European Journal of Ophthalmology / Vol. 17 no. 3, 2007 / pp. 315-319

Comparison of divide and conquer and phaco-chop techniques during fluid-based phacoemulsification

A. TSORBATZOGLOU, L. MÓDIS, K. KERTÉSZ, G. NÉMETH, A. BERTA

Department of Ophthalmology, Medical and Health Science Center, University of Debrecen, Debrecen - Hungary

PURPOSE. *To determine whether, similar to ultrasound phacoemulsification, applied energy and surgery time decrease using phaco-chop nucleus fragmentation method compared to divide and conquer technique using the fluid-based system.*

METHODS. *This prospective, comparative, randomized clinical study included patients with cataract who were randomly assigned to use either standard divide and conquer technique (25 eyes of 25 patients, Group 1) or Nagahara phaco-chop maneuver (25 eyes of 25 patients, Group 2) during fluid-based phacoemulsification. Surgical parameters were recorded and patients were examined 1 day, 10 days, and 1 month after surgery. Statistical analyses were performed using the paired test of Wilcoxon.*

RESULTS. *Fluid-based time, mean fluid-based magnitude, effective fluid-based time, and the number of pulses were significantly less using phaco-chop technique compared to divide and conquer method ($p<0.001$). Surgery time was similar using the two nucleofractis techniques ($p=0.97$). Visual acuities showed no statistical differences between the two groups ($p>0.05$).*

CONCLUSIONS. *Nuclear fragmentation can be performed with Nagahara phaco-chop technique using the fluid-based system as well. The applied fluid-based energy decreases compared to divide and conquer method. However, surgery time is not reduced due to the difficulties reaching the full occlusion necessary to hold the nucleus during the chop maneuver (Eur J Ophthalmol 2007; 17: 315-9)*

KEY WORDS. *Aqualase, Divide and conquer, Fluid-based system, Phaco-chop, Phacoemulsification*

Accepted: December 17, 2006

INTRODUCTION

Most lens nuclei must be divided first, after which they can be safely removed during phacoemulsification. Gimbel described divide and conquer technique in which a cross-shaped space is created in the center of the nucleus (sculpting) and then the nucleus is divided into four fragments by laterally moving the phaco tip and the spatula in the depth of the craters (1). Many techniques have been introduced to enhance the efficacy of nuclear cracking. The purpose of these methods is to fragment the nucleus with the help of a second instrument (chopper). Nagahara was the first to develop an endocapsular nucleofractis technique, called phaco-chop, in which nuclei are broken without central sculpting (Nagahara K. Phaco-chop. Film presented at the 3rd American International Congress on Cataract, IOL and Refractive Surgery; Seattle; USA, May 1993).

In recent years, fluid-based surgical procedure has been developed. In the course of this type of phacoemulsification, short pulses of warmed balanced salt solution liquefy the lens material. There is no ultrasound and heating effect during the procedure (2).

It has been proven that using ultrasound system phaco-

 1120-6721/315-05$15.00/0

chop technique helps decrease surgery time and the use of ultrasound energy delivered inside the eye compared to divide and conquer maneuver (3-6). However, the effect of this nucleofractis technique to the surgical parameters using the fluid-based system is unknown. The aim of this study was to determine whether surgical parameters decrease using the Nagahara phaco-chop technique during the fluid-based method.

PATIENTS AND METHODS

Patient selection

This single-center, prospective, comparative, randomized clinical study comprised patients with cataract who were randomly assigned to undergo divide and conquer technique (25 eyes of 25 patients, Group 1) or Nagahara phaco-chop nucleofractis method (25 eyes of 25 patients, Group 2) during fluid-based phacoemulsification. Patients were randomized by an assistant's choosing an envelope containing their group number (Group 1 or 2) just before the surgery.

A complete ophthalmologic examination was performed on each patient preoperatively. Nuclear hardness was graded by the surgeon using the LOCS III system (7, 8). Exclusion criteria were any other eye pathology than cataract, age less than 50 years, high refractive errors (>4 D), pupillary dilation problem, and history of any ocular surgery or trauma. After the nature of the procedures had been fully explained, informed consent was obtained from the patients. The research was conducted in accordance with the Declaration of Helsinki and the ethical standards of the local ethics committee.

Surgical procedure

All surgeries were carried out using the Aqualase™ system (Infiniti™ Vision System, Alcon Laboratories, Forth Worth, TX, USA) by the same surgeon, who was experienced in fluid-based phacoemulsification using both nuclear fragmentation techniques.

All procedures were performed under topical anesthesia. A 3.2-mm clear corneal incision was made at the steepest meridian of the cornea in all cases. The anterior chamber was filled with ophthalmic viscosurgical device (OVD; Amvisc Plus™, Bausch and Lomb Incorporated, Rochester, NY, USA) and side port was prepared 2 clock hours to the left of the incision. After capsulorhexis (approximately 5.0 mm) cortical cleaving hydrodissection and hydrodelineation were implemented (9). The superficial cortex and epinucleus were aspirated.

In Group 1 (divide and conquer) deep cross-shaped crater was created in the center of the nucleus followed by insertion of the Aqualase ™ tip and the spatula parallel to each other inside the nuclear rim, and then the nucleus was cracked by moving away the two instruments. Four fragments were made, and the quadrants were emulsified in the center of the capsule.

In Group 2 (phaco-chop) the nucleus was stabilized with the Aqualase™ tip using vacuum alone (footswitch position 2) followed by placement of the chopper to the equator of the nucleus, and then the chopper was moved toward the tip, chopping the nucleus in half. After rotation of the nucleus the same procedure was repeated to divide it into smaller pieces, which were then emulsified in the center of the capsule.

Instrument settings used with both nuclear fragmentation methods are indicated in detail in Table I. Fluid-based magnitude and burst were set depending on nucleus hardness in both groups during fragment removal.

The removal of the nucleus was followed by irrigation/aspiration of the epinucleus and cortex, and then capsular polishing was performed in both groups. After filling the capsular bag with OVD, single-piece acrylic posterior chamber IOL was implanted in the bag using injector. The OVD was aspirated and the anterior chamber reformed with BSS Plus™ (Alcon Laboratories). The clear corneal incision was left sutureless. The corneal wound and the side port were hydrated, and dexamethasone (Dexa-Ratiopharm™, Merckle GmbH, Ulm, Germany) and tobramycin (Brulamycin™, Biogal, Debrecen, Hungary) were administrated by a subconjunctival injection. The eyes were patched with gentamicin + betamethasone ointment (Garasone™, Schering-Plough Europe, Brussels, Belgium). All procedures were uneventful; intra- and postoperative complications did not occur.

At the end of the surgery the following variables were recorded: fluid-based time, average fluid-based magnitude, effective fluid-based time, number of pulses, aspiration time, and surgery time. Effective fluid-based time is the time that theoretically would be necessary for the same surgery had 100% fluid-based magnitude been used throughout (effective fluid-based time = fluid-based time × mean fluid-based magnitude/100).

Postoperatively patients received tobramycin + dexamethasone eyedrops (TobraDex™, Alcon Laboratories) five times for 4 weeks. The patients were examined on the first postoperative day, 10 days, and 1 month after the surgery, when the best-corrected distance visual acuity, intraocular pressure, slit lamp findings, binocular fundus examination, and corneal astigmatism were recorded.

Statistical analysis

Statistical analysis was performed using SPSSWIN12 software (SPSS Inc., Chicago, IL, USA). The data were indicated descriptively (mean values ± standard deviation [SD] and range). Differences in surgical parameters between the two nucleofractis techniques were recorded with the paired test of Wilcoxon. Best-corrected distance visual acuities were evaluated with chi square test. P value of 0.05 was considered as the level of significance.

RESULTS

The mean age was 70.0±8.7 years (range 51–85 years) in Group 1 and 70.7±10.9 years (range 52–86 years) in Group 2 (p=0.8).

The nucleus hardness was similar in the two groups (mean 3.3±0.5 in Group 1 and 3.1±0.5 in Group 2) (p=0.1). The mean fluid-based time was significantly less in the phaco-chop group (2.65±1.86 sec in Group 1 and 1.08±0.89 sec in Group 2) (p<0.001). The average fluid-based magnitude was 57.2±10.7 % in Group 1 and 27.7±11.7 % in Group 2 (p<0.001). The effective fluid-based time was 1.58±1.28 sec in Group 1 and 0.37±0.41 sec in Group 2. The difference was statistically significant (p<0.001).

The mean number of pulses was also less in the phaco-chop group (3698±2339 in Group 1 and 1842±1535 in

TABLE I - INSTRUMENT SETTINGS USED WITH BOTH NUCLEAR FRAGMENTATION METHODS

	Group 1 (divide and conquer)	Group 2 (phaco-chop)
Flow rate (mL/min)	35 (linear)	40–50 (fixed)
Dynamic rise	Sculpting: 0	Chopping: 2
	Quadrant removal: 2	Fragment removal: 2
Vacuum (mmHg)	Sculpting: 100 (fixed)	Chopping: 500 (fixed)
	Quadrant removal: 500 (fixed)	Fragment removal: 500 (fixed)
Fluid-based magnitude (percent)	Sculpting: 80–100 (linear)	Chopping: 0
	Quadrant removal: 40–100 (fixed)	Fragment removal: 40–100 (fixed)
Burst (percent)	Sculpting: 100 (fixed)	Chopping: 0
	Quadrant removal: 40–70 (fixed)	Fragment removal: 40–70 (fixed)
Bottle high (cm)	Sculpting: 100	Chopping: 110–140
	Quadrant removal: 110	Fragment removal: 110–140

TABLE II - SURGICAL PARAMETERS, MEAN ± STANDARD DEVIATION (range)

	Group 1 (divide and conquer)	Group 2 (phaco-chop)	p value
Nucleus hardness (LOCS III)	3.3±0.5 (2–4.5)	3.1±0.5 (2–4)	0.1
Clear corneal incision (eyes)			
Temporal	20	18	
12 o'clock	5	7	
Fluid-based time (sec)	2.65±1.86 (0.5–7.5)	1.08±0.89 (0.1–3.3)	<0.001
Average fluid-based magnitude (percent)	57.2±10.7 (30–81)	27.7±11.7 (10–64)	<0.001
Effective fluid-based time (sec)	1.58±1.28 (0.18–5.25)	0.37±0.41 (0.01–1.41)	<0.001
Number of pulses	3698±2339 (866–9530)	1842±1535 (40–5952)	0.001
Aspiration time (min)	6.2±1.5 (3.5–9)	6.5±2 (2.5–11)	0.34
Surgery time (min)	15.5±3.1 (10.7–22.5)	15.7±3.9 (8.5–24)	0.97

Number of pulses = Sum of 4 μL water pulses during the surgery
p<0.05 = Statistically significant

Group 2) (p=0.001).

Aspiration time (Group 1: 6.2±1.5 min, Group 2: 6.5±2 min, p=0.34) and surgery time (Group 1: 15.5±3.1 min, Group 2: 15.7±3.9 min, p=0.97) were similar in the two groups.

Surgical parameters are indicated in detail in Table II.

Best-corrected distance visual acuities were similar in both groups before and after surgery (preoperatively: 20/50 or better in 32% [Group 1] and 36% [Group 2] of eyes, p=0.76; 1 day postoperatively: 20/40 or better in 88% and 68% of eyes, p=0.1; 10 days after surgery: 20/25 or better in 76% and 88% of eyes, p=0.27; 1 month after surgery: 20/20 or better in 80% and 88% of eyes, p=0.44 and 20/25 or better in all eyes).

DISCUSSION

The development of phacoemulsification ensures more effective and safer nuclear fragmentation methods. The different types of phaco-chop techniques help decrease surgery time and the use of ultrasound energy (3-6). These maneuvers have other advantages, such as the ultrasound energy directs away from the endothelial cells; the phaco tip operates in occlusion, therefore danger of posterior capsule damage is less; less strain is put on the zonules; phaco tip movement through the incision is reduced, lowering the risk of detaching Descemet membrane; and less balanced salt solution is used during the surgery (3, 4, 6). The main disadvantages of phaco-chop techniques are the longer learning curve, the difficult removal of the first nuclear piece, the greater generation of heat, and the higher incidence of tears in the continuous curvilinear capsulorhexis (6, 10).

The fluid-based system works by short pulses (4 μL) of warmed balanced salt solution, while the irrigation fluid surrounds the warmed pulsating fluid, allowing it to cool (2, 11). Therefore, corneal burn does not occur. These pulses have far-field and near-field effects. The far-field effect, which is distal to the tip, delaminates the nucleus and makes sculpting possible. Divide and conquer maneuver described by Gimbel has to be slightly changed using the fluid-based equipment, because in contrast to the ultrasound system, direct contact between the tip and the nucleus is not required during sculpting. Otherwise, the procedure is the same. The near-field effect liquefies the lens material inside the tip. As we experienced using the ultrasound system, repeated stuffing of the nuclear fragments into the phaco tip with the chopper ensures more effective emulsification during the fluid-based system as well (12). The tip is composed of soft material that makes it capsule-friendly (2, 11). To our knowledge, we were the first to compare phaco-chop and divide and conquer techniques using the fluid-based system.

In this study, we found that fluid-based time, mean fluid-based magnitude, effective fluid-based time, and the number of pulses were significantly less using phaco-chop technique compared to divide and conquer method. However, in contrast to the ultrasound system, surgery time was not shortened using phaco-chop technique in comparison to divide and conquer procedure. This was caused by the difficulty of reaching the full occlusion necessary to hold the nucleus during the chop maneuver. This factor is the main difference between ultrasound and fluid-based phaco-chop techniques. It occurs because in pressing down the footswitch to position 3, the tip digs itself into the nucleus, and it is easy to reach the full occlusion of the tip using traditional ultrasound. In contrast, the nucleus is moved away by fluid pulse during footswitch position 3 using the fluid-based system. This makes it difficult to find the correct position between the tip and the nucleus where fluid escape does not occur, while footswitch position 3 should be avoided. To reach the full occlusion as soon as possible high flow rate (fixed not linear), high vacuum (fixed not linear), high bottle position, using dynamic rise (which increases flow rate when the vacuum is rising), turning tip upside down, and close tip and chopper position are advisable during fluid-based chop. Despite the above-mentioned settings the holding force is less than we have become used to with ultrasound, and the nucleus can be pushed down by the chopper. For this reason we do not recommend using vertical phaco-chop technique, because when the vacuum falls down immediately, posterior capsule rupture may occur. On the other hand, using horizontal chop maneuver (Nagahara phaco-chop), the nucleus can move only horizontally when the vacuum decreases, which cannot cause posterior capsule damage (injury of the zonules may theoretically occur, but this was not observed). In accordance with other authors, in our experience, the fluid-based system is not effective enough in patients with hard cataract even using phaco-chop technique, and the ultrasound remains advisable in these cases (2).

In our study intraoperative complications did not occur. One limitation of this study is the fact that complication rates are less than 5% in modern cataract surgery (5).

Therefore, large numbers of patients are needed to demonstrate statistically significant differences in the complication rates between the two techniques.

It is also known that phaco-chop technique reduces endothelial cell loss compared to divide and conquer method using the ultrasound (4, 13-15). Our study demonstrated that the applied fluid-based energy is less using chop maneuver during fluid-based phacoemulsification. However, it is not sure that endothelial cell loss is also reduced, because surgery time is not shorter, higher flow-rate and bottle height is necessary, and the mechanical manipulation is greater. Further prospective randomized clinical trials are needed to investigate endothelial cell loss using phaco-chop technique during fluid-based surgery.

In conclusion, we were the first to investigate the effect of phaco-chop technique to the surgical parameters using the fluid-based system. We demonstrated that the fluid-based time, the average fluid-based magnitude, the effective fluid-based time, and the number of pulses are reduced by chop maneuver, but that surgery time is not shortened.

The authors have no commercial or proprietary interests in any of the products used in this study.

Reprint requests to:
Alexis Tsorbatzoglou, MD
Department of Ophthalmology
University of Debrecen
Nagyerdei krt. 98
H-4012 Debrecen, Hungary
alex@jaguar.unideb.hu

REFERENCES

1. Gimbel HV. Divide and conquer nucleofractis phacoemulsification: development and variations. J Cataract Refract Surg 1991; 17: 281-91.
2. Mackool RJ, Brint SF. Aqualase: a new technology for cataract extraction. Curr Opin Ophthalmol 2004; 15: 40-3.
3. Garcia AS, Limao AM, Sampaio AM, Ilharco JF. Chop and re-chop. J Cataract Refract Surg 1998; 24: 147-8. Letter.
4. Pirazzoli G, D'Eliseo D, Ziosi M, Acciari R. Effects of phacoemulsification time on the corneal endothelium using phacofracture and phaco chop techniques. J Cataract Refract Surg 1996; 22: 967-9.
5. DeBry P, Olson RJ, Crandall AS. Comparison of energy required for phaco-chop and divide and conquer phacoemulsification. J Cataract Refract Surg 1998; 24: 689-92.
6. Wong T, Hingorani M, Lee V. Phacoemulsification time and power requirements in phaco chop and divide and conquer nucleofractis techniques. J Cataract Refract Surg 2000; 26: 1374-8.
7. Chylack LT, Wolfe JK, Singer DM, et al. The lens opacities classification system III. Arch Ophthalmol 1993; 111: 831-6.
8. Smith JMA, El-Brawany M, Nassiri D, Tabandeh H, Thompson GM. The relationship between nuclear colour and opalescence on the LOCSIII scale and physical characteristics of cataract nuclei. Eye 2002; 16: 543-51.
9. Fine IH. Cortical cleaving hydrodissection. J Cataract Refract Surg 1992; 18: 508-12.
10. Vaypayee RB, Kumar A, Dada T, Titiyal JS, Sharma N, Dada VK. Phaco-chop versus stop-and-chop nucleotomy for phacoemulsification. J Cataract Refract Surg 2000; 26: 1638-41.
11. Sandoval HP, Al Sarraf O, Vroman DT, Solomon KD. Corneal endothelial cell damage after lens extraction using the fluid-based system compared to ultrasound phacoemulsification in human cadaver eyes. Cornea 2004; 23: 720-2.
12. Vasavada AR, Desai JP. Stop, chop, chop, and stuff. J Cataract Refract Surg 1996; 22: 526-9.
13. Can I, Takmaz T, Cakici F, Ozgul M. Comparison of Nagahara phaco-chop and stop-and-chop phacoemulsification nucleotomy techniques. J Cataract Refract Surg 2004; 30: 663-8.
14. Hayashi K, Hayashi H, Nakao F, Hayashi F. Risk factors for corneal endothelial injury during phacoemulsification. J Cataract Refract Surg 1996; 22: 1079-84.
15. Vargas LG, Holzer MP, Solomon KD, Sandoval HP, Auffarth GU, Apple DJ. Endothelial cell integrity after phacoemulsification with 2 different handpieces. J Cataract Refract Surg 2004; 30: 478-82.