that in longitudinal phacoemulsification (40 kHz), and the stroke length of the tip in torsional mode (40 μ m) is halved compared to longitudinal mode (80 μ m) (data on file, Alcon Laboratories, 2015). The cataract grade was classified preoperatively by grading nuclear opalescence using the Lens Opacities Classification System III [7]. Secondary outcomes included: best spectacle corrected visual acuity (BSCVA) and complications rate. BSCVA prior to phacoemulsification, 1 day after, and 30 days after surgery was recorded in Snellen fractions and converted to LogMAR for statistical analysis. Intraoperative and postoperative complications were recorded. Mann–Whitney test and Kruskal–Wallis test were used to compare values between two or more groups, respectively. *P* values < 0.05 were considered significant. Statistical analysis was performed with SPSS version 20.0 (SPSS Inc., Chicago, Illinois, USA).

Results

In the first part of the study, 30 patients received surgery with the divide-and-conquer technique (Group 1) and 30 patients with the stop-and-chop technique (Group 2). Each group was composed of different stages of cataract (NO2, NO3, and NO4).

There were no differences in age, preoperative BSCVA, cumulative dissipated energy, and BSCVA measured at 1 day and 1-month postoperatively (Table 1). When each group was analyzed separately, based on cataract grade, significant differences of CDE were observed between the NO3 and NO4 cataracts in Group 1. In Group 2, however, this difference was not significant, indicating that with harder nuclei, the stop-and-chop technique allows the surgeon to use less ultrasound. The higher values of CDE did not impact on BSCVA values (Table 2).

In the second part of the study, 50 consecutive cases were analyzed. Different subgroups were identified, based on cataract grade. In this cohort of patients, the cataract grade ranged from NO2 to NO6. The surgeon used one of the two techniques according to personal preference and judgment based on the specific case. As shown in Tables 3 and 4, the stop and chop was often preferred for harder cataracts. Eyes with harder

Table 1 Patient demographics, preoperative and postoperative measurements (study part 1)

	M:F ratio	Age	Pre-Op BSCVA	CDE	BSCVA 1 day post-op	BSCVA 1 month post-op
Total	1:1	67.65 ± 6.10	0.37 ± 0.14	7.21 ± 1.58	0.16 ± 0.06	0.01 ± 0.02
Group 1 (divide + conquer)	1:1	67.17 ± 6.10	0.35 ± 0.14	7.39 ± 1.1	0.15 ± 0.06	0.01 ± 0.02
Group 2 (stop + chop)	1:1	68.13 ± 6.16	0.38 ± 0.14	7.03 ± 1.45	0.16 ± 0.07	0.01 ± 0.02
<i>P</i> value		0.35	0.36	0.37	0.40	0.77

BSCVA best spectacle corrected visual acuity, *pre-Op* preoperative, *post-op* postoperative, CDE cumulative dissipated energy

Table 2 Preoperative and postoperative measurements when stratified by cataract grade (study part 1)

	Cataract NO grade	Number of patients	Pre-Op BSCVA	CDE	BSCVA 1 day post-op	BSCVA 1 month post-op
Group 1 (divide + conquer)	2	10	0.23 ± 0.06	5.48 ± 0.33	0.10 ± 0.02	0.01 ± 0.02
	3	10	0.34 ± 0.10	7.44 ± 0.84	0.20 ± 0.05	0.01 ± 0.02
	4	10	0.48 ± 0.11	9.24 ± 0.88	0.20 ± 0.05	0.01 ± 0.1
	<i>P</i> values		2–3 0.04 3–4 0.02 2–4 <i>P</i> < 0.001	2–3 0.04 3–4 0.03 2–4 <i>P</i> < 0.001	2–3 0.02 3–4 0.14 2–4 0.03	0.49
Group 2 (stop + chop)	2	10	0.27 ± 0.06	5.20 ± 0.27	0.12 ± 0.05	0.02 ± 0.02
	3	10	0.36 ± 0.07	7.45 ± 0.55	0.15 ± 0.05	0.01 ± 0.02
	4	10	0.52 ± 0.15	8.45 ± 0.46	0.21 ± 0.06	0.01 ± 0.02
	<i>P</i> values		2–3 0.04 3–4 0.03 2–4 0.01	2–3 0.02 3–4 0.22 2–4 < 0.001	2–3 0.04 3–4 0.13 2–4 0.01	0.35

NO nuclear opalescence, BSCVA best spectacle corrected visual acuity, *pre-Op* preoperative, *post-op* postoperative, CDE cumulative dissipated energy

Significant *P* values highlighted in bold

Table 3 Patient demographics, preoperative and postoperative measurements (study part 2)

	Number	M:F ratio	Age	Pre-Op BSCVA	CDE	BSCVA 1 day post-op	BSCVA 1 month post-op
Total	50	1:1.38	69.18 ± 7.35	0.76 ± 0.35	8.50 ± 2.57	0.27 ± 0.22	0.02 ± 0.02
Divide + conquer	17	1.8:1	66.82 ± 7.28	0.54 ± 0.36	7.72 ± 3.63	0.24 ± 0.24	0.01 ± 0.02
Stop + chop	33	1:2.3	70.39 ± 7.19	0.87 ± 0.29	8.89 ± 1.73	0.28 ± 0.21	0.02 ± 0.02
<i>P</i> value			0.90	0.002	0.015	0.053	0.490

BSCVA best spectacle corrected visual acuity, *pre-Op* preoperative, *post-op* postoperative, CDE cumulative dissipated energy

Significant *P* values highlighted in bold

cataract grades, as expected, were characterized by significantly reduced preoperative BSCVA and

significantly higher mean CDE. When considering the most advanced cataracts NO5 and NO6, patients

Table 4 Patient demographics, preoperative and postoperative measurements (study part 2)

Cataract grade	Divide + conquer				Stop + chop			
	Number	CDE	BSCVA 1 day	BSCVA 1 month	Number	CDE	BSCVA 1 day	BSCVA 1 month
2	7	5.13 ± 0.42	0.13 ± 0.03	0.01 ± 0.02	3	5.07 ± 0.32	0.17 ± 0.12	0.00 ± 0.00
3	5	6.88 ± 1.08	0.19 ± 0.04	0.01 ± 0.02	5	7.74 ± 1.24	0.19 ± 0.08	0.02 ± 0.03
4	2	8.5 ± 1.13	0.17 ± 0.18	0.00 ± 0.00	8	8.65 ± 0.90	0.25 ± 0.10	0.02 ± 0.02
5	2	13.9 ± 1.98	0.61 ± 0.55	0.02 ± 0.03	8	9.86 ± 0.69	0.21 ± 0.07	0.02 ± 0.02
6	1	16.2	0.70	0.05	9	10.17 ± 0.96	0.46 ± 0.33	0.02 ± 0.02

BSCVA best spectacle corrected visual acuity, CDE cumulative dissipated energy

who received surgery with the divide-and-conquer technique had higher CDE values compared to stop and chop. Statistical analysis was not performed because of the low sample size.

In the first part of the study, no intraoperative complications occurred. In the postoperative follow-up period, no anomalies other than transient faint corneal edema were found. In the second stage of the study, posterior capsule rupture occurred in one case during phacoemulsification. The patient had a NO2 cataract and received surgery with the stop-and-chop technique. Anterior vitrectomy was performed with no consequences, a three-piece IOL was implanted with the haptics in the sulcus, and the optic was captured in the bag. The patient did not show any postoperative complication.

Discussion

Cataract surgery learning is one of the most taught as well as important tasks in the career of young ophthalmologists. Numerous studies have focused on phacoemulsification surgical training pathways [8–11], and outcomes of resident surgeons [12–15]. These studies revealed that nuclear disassembly is one of the most difficult surgical steps to master. In most teaching scenarios, the 4 quadrant divide-and-conquer technique is used as a first approach [6]. A previous study by Gross et al. [5] demonstrated that other methods, such as the pop and chop, may lead to similar results with increased efficiency in terms of time and dissipated energy. According to a recent survey, the stop-and-chop technique is the second most common technique to teach phacoemulsification used [6].

Chopping strategies are more efficient than divide and conquer in the hands of expert surgeons, but it remains unclear whether such benefits are present also in the learning curve. In the first part of our study, we compared ultrasound parameters and visual outcomes of the two techniques most commonly used by cataract surgeons in training: the divide-and-conquer and stop-and-chop techniques. Average CDE and visual outcomes were comparable between the two groups. When patients were stratified according to cataract grade, in Group 1, there was a significant difference in CDE when comparing NO3 and NO4 cataracts. In Group 2, CDE was comparable for NO3 and NO4 cataracts, indicating that for harder cataracts, the stop-and-chop technique allows the surgeon to use less ultrasound energy. Even though final visual outcomes were similar between the two techniques, the stop-and-chop technique allowed the surgeon to utilize less ultrasound energy for harder cataracts, indicating that surgeons should aim at gradually moving forward to chop techniques during their learning curve.

The second part of the study simulated a “real-life” scenario, where the surgeon operated patients with different cataract grades, and utilized one of the two techniques according to personal preference and judgment based on the specific case. In this cohort of patients, the cataract grade ranged from NO2 to NO6 (maximum nucleus hardness). The final results indicate a shifting trend toward the utilization of the stop-and-chop technique for harder cataracts.

Both techniques had an excellent safety profile. The most common complication, transient faint corneal edema, was spontaneously resolved during the follow-up. In one case, we experienced a posterior capsule rupture with vitreous loss requiring anterior

vitrectomy and placement of the IOL in the sulcus. The complication occurred using the stop-and-chop technique. Although this was a single event, divide-and-conquer technique might be a better choice for softer cataracts, at least for the surgeons in training.

The present study has several limitations. All the data derive from the experience of a single surgeon in training and could not be generalizable in every setting. The follow-up period is short and does not provide any information about late complications. Since an alternating (and not a randomized) method was used to allocate patients in the first part of the study, the reader must be aware of possible selection biases.

Overall, the role of this study is to indicate a pathway for the development of an efficient and safe surgical technique for phacoemulsification. Both divide-and-conquer and stop-and-chop are efficacious and safe for the novice surgeon. When the surgeon has reached sufficient experience with the divide-and-conquer and the stop-and-chop techniques, the objective should be to switch to a stop-and-chop technique, allowing lower levels of ultrasound energy, especially for harder cataracts. The ultimate goal should be the transition from a stop-and-chop technique to a direct chop technique, which will occur in the later stages of surgical development and training, allowing even lower levels of ultrasound utilization.

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