Study of Corneal Endothelial changes following Divide-and-conquer versus stop-and-chop Phacoemulsification techniques

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Short tile: Corneal endothelial changes following Phacoemulsification techniques.

Abstract:

Purpose: To evaluate and compare Corneal endothelial changes following Divide-and-conquer versus stop-and-chop Phacoemulsification techniques

Methods: The study was conducted on 90 senile cataract eyes that were prepared to have phacoemulsification and posterior chamber intraocular lens (IOL) and at Mansoura ophthalmology center in the period from May 2019 till June 2020. The eyes were divided into two groups; each group had 45 eyes. One group subjected to 'divide & conquer' phacoemulsification technique. The other group subjected to 'stop & chop' phacoemulsification technique. Full history and ocular examination have been done for all individuals. Specular microscopy has also been done pre-operative and post-operative at one week, one month and three months to assess the count of the endothelial cell and Corneal Pachymetry.

Results: Compared to pre- operative mean ECC the decrease is statistically significant in the mean ECC post-operatively in the two groups at three months (P <0.05*)). There was also decrease in statistically significant in the mean ECC in the 'divide & conquer' group post-operatively compared to pre-operative mean ECC at one week (P <0.014*) and at one months (P <0.012*). Nevertheless, there was statistically insignificant difference (after one week P=0.163, P=0.133 after one month and after three months P=0.256).

Conclusion: One-week post-operation showed the most significant decrease in cell count of endothelia in the two groups compared to pre-operative mean ECC ('divide & conquer' group about 7.1%, 'stop & chop' group about 4.7%). One month showed less cell loss of endothelia in the two groups. Three months showed the least decrease compared to pre-operative mean ECC ('divide & conquer' group about 9.9%, 'stop & chop' group about 8.7%). There was statistically insignificant difference although more endothelial loss (about 9.9%) occur in 'divide & conquer' group when compared with 'stop & chop' group (about 8.7%)

Key words: Endothelial changes, 'stop & chop', phacoemulsification, 'divide & conquer', hexagonal cell ratio cell, C/V, count of endothelia.

INTRODUCTION:

The composition of the corneal endothelium is one layer of cells with limited capacity to generate. The repair of the endothelium occurs by cell migration and enlargement. Any insult to corneal endothelium affects its function & its ability to face another injury[1].

At birth the endothelial cell count ranges between 4000 cells/mm2 and 5000 cells/mm2. With aging the cell count will decline to approximately 2000 to 3000 cells/mm2 in a normal adult eye[2].

All surgery that requires working into the anterior chamber involves damage to a portion of corneal endothelial cells and this occurs due to corneal endothelial touching during surgery. To maintain endothelial integrity some endothelial cells enlarge and move over and this action can be recorded as change in cell morphology and density[3]. If significant number

of corneal endothelial cells are damaged during surgery, prolonged corneal edema may occur as a result and corneal decompensation of the cornea may occur in severe cases and lead to diminution of vision[4].

Serious Complications can occur one of them is corneal edema following intraocular surgery; this complication was recorded during early years of phacoemulsification surgery and was attributed to endothelial cell loss during surgery. This loss during phacoemulsification surgery was reported in several studies to ranges from 4% to 25 %[5].

Certain Endothelial cells number are needed for the corneal endothelium pump function and the main barrier at the corneal posterior surface. 3000 cells/mm2 is the average count of the cell in the young adult. The least cells number for cornea to function, or critical density of the cell, varies from 500 to 600 cells/mm2[6-7].

The amount of ultrasound energy used during phacoemulsification surgery is determined by different factors such as the techniques used during the surgery and in return the effect on the corneal endothelium, the total ultrasound energy is also proportional to the grade of the nucleus, therefore the harder and larger the nucleus, the greater the degree of endothelial injury[8-9].

Novel studies investigate the use of viscoelastic materials and the different techniques of phacoemulsification concerning their rule in reducing corneal endothelial cell loss during surgery[10].

Specular microscope can evaluate the corneal endothelium well which relies on a technique of a non-invasive photograph that allows corneal endothelium analysis and visualization as pachymetry, cell density, variation in size and variation in shape[11].

PATIENTS & METHODS:

Patient enrollment

This was a Prospective cohort study conducted on 90 patient with senile cataract. These patients were prepared to have phacoemulsification and posterior chamber intraocular lens (IOL) at Mansoura ophthalmology center in the period from May 2019 till June 2020. after approval from Institutional review board (IRB), Faculty of Medicine,

The studied individuals were classified into two groups:

Group A: 45 eyes undergo phacoemulsification with the stop & chop technique.

Group B: 45 eyes undergo phacoemulsification with the divide & conquer technique.

All individuals were subjected to:

Full general and ophthalmic history which include Age, Gender, Occupation and socioeconomic status and history of similar condition were performed. Also, ocular history to exclude any previous refractive or ocular surgery and ocular injury was performed. Full eye examination like Visual acuity measurement using chart for visual acuity then transformed to Log MAR was performed and Manifest refractions using the auto-refractometer were done. In addition, full slit lamp examination to assess the anterior segment was performed for cornea, sclera, anterior chamber, iris, pupil and lens. Fundus examination (ophthalmoscope) after installation of mydriatic eye drops and Intraocular pressure (IOP) assessment was done to measure Intraocular pressure is measured as part of comprehensive eye examination after installation of anesthetic eye drops.

As regards, the investigations, the count of the endothelial cell and Corneal Pachymetry was assessed by Specular microscopy. *Endothelial cell count was performed using non-contact specular microscope which is Tomey EM-3000 to measure central thickness of the cornea (CCT) and the count of the endothelial cell (ECC).

Statistical Analysis of the Data:

IBM SPSS (version 20) was utilized to assess the research data. Shapiro-Wilk test was utilized to check the data distribution normality. Significant results achieved when P value < than 0.05. We evaluate quantitative variables as median, SD, mean, IQR, maximum and minimum whereas categorical ones were evaluated as ratio and percent. Mann Whitney and Independent T tests were used for intergroup (among cases) comparing the data without follow up readings in a corresponding way.

RESULTS:

Patient's characteristics

This study was performed on 90 patients eyes with senile cataract, divided into 54 males (60%) and 36 females (40%).with their average age of 60.85(+/-)13.1 years. The

results between the two groups as regards age and gender show no difference in the statistically significance. (Table 1).

Table (1): Demographic characteristics in groups:

		Group A (N = 45)	Group B (N=45)	Total (N=90)
Age		59.53±5.68	62.71±4.31	60.85±4.99
gender	Male	28(62%)	26(58%)	54 (60%)
	female	17(38%)	19(42%	36 (40%)

I. Endothelial cell count (ECC) in Studied Groups:

Regarding endothelial cell density among group 1 (stop and chop group) the pre- operative mean endothelial cell count was 2525.8(+/-) 271.2 compared to 2410.9(+/-) 247.1 one week post-operatively, 2349.1(+/-) 246.7 one month post-operatively and 2305(+/-) 251.8 three months post-operatively. (Table 2)

Table (2): Evaluation of pre and postoperative endothelial cell density among group 1

Duration	Mean(cells/mm^2)	SD (+/-)
Preoperative	**2525.8**	**271.2**
1 Week	**2410.9**	**247.1**
1 Month	**2349.1**	**246.7**
3 Month	**2305**	**251.8**

In-group 2 (Divide and conquer) the pre- operative mean endothelial cell count was 2537.2 (+/-) 203.8 compared to 2362.7 (+/-) 196.5 one week post-operatively, 2318.6 (+/-) 159.1 one month post- operatively and 2287.6 (+/-) 162.8 three months post- operatively. (Table 3)

Table (3): Evaluation of pre and postoperative endothelial cell density among group 2

Duration	Mean (cells/mm^2)	SD (+/-)
Preoperative	2537.2	203.8
1 Week	2362.7	196.5
1 Month	2318.6	159.1
3 Month	2287.6	162.8

Post-operatively, there was statistically significant decrease in the mean ECC in both groups compared to pre-operation at 3month (P <0.05*). (Table 4)

Table (4): Comparison between the two studied groups according to endothelium cell count

Endo count	Group 1 (n = 45)	Group 2 (n = 45)	t	P
Pre				
Min. – Max.	1647 – 3096	2014 – 3040		
Mean ± SD.	2525.8 ± 271.2	2537.16 ± 203.8	0.224	0.824
Median	2531	2548		
1 week				
Min. – Max.	1564 – 2878	1973 – 2898		
Mean ± SD.	2410..91 ± 247.1	2362.73 ± 196.5	1.023	0.309
Median	2411	2366		
1 month				
Min. – Max.	1450 – 2883	1917 – 2731		
Mean ± SD.	2349.0 ± 246.7	2318.6 ± 159.1	0.696	0.488
Median	2379	2320		
3 months				
Min. – Max.	1419 – 2806	1897 – 2750		
Mean ± SD.	2305 ± 251.8	2287.2 ± 162.8	0.389	0.698
Median	2310	2294		

t: Student t-test

p: p value for comparing between the studied groups

Group 1: stop and chop phacoemulsification

Group 2: divide and conquer phacoemulsification

Also, Divide and conquer group show decrease in statistically significance in the mean ECC compared to pre-operative at 1 week result was (P <0.014*) and 1 months result was (P <0.012*). (Table 5) (figure1).

Table (5): Comparison between the different studied periods according to endothelium cell count:

			Post		F	p
Endo count	**Pre**	**1 week**	**1 month**	**3 months**		
Group 1 (n = 45)						
Min. – Max.	1647 – 3096	1564 – 2878	1450 – 2883	1419 – 2806		
Mean ± SD.	2525.8 ± 271.2	2410..91 ± 247.1	2349.0 ± 246.7	2305 ± 251.8	90.76	0.001*
Median	2531	2411	2379	2310		
% of decrease		4.7%	6%	8.7%		
p_1		<0.001*	<0.001*	<0.001*		
Group 2 (n = 45)						
Min. – Max.	2014 – 3040	1973 – 2898	1917 – 2731	1897 – 2750		
Mean ± SD.	2537.16 ± 203.8	2362.73 ± 196.5	2318.6 ± 159.1	2287.2 ± 162.8	78.06	0.004*
Median	2548	2366	2320	2294		
% of decrease		7.1%	8.9%	9.97%		
p_1		<0.001*	<0.001*	<0.001*		

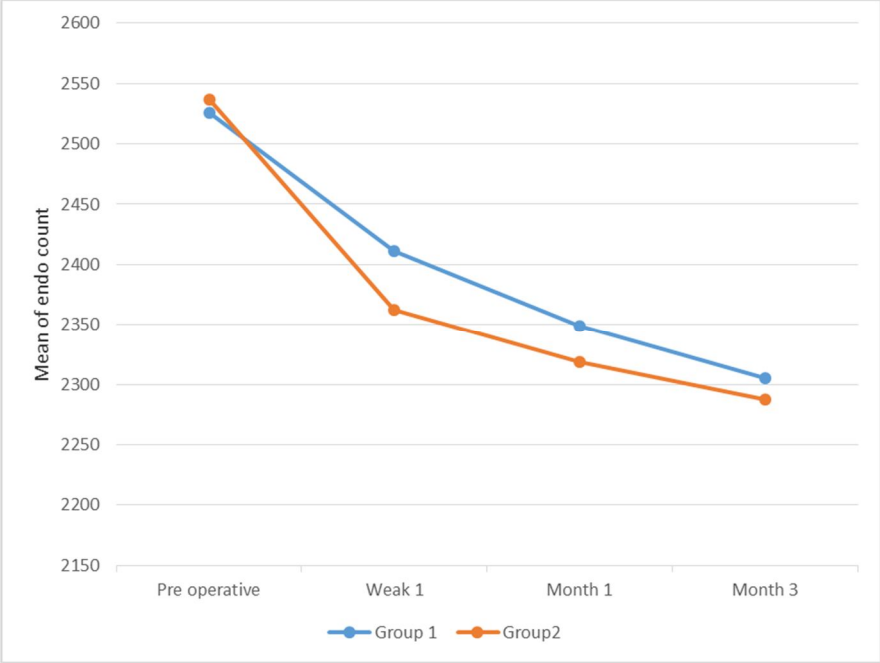
F: F test (ANOVA) with repeated measures, Sig. bet. periods was done using **Post Hoc Test (Bonferroni)**

p: p value for comparing between the studied periods p_1: p value for comparing between **pre** and each other periods

*: Statistically significant at $p \leq 0.05$

Group 1: stop and chop phacoemulsification

Group 2: divide and conquer phacoemulsification



Figures (1): Comparison between the different studied periods according to endothelium cell count.

However, There was statistically insignificant difference between both groups (after 1 week P=0.163, after 1 month P=0.133 and after 3 months P=0.256).

No statistically significant difference in data of endothelial cell density showed at any period of the follow up between both groups.

II. Central Corneal Thickness (CCT) in both Studied Groups:

Post-operation, there was increase in the statistically insignificance in the mean CCT in both groups (figure 2).

Moreover, there was statistically insignificant difference between both groups (after 1 week P=0.37, after 1 month P=0.21 and after 3 months P=0.19) (Table 6&7).

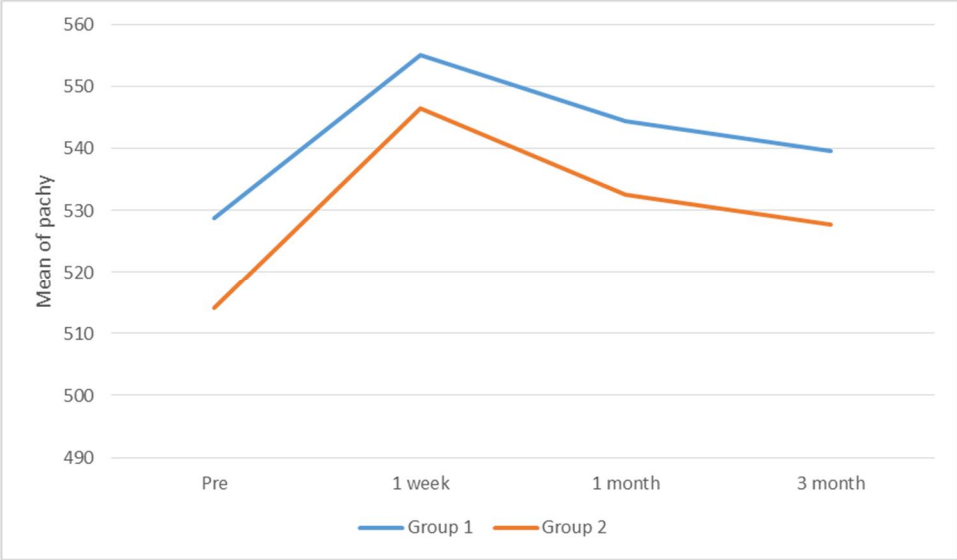


Figure (2): Comparison between the different studied periods according to Central Corneal Thickness.

Table (6): Comparison between the two studied groups according to pachymetry.

Pachy	Group 1 (n = 45)	Group 2 (n = 45)	t	p
Pre				
Min. – Max.	441 – 581	438 – 577	1.95	.0544
Mean ± SD.	528.87 ± 35.53	514.1 ± 36.16		
Median	534	520		
1 week				
Min. – Max.	471 – 623	440 – 622	0.9	0.37
Mean ± SD.	555.09 ± 38.51	546.62 ± 49.59		
Median	562	557		
1 month				
Min. – Max.	453 – 597	423 – 627	1.22	0.21
Mean ± SD.	544.47 ± 40.48	532.56 ± 51.60		
Median	553	541		
3 months				
Min. – Max.	456 – 599	438 – 612	1.31	0.19
Mean ± SD.	539.6 ± 41.39	527.82 ± 43.89		
Median	544	529		

t: Student t-test.

P: p value for comparing between the studied groups

Group 1: stop and chop phacoemulsification

Group 2: divide and conquer phacoemulsification

Table (7): Comparison between the two studied groups according to % of change pachymetry

			Post		F	p
pachy	**Pre**	**1 week**	**1 month**	**3 months**		
Group 1 (n = 45)						
Min. – Max.	441 – 581	471 – 623	453 – 597	456 – 599		
Mean ± SD.	528.87 ± 35.53	555.09 ± 38.51	544.47 ± 40.48	539.6 ± 41.39	6.218	0.0005*
Median	534	562	553	544		
% of increase		5.2%	3.5%	1.9%		
p_1		<0.001*	0.096	0.021		
Group 2 (n = 45)						
Min. – Max.	438 – 577	440 – 622	423 – 627	438 – 612		
Mean ± SD.	514.1 ± 36.16	546.62 ± 49.59	532.56 ± 51.60	527.82 ± 43.89	4.897	0.0029*
Median	520	557	541	529		
% of increase		7.1%	4%	1.7%		
p_1		0.001*	0.043*	0.089		

F: F test (ANOVA) with repeated measures, Sig. bet. Periods was done using **Post Hoc Test** (**Bonferroni)**

P: p value for comparing between the studied groups.

Group 1: stop and chop phacoemulsification

Group 2: divide and conquer phacoemulsification

DISCUSSION:

Now, several techniques exist using phacoemulsification energy for extraction of cataract. The most commonly used are 'stop & chop' 'divide & conquer' and 'phaco chop' techniques[12].

Thus, evaluation and comparing changes in corneal endothelial cells after divide & conquer versus stop & chop phacoemulsification techniques are the aim of the current study.

Concerning ECC, there was statistically significant endothelial cell loss throughout the study in the two groups as compared to preoperative values, but between the two groups, there was no statistically significance difference in the results recorded.

Although less endothelial loss occur in stop and chop group (about 8.7%) when compared with divide & conquer group (about 9.9%) the difference was statistically insignificant.

In their study, comparing 'phaco-chop' versus 'Divide & conquer' technique Storr-Paulsen et al. found that the two groups showed a significant decrease concerning cell loss of endothelia at three and twelve months. In phaco chop group they found that the mean loss was 6.3% (173 cells/mm2) at 3 months and the loss was 5.7% (155 cells/mm2) at 12 months post-operatively. In the divide& conquer group they found that the mean cell loss was 138 cells/mm2 (5.0%) at 3 months and the loss was 94 cells/mm2 (3.5%) at 12 months postoperatively. The two groups showed non-significant difference throughout the follow up periods. Compared to the results in our study where the endothelial loss in stop and chop group was (about 8.7%) at 3 months and in divide & conquer group was (about 9.9%) at 3 months[13].

In Alio et al study, they found that performing phacoemulsification in the anterior chamber had the same safety margin as performing phacoemulsification of endocapsule using the 'stop & chop' technique. They also reported a mean cell loss of endothelia at about (11%) in the two groups[14].

In their study, Park et al. compared the 'stop & chop', 'phaco-chop' and 'divide & conquer' techniques. They found that the loss of endothelial cell using the 'divide & conquer' technique pre-operatively was (9.1% + 1.2%) with (mean ECC, 2633.7 (+/-) 303.6 cells/mm2 p and post-operatively 2394.0 (+/-) 245.7 cells/mm2) and using the 'stop-&-chop' technique the loss of endothelial cell pre-operatively was (7.2% (+/-) 1.0%) with (mean ECC, 2480.3 (+/-) 267.5 cells/mm2 and post-operatively 2455.5 (+/-) 250.5

cells/mm2). Compared to the results in our study where the endothelial loss in stop and chop group was (about 8.7%) at 3 months and in divide & conquer group was (about 9.9%) at 3 months these results were compatible with our results[15].

In their study, Vajpayee et al. compared 'stop & chop' versus 'phaco-chop' techniques for phacoemulsification and found that at three months end, the percentage of loss of endothelial cell was 7.17 % in 'stop & chop' Group and 6.89 % in 'phaco-chop' Group[16].

Pereira et al. compared 'stop & chop' and nuclear preslice phacoemulsification techniques and found a significant endothelial cell density decrease (8.70%) post-operatively using 'stop & chop' technique. Compared with the endothelial loss in nuclear preslice group the loss was the same with the two techniques (8.72% nuclear preslice; 8.70% 'stop & chop')[17].

Faramarzi et al. studied the Corneal loss of endothelial cell during phacoemulsification using 'stop & chop' technique comparing bevel-down versus Bevel-up phaco tip and found that the mean average of loss in endothelial cell in that study concerning the bevel-down and bevel-up groups after surgery at 3 months were approximately (14% and 6%, respectively). They reported that performing phacoemulsification with the 'stop & chop' technique resulted in an average percentage of loss of endothelial cell of 4.7% to 11.0% after surgery at 3 months in previous studies[14].

O'Brien et al found in their study for changes in endothelial cell after phacoemulsification using a 'divide & conquer' technique that the overall mean endothelial cell loss was 11.6 % [18].

As regard mean CCT, there was statistically significant increase in both groups as compared to preoperative values. The most significant increase was at 1 week post-operatively (about 5.2% in 'divide & conquer' group and 7.1% in 'stop & chop' group as compared to pre-operative mean CCT). There was less increase in mean CCT in the two groups after one month and least increase after three months (about 1.9% in 'divide & conquer' group and 1.7% in 'stop & chop' group as compared to pre-operative mean CCT).

Although more increase in mean CCT in 'stop & chop' group (7.1%) when compared with 'divide & conquer' group (about 5.2%) the difference was statistically insignificant.

In a study by Farahat et al. concerning central corneal thickness (CCT) after phacoemulsification by 'divide & conquer, they found that at 0ne week there was a significant difference between pre-operative CCT and post-operative CCT in all studied groups and at three months there was no significant difference between pre-operative CCT and post-operative CCT in all studied groups[19].

In a study by Park et al. comparing the 'stop & chop,' 'phaco-chop', and 'divide & conquer' techniques, they found that with the 'phaco-chop' technique the change was less in the central corneal thickness (CCT) in all groups with cataract density compared with the 'stop & chop' and 'divide & conquer' techniques postoperative at two months, however there was no statistically significant difference[15].

Davison et al. used a side-view camera video, which showed that the 'phaco-chop' technique delivers less US power behind the iris than the 'divide & conquer' technique. In addition, their study showed that in 'phaco-chop' technique, fragments manipulation long period is required in the anterior chamber than 'divide & conquer' technique, in which behind the iris most manipulation takes place. This probably why they observed similar cell loss of endothelia with the two techniques in spite of less significant energy in phaco. Patients with a shallower anterior chamber and shorter AL that show higher loss of cell may support this idea., Lens fragments and phaco tip are closer to the endothelium as in a shallow chamber[13].

Divide & conquer technique has been successfully and safely practiced, and more established than phaco chop. Phaco chop technique includes some difficulties during surgery such as greater heat generation during the chopping occlusion phase, this is because it requires phaco energy in tightly packed segments dislodging and during occlusion that can be technically difficult so that for emulsification the first fragments of the nuclei probably have to be pulled up into the anterior chamber[20].

Phacoemulsification surgery can lead to a serious concern that is the loss of corneal endothelial cells during surgery. This can cause corneal decompensation if the loss is severe enough. Several pre-operative and intra-operative parameters can influence damage of endothelial cell. Factors that can lead to more damage before operation include nucleus hardness, small

diameter of pupil, shorter length of axia (AL) and older age. Factors used during operation include the size and design of the incision, time of the phacoemulsification, type and technique of phacoemulsification of ophthalmic viscosurgical material. Several mechanisms during phacoemulsification have been suggested for endothelial cell damage; some of which are instruments or lens fragments related direct trauma, nuclear fragments mechanical contact, cavitation bubbles formation, fluids turbulence and movement and irrigation flow. To provide effective removal of lens at lower levels of power and US energy, systems of power modulation are now designed because during phacoemulsification ultrasound delivery lowering into the eye may reduce the risk of loss for endothelial cell[14].

Conclusion:

The current study concluded that, there was no statistically significant difference between (divide & conquer) technique and (stop & chop) technique regarding count of endothelial cell and central thickness of cornea.

DATA AVAILABILITY

All data are included in this article.

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None

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Ethics declarations

Conflict of interest

Mohamed S. Mahmoud, Sherief E. ElKhouly, Ashraf E. Moawad, Ahmed M. Ismail all authors have no conflicts of interest that are directly relevant to the content of this review.

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