ORIGINAL ARTICLE

A PROSPECTIVE COMPARATIVE STUDY ON ENDOTHELIAL CORNEAL CELL AFTER CATARACT SURGERY USING TORSIONAL VS LONGITUDINAL PHACOEMULSIFICATION

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ABSTRACT

Introduction: *Our aim was to compare endothelial corneal cell changes after cataract surgery performed with Torsional and Longitudinal phacoemulsification in patient with senile cataract.*

Methods: *In this prospective study, the patients were divided into two groups, 24 eyes underwent cataract surgery using Torsional (OZil Infiniti Vision System, Alcon) and 23 eyes using Longitudinal phacoemulsification (Stelaris, Bausch & Lomb). Preoperative, 1 day, and 1 week post-operative examinations on endothelial corneal cells were performed using specular microscope. Cataracts were subdivided according to the LOCS III grading of nucleus. Intraoperative parameters using phacoemulsification time were evaluated.*

Result: *On the results of CCT at 1 day and 1-week post-operative, there were significant changes in group Torsional and Longitudinal 601±68.67; 562.45±46.53 (p=0.033) and 561,71±36,37; 519.52±79.93 (p = 0.015). However, there were no significant changes of CD, CV, HEX 1 day and 1 week post operatively between two groups. The phacoemulsification time was lower in group Torsional 17.11±15.86 seconds than group Longitudinal 18.53±15.46 seconds (p=0.595) but not significantly different.*

Conclusion: *Torsional phacoemulsification outperforms the Longitudinal with a lower phacoemulsification time on soft and medium cataracts, but the differences were not significant. Torsional caused more corneal edema at 1 day and 1 week postoperative significantly and more endothelial cell losses but insignificantly.*

Keywords: *Cataract, Corneal endothelial cell, Longitudinal phacoemulsification, Torsional phacoemulsification, Cataract Surgery*

INTRODUCTION

Cataract is one of the leading causes of blindness worldwide, and ±15 million people aged >50 years old experienced blindness due to cataract. World Health Assembly (WHA) stated that cataract is a cause of vision problems that can be treated effectively by surgery.[1] Phacoemulsification is a modern operating technique of cataract management using ultrasound energy to break the cataract into small fractions so that it can be aspirated.[2,3]

Longitudinal phacoemulsification is a traditional technology that produces ultrasound energy when the phaco tip moves forward and backward.[3,4] Another technology is torsional phacoemulsification which the phaco tip moves in a torsional movement to reduce the repulsion effect so that the lens material followability at the phaco tip is better and has a lower ultrasound frequency.[4] Repulsion and high ultrasound energy increase corneal endothelial cell injury.[5]

Corneal endothelium is a layer of hexagonal cells on the cornea's posterior surface.[6] Corneal endothelial cells are sensitive to trauma and cannot regenerate after injury. The loss of corneal endothelial cells due to surgery will affect the cornea's function in maintaining its transparency, causing an increase in corneal thicknesses, and affecting vision.[5,7] This study aimed to compare corneal endothelial cells after cataract surgery between Torsional and Longitudinal phacoemulsification.

METHODS

Study design and patients

This study used a prospective method that compared corneal endothelial cells in patients before and after cataract surgery with phacoemulsification accompanied by an intraocular lens (IOL) implantation at dr. Kariadi Hospital, Semarang in February-April 2021. The research was approved by RSUP dr. Kariadi ethics committee (149/UN7.5.4/MT/PP/2021), and participants were willing to participate in this research. The inclusion criteria in this study were cataract patients with age >40 years old with lens nuclear opacity grade 1-6 and who underwent phacoemulsification surgery + Intraocular Lens (IOL) implantation. The exclusion criteria were age <40 years old, traumatic cataracts, corneal abnormalities, and did not meet the inclusion criteria. Patients who met the inclusion criteria had an ophthalmological examination preoperatively with a slit lamp to determine both cataract grade and type. The examiner determined the nuclear opacity grade based on Lens Opacities Classification System III (LOCS III) with grades 1-6 and divided it into three groups: soft NC (Nuclear Cataract) 1-2, medium NC 3-4, and hard NC 5-6.

Corneal cell assessment

Corneal cell examination was obtained with NIDEK CEM-530 non-contact Specular microscope (corneal endothelial cells and pachymetry), including Central Corneal Thickness (CCT), Cell Density (CD), Coefficient Variation (CV) and Hexagonal Cell (HEX). The examination was performed preoperatively, one day (D+1), and one week (D+7) postoperatively.

Operating Procedure

An opthalmologist carried out the operating procedures at Kariadi Hospital. Phacoemulsification technology used intraoperatively was Torsional phacoemulsification with *OZil Infiniti Vision System*, *Alcon* machine, and Longitudinal phacoemulsification with *Stelaris*, *Bausch & Lomb* machine. Phacoemulsification time/Phacotime was recorded in every operation.

Statistical analysis

Total number of samples was 47, therefore, data normality tests were conducted using Saphiro Wilk. In each group, statistical analysis was done using paired t-test in normally distributed data, whereas the wilcoxon signed rank test were performed in data that were not normally distributed (Table 3 and 4).

In both groups, data analysis with independent t-test were done in data with normal distribution, while data that were not normally distributed was analyzed with the Mann-Whitney test (Figure 1). P value < 0.05 is statistically significant.

RESULTS

There were 47 patients who participated in this study (24 patients in the torsional group and 23 patients in the longitudinal group), the average age was 57 years, with 23 men and 24 women. No significant difference in both groups (p=0.464). The most common comorbidities were diabetes mellitus (p=1,000), and high myopia (p=1,000), with the most prevalent cataract grades were Nuclear Cataract 3-4. The differences between two groups were not significant (p=0,112). Subject characteristics distribution in both groups are presented in Table 1. Mean values of preoperative CCT, CD, CV, HEX in both groups are shown in Table 2, with insignificant differences in both groups (p>0.05).

Table 1. Subject Characteristics

Variable	Total (n=47)	Torsional (n= 24)	Longitudinal (n= 2	*p*
	n (%)	n (%)	n (%)	
Age (years)*	57,23 ± 9,92	55,42 ± 7,88	59,13 ± 11,55	0,203[†]
Sex				
Male	23 (48,9)	13 (54,2)	10 (43,5)	0,464[χ]
Female	24 (51,1)	11 (45,8)	13 (56,5)	
Comorbidities				

Diabetes Mellitus	8(17)	4 (16,7)	4 (17,4)	1,000$^{\chi}$
Hypertension	5 (10,6)	3 (12,5)	2 (8,7)	1,000$^{\chi}$
High myopia	6 (12,8)	3 (12,5)	3 (13,0)	1,000$^{\chi}$
Steroid-induced cataract	3 (6,4)	2 (8,3)	1 (4,3)	1,000$^{\chi}$
Secondary glaucoma	2 (4,3)	2 (8,3)	0 (0)	0,489$^{\chi}$
Vitrectomized eye	5 (10,6)	2 (8,3)	3 (13,0)	0,666$^{\chi}$
Vitreous Haemorraghe	2 (4,3)	2 (8,3)	0 (0)	0,489$^{\chi}$
Age Macular Degeneration	1 (2,1)	0 (0)	1 (4,3)	0,489$^{\chi}$
Cataract grading				
NC 1-2 (soft cataract)	20 (42,6)	10 (43,7)	10 (43,5)	0,112$^{\chi}$
NC 3-4 (medium cataract)	23 (48,9)	10 (41,7)	13 (56,5)	
NC 5-6 (hard cataract)	4 (8,5)	4 (16,7)	0 (0)	

n= number of subjects; *mean ± standard deviation (SD); p= difference value between 2 groups; $^{\chi}$*Chi Square test*; †*independent t-test.*

Table 2. CCT, CD, CV, and HEX Preoperative Value

Preoperative Variable	**Mean ± SD**		***p***
	Torsional	**Longitudinal**	
Central corneal thickness (μm)	541,37 ± 35,54	511,43 ± 75,51	0,077^{M}
Corneal cell density (mm^2)	2655,96 ± 312,36	2626,78 ± 245,54	0,724†
Coeficient variation (%)	29,75 ± 3,99	31,43 ± 6,44	0,291†
Hexagonal (%)	67,83 ± 4,64	68,35 ± 4,33	0,697†

SD, standard deviation; *p*, difference value between 2 groups; *Significant (*p* <0,05); †*independent t-test*, ^{M}*Mann Whitney*

The comparison of corneal endothelial cells and corneal thicknesses in each group are presented in Tables 3 and 4. There were significant differences in CCT D+1 postoperative results (p<0.001) and D+7 postoperative (p <0.001) with preoperative CCT in Torsional Group. Similar results were found in D+1 postoperative and D+7 postoperative CD (p=0,026 and p=0,004). Neither CV nor HEX was found to significantly differ in either D+1 or even D+7 postoperative (Table 3).

In Table 4, the postoperative Longitudinal group's CCT values D+1 and D+7 showed significant differences from preoperative CCT with p<0.001 and p=0.015. D+1 and D+7 postoperative CD also obtained significant results compared to preoperative CD with p=0.008 and p=0.033. CV and HEX values did not significantly differ in either D+1 or D+7 postoperative compared to preoperative.

Table 3. Comparison of Preoperative and Postoperative CCT, CD, CV, and HEX Value in Torsional Group

Variable	Mean ± SD		p	Mean ± SD		p
	Preoperative	Postoperative D+1		Preoperative	Postoperative D+7	
CCT	541,37 ± 35,54	601,00 ± 68,67	<0,001¶*	541,37 ± 35,54	561,71 ± 36,37	<0,001¶*
CD	2655,96 ± 312,36	2531,53 ± 360,67	0,026¶*	2655,96 ± 312,36	2424,46 ± 592,83	0,004ω*
CV	29,75 ± 3,99	32,42 ± 5,66	0,086¶	29,75 ± 3,99	32,88 ± 5,74	0,154¶
HEX	67,83 ± 4,64	64,29 ± 6,23	0,136ω	67,83 ± 4,64	64,00 ± 5,96	0,139¶

CCT, *central corneal thickness*; CD, *corneal cell density*; CV, *coefficient variation*; HEX, *hexagonal;* SD, standard deviation; *p*, difference value between 2 groups; *Significant (p <0,05); ¶*paired t-test*; ω *Wilcoxon signed rank test.*

Table 4. Comparison of Preoperative and Postoperative CCT, CD, CV, and HEX Value in Longitudinal Group

Variable	Mean ± SD		p	Mean ± SD		p
	Preoperative	Postoperative D+1		Preoperative	Postoperative D+7	
CCT	511,43 ± 75,51	562,45 ± 46,53	<0,001ω*	511,43 ± 75,51	519,52 ± 79,93	0,015ω*
CD	2626,78 ± 245,54	2483,05 ± 412,07	0,008ω*	2626,78 ± 245,54	2475,04 ± 421,34	0,033¶*
CV	31,43 ± 6,44	32,55 ± 7,20	0,613ω	31,43 ± 6,44	33,09 ± 6,01	0,782ω
HEX	68,35 ± 4,33	66,91 ± 4,89	0,237¶	68,35 ± 4,33	66,50 ± 3,20	0,138¶

*Significant (p <0,05); ¶*paired t-test*; ω *Wilcoxon signed rank test.*

Mean CCT D+1, D+7 postoperative and delta/change CCT D+7 (p=0,033; p=0,015; and p=0.017) in the Torsional group were significantly higher than the Longitudinal group (Table 5 and Figure 1). Mean CD D+1 and D+7 postoperative and delta CD D+1 and D+7 in the Torsional group showed more decreases in CD than the Longitudinal group. Still, the difference was not statistically significant (p>0.05). Whereas corneal cell morphology, namely CV and HEX in the Torsional group, both in D+1, D+7, Delta D+1, or even Delta D+7 postoperative, obtained an increase in CV and a decrease in Hexagonal compared to the Longitudinal group, but this difference is also not significant (p>0.05).

Table 5. Comparison of CCT, CD, CV, HEX Value Changes in Torsional and Longitudinal Group

Variable		Torsional	Longitudinal	*p*
		Mean ± SD	Mean ± SD	
CCT	Delta D+1	59,62 ± 58,00	50,05 ± 75,53	0,328ᴹ
	Delta D+7	20,33 ± 19,81	8,09 ± 13,23	0,017†*
CD	Delta D+1	-170,21 ± 306,47	-143,73 ± 365,57	0,754ᴹ
	Delta D+7	-231,50 ± 459,78	-151,74 ± 319,93	0,798ᴹ
CV	Delta D+1	2,68 ± 6,45	1,12 ± 8,54	0,424ᴹ
	Delta D+7	3,13 ± 7,07	1,66 ± 6,18	0,189ᴹ
HEX	Delta D+1	-3,54 ± 7,77	-1,43 ± 5,66	0,295ᴹ
	Delta D+7	-3,83 ± 8,52	-1,85 ± 4,43	0,875ᴹ

Delta D+1= preoperative and postoperative (D+1) value difference; Delta D+7= preoperative and postoperative (D+7) value difference; *Significant (p <0,05); †*independent t-test*, ᴹ*Mann Whitney*

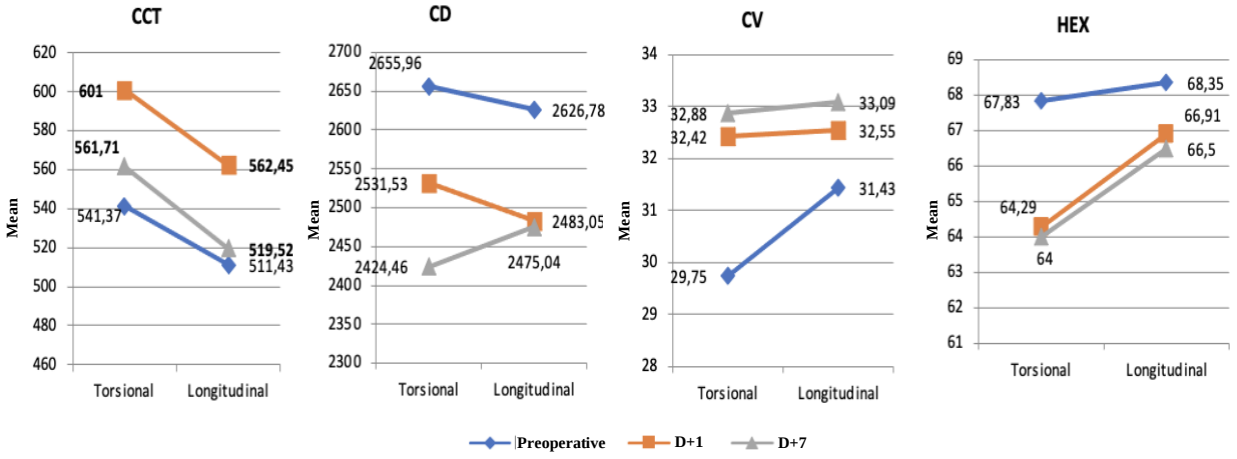

Figure 1. CCT, CD, CV, HEX Difference in Torsional and Longitudinal Group

Delta CCT, CD, CV, and HEX D+1 and D+7 postoperative based on cataract grade, which was soft and medium cataracts, also showed in-line results with the initial analysis where no grouping based on cataract grade (Figure 2). The Torsional group had more increased CCT and decreased CD values than the Longitudinal group, but they were not statistically significant (p>0.05). Delta CV values D+1, D+7 appeared higher, and delta HEX values D+1 and D+7 were more decreased in the Torsional group compared to the Longitudinal, but also did not differ significantly (p>0.05).

The torsional group had faster phacoemulsification time/phacotime, 17.11±15.86 seconds, than the Longitudinal group, 18.53±15.46 seconds, in both soft and medium cataracts with statistically insignificant differences (p=0.595) (Table 6).

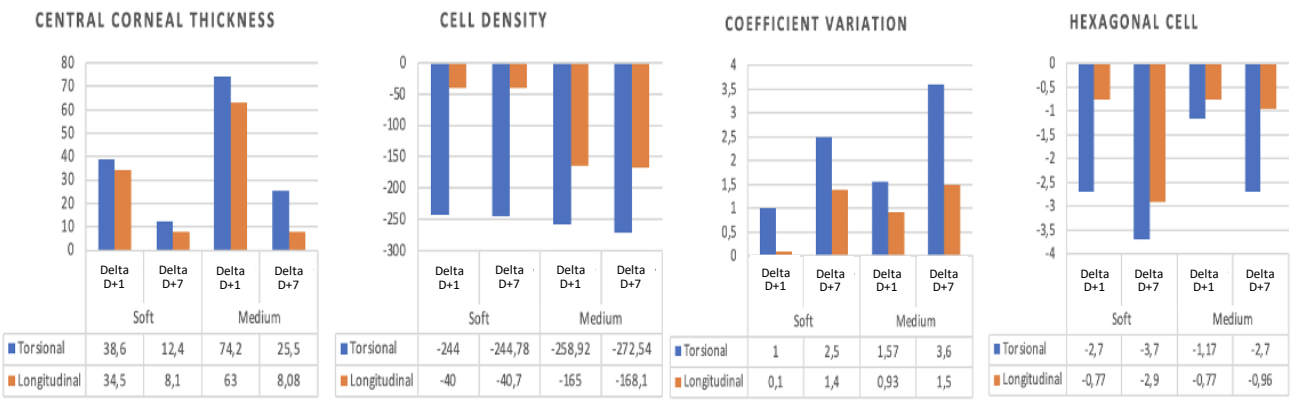

Figure 2. CCT, CD, CV, and HEX Changes in Soft and Medium Cataracts in Torsional and Longitudinal Group

Table 6. Phacoemulsification Time in Torsional and Longitudinal Group

Cataract Grade	Mean ± SD *Phacoemulsification Time*		*p*
	Torsional	**Longitudinal**	
Soft	8,45 ± 6,26	15,49 ± 18,13	0,597[M]
Medium	16,25 ± 12,57	20,86 ± 13,35	0,409[†]
Hard	40,90 ± 18,14	–	–
Total	17,11 ± 15,86	18,53 ± 15,46	0,595[M]

*Significant (p <0,05); [†]*independent t-test,* [M]*Mann Whitney*

DISCUSSION

Technology in phacoemulsification continues to develop to make safer and more efficient extraction by reducing the energy and duration of the operation. Several studies reported that Torsional phacoemulsification was superior to Longitudinal in surgery duration, followability, corneal edema, and loss of corneal endothelial cells. In Longitudinal phacoemulsification, Jack Hammer effect causes the lens fragment to be pushed away from the tip. In contrast, in the Torsional, the tip moves in rotation motion so that followability and the duration of operation become faster.[4] This is consistent with the results of this study that phacoemulsification time in the Torsional group was shorter than the Longitudinal group, although it did not differ significantly. Longer operation duration leads to higher energy used, and greater heat energy discharged on cornea's surface increases risk of corneal endothelial cell damage.[8]

This study showed a significant increase in CCT D+1 and D+7 postoperative in both Torsional and Longitudinal groups. There was also a significant increase in the Torsional group compared with the Longitudinal group. The result showed presence of postoperative corneal edema in both groups which was worse in Torsional group. Corneal endothelial cell morphology, CV, and HEX showed similar polymegatism and pleomorphism in D+1 and D+7 postoperative in both groups and corresponded to cell density changes. The results of this study were consistent with the Reuschel study, which reported no significant differences in reducing CD in 6.7% Torsional and 6.4% Longitudinal groups at three months after surgery.[9] However, a study from Christakis reported that Torsional phacoemulsification had less corneal edema, and the Sawhney study reported less cell density reduction in Torsional phacoemulsification.[8–10]

The different results in other studies compared to this study may be due to larger sample numbers, longer follow-up duration (one week, one month, and three months postoperative), and the machines used in their study, either at the Torsional or the Longitudinal groups were identic (Infiniti, Alcon). In this study, follow-up duration was limited to 1 day and 1 week

postoperatively, also the phacoemulsification machine used in this study were Infiniti for Torsional and Stelaris for Longitudinal phacoemulsification in which Stelaris has stable chamber fluidics technology that provides higher eye chamber stability in the phacoemulsification process. This system puts additional pressure on the solution from the Balanced Salt Solution (BSS) bottle, which enters anterior eye chamber quickly and in a short time. In addition, electric vacuum pumps in machines are controlled by computers with Stable Chamber Fluidics Module^{tm} so that it can adjust pump speed, vacuum control valve, and pressure; therefore, post-occlusion surge can be minimized. Stelaris is also equipped with stable camber tubing, which can withstand high vacuum pressure, thereby reducing the eye chamber instability, post-occlusion surge, and preventing clogging. Whereas in Infiniti, there is a possibility of experiencing clogging that becomes a disruption when facing a hard nuclear cataract.[3] Other studies also proved the occurrence of post-occlusion surge (POS) on Infiniti machines compared to other machines.[11.] But in this study, that cannot be compared since patients with hard nuclear cataract were found only in Torsional group.

Based on existing studies, there have been many factors reported that can cause corneal endothelial cell damages in phacoemulsification, including patient's age, eye-related diseases / ocular comorbidity, cataract types, type of solutions used in surgery, amount of BSS used, ultrasound total energy (US power), surgery duration, intraoperative complications such as posterior capsule rupture, mechanical trauma at corneal endothelium, occurrence of occlusion surge, implantation of IOL, phacoemulsification techniques and operator experiences.[3,12–14]

In this study, there were some limitations such as follow-up duration, and limited sample number, cataract grade was not classified by one examiner, there was no data on postoperative inflammatory conditions or even operating parameters such as US *power*, type of IOL, type and amount of BSS fluid used, intraoperative complications, also many surgeons got involved in this study had different experiences and operating techniques that could affect study results.

CONCLUSION

The outcomes of secondary anterior chamber IOL implantation after pars plana vitrectomy and complicated cataract surgery were found similar. There was a significant difference in the proportion of complication in both groups

REFERENCES

1. Güell, Jose L., et al. "Secondary iris-claw anterior chamber lens implantation in patients with aphakia without capsular support." *British Journal of Ophthalmology* 98.5 (2014): 658-663.
2. Finn, Avni P., et al. "Outcomes of Anterior Chamber Intraocular Lens Implantation in Patients Undergoing Pars Plana Vitrectomy." *Ophthalmology Retina* 2.9 (2018): 895-899.

3. Acar, Nur, et al. "Secondary iris claw intraocular lens implantation for the correction of aphakia after pars plana vitrectomy." *Retina* 30.1 (2010): 131-139.
4. Ersöz, M. Giray, et al. "Dislocated Intraocular Lens Extraction and Iris-Claw Lens Implantation in Vitrectomized and Non-vitrectomized Eyes." *Turkish journal of ophthalmology* 49.5 (2019): 277.
5. Moschos, Marilita M., and Eirini Nitoda. "The correction of aphakia using anterior chamber intraocular lens." *In Vivo* 30.6 (2016): 733-738.
6. van der Meulen, Ivanka J., et al. "Artisan lens implantation to correct aphakia after vitrectomy for retained nuclear lens fragments." *Journal of Cataract & Refractive Surgery* 30.12 (2004): 2585-2589.
7. Badr, Mai, et al. "Central Corneal Thickness Variances Among Different Asian Ethnicities in Glaucoma and Nonglaucoma Patients." *Journal of glaucoma* 28.3 (2019): 223-230.
8. Deshpande, Shrikant, et al. "Study of Central Corneal Thickness (CCT) bBefore and aAfter Small-Incision Cataract Surgery (SICS) and phacoemulsification surgery." *Nigerian Journal of Ophthalmology* 26.1 (2018).
9. De Silva, Samantha R., et al. "Iris-claw intraocular lenses to correct aphakia in the absence of capsule support." *Journal of Cataract & Refractive Surgery* 37.9 (2011): 1667-1672.