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Comparison of Phaco-Chop versus Stop-and-Chop Nucletomy Techniques in Patients with Soft to Moderate Nucleus

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Abstract

Various phacoemulsification techniques are commonly used, with phaco-chop and stop-and-chop techniques as the most popular ones. Phacoemulsification inevitably leads to endothelial cell destruction, which, in severe cases, might result in vision impairment. This study aimed to compare endothelial cell characteristics between two phacoemulsification procedures, phaco-chop, and stop-and-chop, in patients with soft to moderate nucleus cataracts. This study was conducted on 142 patients at the National Eye Center of Cicendo Hospital between April and August 2018. Of those, 66 patients underwent the phaco-chop technique, while 76 patients underwent the stop-and-chop technique. Intraoperative parameters such as effective phaco time (EPT), phaco time, average power, and duration were recorded. Endothelial density, hexagonality, coefficient of variation (CV), and central cornea thickness (CCT) were also recorded before surgery, as well as one week and four weeks after surgery. Mean power, EPT, phaco time, and duration in the phaco-chop group were significantly lower than in the stop-and-chop group. Mean (SD) endothelial density at one-week and four-week evaluation in the phaco-chop group were considerably lower than in the stop-and-chop group (p-value=0.024 and p-value=0.000, respectively). Mean (SD) CV at one-week evaluation in the phaco-chop group was significantly higher compared to a stop-and-chop group, 43.3 (8.0) versus 40.0 (6.7)% (p-value=0.009). Mean (SD) hexagonality at four-week evaluation in the phaco-chop group was significantly higher compared to a stop-and-chop group (43.1 (17.6) versus 48.7 (13.2) respectively, p-value=0.045). Phaco-chop technique have significantly lower EPT, average power, phaco time, and surgery duration than stop-and-chop techniques at one-week and four-week evaluation after phacoemulsification.

Keywords: Anterior chamber depth, cataract, endothelial cell, phacoemulsification

Introduction

There are several different phacoemulsification procedures available today.[1] Along with the advancements in phacoemulsification technology, cataract surgeons' main goal is to improve phacoemulsification efficiency. Each technique aims to reduce zonular stress while also using less ultrasonic time and energy during nucleus emulsification. Various degrees of corneal endothelial damage are unavoidable during uncomplicated cataract surgery. Corneal endothelial damage is an inevitable occurrence even in uncomplicated cataract surgery. The occurrence of endothelial cell injury is an unavoidable consequence of the phacoemulsification method. Corneal endothelial damage can occur during cataract surgery as a result of factors such as irrigation flow and turbulence, as well as direct trauma produced by the instruments or nucleus fragments. Furthermore, there was a correlation between higher power levels longer phacoemulsification durations, and the loss of endothelial cells. The occurrence of endothelial cell death during phacoemulsification surgery is associated with compromised visual acuity. Identifying safe and effective strategies for protecting intraocular tissue, including the corneal endothelium, during surgery is the main objective of phacoemulsification to lower postoperative complications.[2,3,4]

The phacoemulsification techniques that are most frequently implemented are phaco-chop and stop-and-chop. Both techniques use a chopper to divide the nucleus mechanically

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into small fragments. The stop-and-chop technique is initiated by creating a central groove using ultrasonic energy, which is the primary distinction between the two techniques. The surgeon fractured the posterior plate and cracked the nucleus into two pieces after the groove was deep enough. Although the ultrasound energy used in the phaco-chop technique for nuclear management is lower than the stop-and-chop technique, reports showed that there is no difference in endothelial loss between both techniques.[1,2,5] The objective of this study is to conduct a comparative analysis of the phaco-chop and stop-and-chop approaches in terms of their impact on endothelial cell loss during phacoemulsification procedures for mild to moderate nuclear cataracts. In contrast to previous research that examined the comparative efficacy of phaco-chop and stop-and-chop techniques throughout the entire spectrum of cataract nucleus hardness, the present study only focused on comparing these approaches in relation to two specific degrees of cataract hardness.

Methods

This was a prospective study conducted at the Cataract and Refractive Surgery Department at Cicendo National Eye Hospital from April to August 2018. The inclusion criteria of the study were patients aged more than 30 years old with grade II-IV cataracts according to Buratto classification who underwent phacoemulsification with intraocular lens (IOL) implantation. Exclusion criteria for this study were patients with preoperative intraocular pressure (IOP) >21 mmHg, endothelial cell density <1.500/mm^2, history of intraocular surgery, pseudoexfoliative syndrome, zonular weakness, and had a complication during or after the surgery. We randomized the patients into two groups: the phaco-chop technique group and the stop-and-chop technique group.

Two cataract surgeons (BU, ES) who underwent equivalent training and have comparable surgical skills, were chosen based on their adherence to a standardized operating procedure. Both surgeons adhered to the same standardized process and utilized identical parameters during the surgeries. The surgical procedures were conducted utilizing the WhiteStar Signature PRO Abbott Medical Optic (AMO), Santa Ana, CA. The identical settings parameter was utilized for both surgeons for all of the cases. To achieve sufficient pupil dilation before surgery, tropicamide 1% eye drops were administered. Intracameral epinephrine 1: 100,000 was added intraoperatively to get maximal dilatation of the pupil. The following steps were taken during the phacoemulsification procedure: topical anesthesia on the corneal with tetracaine hydrochloride 2%, aseptic and antiseptic procedure with povidone-iodine, sterilization of drape and speculum, a three-plane clear corneal incision in the temporal area using 2.75 mm keratome knife, injection of Healon-5 viscoadaptive to form the anterior chamber, continuous curvilinear capsulorhexis with cystotome, hydro dissection, and hydro delineation, side port incision with 15-degree slit knife, phacoemulsification using phaco-chop or stop-and-chop technique, aspiration and irrigation of epinucleus and cortex, Healon-5 viscoleastic injection, IOL implantation in the capsular bag, aspiration and irrigation of viscoelastic, and hydration of main incision.

All the patients were given oral ciprofloxacin twice a day, levofloxacin eye drops 6 times daily, and prednisolone acetate eye drops 6 times daily. In this study, endothelial cell density, hexagonality, coefficient of variation (CV), and central corneal thickness (CCT) were evaluated one week and four weeks after the surgery.

The effective phaco time, mean ultrasound power and effective phaco time were recorded. Using a Top-Con SP-3000P (Topcon Corporation, Tokyo, JP) specular microscope, we also examined corneal endothelial density, hexagonality, CV, and CCT preoperatively, 1 week after surgery and 4 weeks after the surgery.

Statistical Package for the Social Sciences (SPSS) Version 22 (IBM, Inc., Chicago, IL) was used to conduct the statistical analysis in this study. The data's normality was evaluated using the Shapiro-Wilk test. Unpaired t-test, t-test, or Mann-Whitney test were used to compare intraoperative parameters, endothelial cell density, hexagonality, CV, and CCT preoperative and postoperative between the groups. The result was considered statistically significant if the p-value was less than 0.05.

Results

The study included 142 patients, 66 of the patients underwent the phaco-chop technique and 76 patients underwent the stop-and-chop technique. In both groups, there was no statistical difference between the sexes. The

Table 1 Demographic Status

	Techniques		
	Phaco-chop (n=66)	**Stop-and-chop (n=76)**	**P**
Gender			0.118*
Male	34	49	
Female	32	27	
Age (years)			0.447**
Mean (SD)	62.1 (9.8)	60.8 (10.5)	

*Chi square test; **Mann-Whitney test; SD: standard deviation

Table 2 Mean Endothelial Density, Hexagonality, Coefficient or Variation and Central Corneal Thickness Before Surgery

	Techniques		
	Phaco-chop (n=66)	**Stop-and-chop (n=76)**	**p***
Endothelial density (cells/mm^2)			0.411
Mean (SD)	2531.8 (390.4)	2483.3 (308.6)	
Hexagonality (%)			0.324
Mean (SD)	53.1 (10.6)	51.4 (9.3)	
CV (%)			0.792
Mean (SD)	37.8 (6.7)	37.5 (5.4)	
CCT (µm)			0.072
Mean (SD)	508.8 (28.6)	517.9 (30.4)	

*Unpaired t-test; CV: coefficient of variation; CCT: central corneal thickness; SD: standard deviation

Mean (SD) age in the phaco-chop group was 62.1 (9.8) years old, and 60.8 (10.5) years old in the stop-and-chop group respectively (Table 1). There were no statistical differences in the mean (SD) endothelial cell density, hexagonality, coefficient of variation (CV), and central corneal thickness (CCT) between both groups before the surgery (Table 2).

Mean (SD) power in the phaco-chop group was significantly lower than the stop-and-chop group, 11.4 (2.9) % and 19.4 (6.7) % respectively (p-value 0.000) (Table 3). The Mean (SD) of effective phaco time (EPT) in the phaco-chop group was significantly lower than the stop-and-chop group, 4.1 (4.0) seconds and 25.4 (20.5) seconds respectively (p-value 0.000) (Table 3). At the one-week evaluation, mean (SD) endothelial density in the phaco-chop group was significantly lower compared to stop-and-chop group, 1811.9 (573.8) and 2011 (462.7) cells/mm2 (p-value 0.024) (Table 4). Mean (SD) CV at one-week evaluation in the phaco-chop group was higher significantly compared to the stop-and-chop group, 43.3 (8.0) and 40.0 (6.7)% respectively (p-value 0.009) (Table 4).

At four-week after the surgery, mean (SD)

Table 3 Mean Phacoemulsification Parameters

	Techniques		
	Phaco-chop (n=66)	**Stop-and-chop (n=76)**	**p***
Average power (%)	11.3 (2.9)	19.4 (6.7)	0.000
Phaco time	32.6 (26.0)	122.7 (81.5)	0.000
EPT (second)	4.1 (4.0)	25.4 (20.5)	0.000
Duration (minutes)	5.7 (1.4)	17.7 (6.2)	0.000

*Unpaired t-test; EPT: effective phaco time

Table 4 One-week Evaluation after Phacoemulsification

Mean (SD)	Techniques		
	Phaco-chop (n=66)	Stop-and-chop (n=76)	p*
Endothelial density (cells/mm^2)	1811.9 (573.8)	2011 (462.7)	0.024
Hexagonality (%)	42.4 (16.4)	45.9 (14.9)	0.186
CV (%)	43.3 (8.0)	40.0 (6.7)	0.009
CCT (µm)	542 (53.8)	513 (34.2)	0.145

*Unpaired t test; CV: coefficient of variation; CCT: central corneal thickness; SD: standard deviation

Table 5 Four-week Evaluation after Phacoemulsification

Mean (SD)	Techniques		
	Phaco-chop (n=66)	Stop-and-chop (n=76)	p*
Endothelial density (cells/mm^2)	1531.5 (548.1)	1911.3 (489.5)	0.000*
Hexagonality (%)	43.1 (17.6)	48.7 (13.2)	0.045*
CV (%)	41.1 (9.6)	37.7 (6.8)	0.095**
CCT (µm)	519 (30.9)	521.1 (34.3)	0.715*

*Unpaired t-test; **Mann-Whitney U test; CV: coefficient of variation; CCT: central corneal thickness; SD: standard deviation

endothelial density in the phaco-chop group was significantly lower compared to the stop-and-chop group, 1531.5 (548.1) and 1911.3 (489.5) cells/mm^2 (p-value 0.000) (Table 5). Mean (SD) hexagonality at four-week evaluation in the phaco-chop group was higher significantly compared to the stop-and-chop group, 43.1 (17.6) and 48.7 (13.2) respectively (p-value 0.045) (Table 5).

Discussion

Endothelial cell damage is inevitable during the phacoemulsification procedure. During cataract surgery, irrigation flow, and turbulence, direct trauma caused by the instruments or nucleus fragments may cause corneal endothelial damage. Additionally, increased power and a longer phacoemulsification time were associated to endothelial cell loss. Proper use of ophthalmic viscosurgical devices (OVDs), enhanced instruments, and improvements in surgical techniques may help reduce corneal endothelial trauma during phacoemulsification.[1,3,6,7]

Phaco-chop technique was first introduced by Nagahara in 1993. The nucleus is manually chopped into smaller fragments and phaco energy is primarily used for fragment emulsification, the phaco-chop technique can reduce phaco time and power. The stop-and-chop technique developed by Koch and Katzen requires to create of a central deep groove that provides space and facilitates separation of the posterior plate. The remaining fragments of the nucleus are then cracked and chopped using this method. The amount of ultrasound energy used to create the central groove is the main difference between the phaco-chop and the stop-and-chop technique.[1,2]

The endothelial cell density, hexagonality, coefficient of variation (CV), and central corneal thickness (CCT) before surgery between the phaco-chop and stop-and-chop groups before the surgery were not statistically different in this study. Effective phaco time (EPT) and average power during phacoemulsification were lower in a phaco-chop group compared to the stop-and-chop group. Phaco time and surgery duration were also significantly lower in the phaco-chop group compared to the stop-and-chop group in this study. Similar findings were also reported by Astriyani et al. who demonstrated that the phaco-chop technique significantly reduced phaco time, phaco power, and EPT in comparison to the stop-and-chop technique. The phaco-chop technique also resulted in significantly shorter mean times to achieve the best corrected visual acuity (BCVA) and recovery to preoperative corneal thickness was also significantly shorter with the phaco-chop technique. However, the corneal thickness increase was higher using the

stop-and-chop technique.[2,3]

Sharma et al. reported that both phaco-chop and stop-and-chop techniques were comparable and equally efficient for nuclear management in immature senile cataracts regarding mean EPT and endothelial cell loss. Park et al. found that phaco-chop and stop-and-chop techniques were comparable regarding EPT in moderate nucleus density. However, the phaco-chop technique required less EPT compared to the stop-and-chop technique in dense cataracts. Central corneal thickness and corneal endothelial were similar between groups.[5,8]

In this study, mean endothelial cell density at one-week and four-week evaluation in the phaco-chop group was significantly lower compared to the stop-and-chop group. This result is in contrast with the previous studies that reported that endothelial loss between both techniques was comparable and did not vary significantly.[5,8]

According to several studies, the phaco-chop technique led to shorter phaco time compared to the divide-and-conquer and stop-and-chop techniques.[5,8,9] It has been suggested that lower total energy resulted in lower endothelial cell damage. While some research did not find this positive correlation, others did.[4,10,11] Dzhaber et al.[11] suggested that mechanical contact with nuclear fragments may be the primary cause of endothelial injury considering that they did not find a correlation between phacoemulsification energy and endothelial cell loss.

In contrast to the stop-and-chop technique, which includes several manipulations of fragments behind the iris, the phaco-chop technique requires a longer time to manipulate pieces in the anterior chamber. This process might be the reason for higher endothelial cell loss in the phaco-chop technique, despite significantly less total phaco energy. This hypothesis might also be reinforced by the fact that patients with shallow anterior chambers experience higher rates of endothelial cell loss. The phaco tip and the lens fragments are closer to the endothelium in patients with shallow anterior chambers.[4,8,12] However, this study did not include anterior chamber depth as a comparison to the present study. According to the study by O'Brien et al.[10] dense cataracts and long absolute phaco time were independent predictors of endothelial cell loss.

The limitation of the study includes other parameters such as ACD, axial length, and balance salt solution (BSS) volume that may correlate with endothelial loss were not assessed in this study. This study also included patients with diabetes mellitus, however, it is still debatable how diabetes mellitus affects the loss of endothelial cell loss in phacoemulsification. The procedure was carried out by two surgeons, which may affect the outcome of the study.[8,9,13] Phaco-chop technique provided lower EPT, average power, phaco time, and also surgery duration compared to stop-and-chop techniques. However, endothelial cell density after phacoemulsification in the phaco-chop group was significantly lower than in the stop-and-chop group.

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