

Linear versus Torsional Phacoemulsification: A Comparative Study

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Purpose: The purpose of the study is to compare the efficacy between Linear and Torsional Phacoemulsification and the impact on the outcome of surgery based on corneal endothelial cell count, central corneal thickness, post operative inflammation and visual acuity.

Methods: Patients having senile cataract with grade NS2-NS3 according to Lens Opacities Classification System III were included. Exclusion criteria included any disease that could hamper vision other than cataract. 108 eyes of 108 patients were studied. Of these, 54 patients were operated by the Torsional technique and 54 patients by the linear technique. Pre operative and post operative Day 1, Day 7, Day 15, Day 28 readings were taken.

Results: The mean age of patients was 60.54 ± 7.06 (SD) years. On postoperative day 28, the endothelial cell loss was less in patients of torsional phacoemulsification technique (97.41 ± 28.61) as compared to linear technique (99.04 ± 26.09) (difference was not significant). Similarly, central corneal thickness in patients of torsional phacoemulsification technique (26.80 ± 11.07) on day 28 was statistically same as those who underwent linear technique (27.37 ± 6.76). 7.4% patients in the linear group and 7.4% patients in the torsional group had postoperative inflammation on day 1, which resolved on subsequent visits. BCVA on postoperative day 1 in patients of torsional group was 6/9 whereas linear group was 6/12.

Conclusion: The torsional technique gives faster visual recovery than the linear technique. Although there was no statistically significant difference in terms of visual acuity, endothelial cell loss, postoperative corneal edema and postoperative inflammation between the two techniques as compared preoperatively and on post operative day 28.

Abstract

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Introduction

Recent studies reported that cataract is still the leading cause of visual impairment in the world, constituting as much as 47.9% of the total causes of visual impairment.¹ In a bid to tackle this gigantic health issue, the surgical treatment of cataract has evolved over the years. The surgical treatment of cataract is a primitive art that spans over two millennia; with passing time, advancements have led us to the present day technique of phacoemulsification which has revolutionized surgical outcomes. It is a well-documented fact that cataract surgery improves visual acuity.²

Phacoemulsification comes from the Greek word 'Phako', meaning lentil, therefore the prefix phaco refers to lens [which is lentil shaped] and 'Emulsification', means to liquefy. In 1967, Kelman devised a machine for phacoemulsification which formed the basis of modern small incision cataract surgery.³ Phacoemulsification has the benefits of self-sealing small incision in the form of wound stability, negligible astigmatism and immediate visual rehabilitation.

Recent developments in phacoemulsification have made cataract removal safer and more efficient and aimed at restoring visual acuity (VA) in order to secure a faster return to normal social life and work. Technological advances have provided more options, allowing surgeons to customize their techniques, to reduce phaco energy and duration.^{4,5} However, phaco energy consumption is still the main risk factor for surgically induced trauma, especially for corneal endothelial cell injury or dysfunction which can become a nightmare for a surgeon post-operatively.⁶

In conventional phaco, the linear movement of the titanium phaco tip (LPKE) tends to push the nuclear fragments away from each other with each forward stroke, so the ultrasound needs to be purposely interrupted to retrieve the nuclear fragment to the tip; Moreover, due to the jack-hammer effect, the emulsifying power of linear phaco is only effective during the forward movement of the tip. On the other hand, the lateral tip movement of torsional phaco (TPKE) shears the lens material while moving in forward and lateral directions without imparting any repellant force. It also uses a lower frequency ultrasound energy (32MHz) than conventional phaco (40MHz), allowing for at least 20% energy conservation, thus significantly improving emulsification efficiency.^{7,8,9}

The corneal endothelium is made of a single layer of cells. These cells do not regenerate when injured. When they are damaged in large quantities, the cornea gets edematous following imbibition of fluids which causes edema and causes subsequent loss of vision.^{10,11,12,13,14} The important causes of corneal endothelial cell loss during phacoemulsification are: repulsion, ultrasound energy (USG), excessive heat production and chamber instability. Early postoperative corneal edema is a one of the significant clinical factors hindering early visual recovery. Corneal edema increases light back-scattering, which results in reduction of contrast sensitivity and increased susceptibility to glare.¹⁵ Inflammation after cataract surgery, which can be persistent, remains an undesirable consequence despite many advances in surgical techniques. The physical trauma associated with

cataract surgery, including disruption of the blood–aqueous barrier (BAB), can induce an inflammatory response and the release of inflammatory mediators such as prostaglandins and leukotrienes from arachidonic acid. Post-cataract surgery inflammation presents as protein flare and inflammatory cells in the anterior chamber.¹⁶

The purpose of the study is to compare the efficacy between Linear and Torsional Phacoemulsification and the impact on the outcome of surgery based on corneal endothelial cell count, central corneal thickness, post operative inflammation and visual acuity.

Materials and Methods

The study was conducted in the Department of Ophthalmology, Shri Guru Ram Rai Institute of Medical and Health Sciences associated with Shri Mahant Indresh Hospital, Patel Nagar, Dehradun between January 2016 and May 2017 over a period of 18 months. All patients with senile cataract presenting to the eye OPD and willing for surgery were included in the study. It was a comparative interventional study and a total of 108 patients were included in the study and equally divided into 2 groups.

Patients aged 40-70 yrs of either sex, and patients having cataract graded NS 2-3 according to Lens Opacities Classification System III [LOCSIII] were included in the study. All patients taken up for the study underwent baseline examination including BCVA, IOP, slit lamp examination, Lens Nucleus Density Grading according to LOCS III and fundoscopic examination of both eyes. In addition to this, central corneal thickness and corneal endothelial cell density was also measured, pre operatively using specular microscope CEM 530® (Nidek; Aichi, Japan), readings were taken 5 times and the average was recorded. All those patients who had any other pathology in the eye other than senile cataract, i.e. previous history of trauma, surgery, drug, systemic diseases, complicated cataract, nuclear sclerosis >3 or were lost to follow up were excluded from the study. The patients were randomly divided into two groups of 54 patients each, group A consisted of patients to be operated by linear phacoemulsification and group B consisted of patients to be operated by torsional phacoemulsification technique by a single surgeon to reduce the bias due to surgeon's factor.

Pre operatively, vision was recorded using Snellen chart, endothelial cell count and central corneal thickness were recorded using specular microscope. All readings of endothelial cell count and central corneal thickness were recorded pre operatively, on post-operative day 1, 7, 15 and 28, 5 times on each occasion and the average of the readings was noted. The intelligent Phaco (IP) was kept off at all times. The phaco machines used were the Centurion vision system (Alcon@Laboratories, Inc., Tx, USA) and the Laureate World Phaco System (Alcon@Laboratories, Inc., Tx, USA).

All eyes were dilated using 0.8% tropicamide+5% phenylephrine hydrochloride and then anesthetized using 0.5% proparacaine hydrochloride eye drops thrice at 10 min intervals prior to surgery. After preparing the eye under complete asepsis, clear corneal triplanar incision was made using 2.2 mm microkeratome along the steepest axis and

two paracenteses were made using 20G-MVR-blade 40 degrees away from the main incision. This was followed by capsulorhexis, hydrodissection-delineation and rotation and phacoemulsification using predetermined machine parameters according to the grade. In all eyes, dispersive ophthalmic viscoelastic device (OVD) methyl cellulose 2% was used. BSS-plus (Alcon Laboratories, Tx, USA) was used as irrigating fluid. The same phaco settings were used for all patients operated by the linear technique in grade 2 cataract, similarly same phaco settings were used for all patients operated by the linear technique in grade 3 cataract. In the torsional technique as well, the same phaco settings were used for patients of grade 2 and grade 3 respectively, the settings being 50 mmHg IOP for both grades of cataract, the limit of vacuum was set at 450 mmHg for grade 2 and for grade 3. The aspiration flow rate was set at 32ml/min for grade 2 and for grade 3 in both techniques. In all cases, chop and stop technique used. The average ultrasound time in Grade 2 cataracts in the longitudinal group was 73.4 ± 9.6 secs, in grade 3 it was 88.7 ± 10.4 secs whereas, in the torsional group, in Grade 2, it was 62.1 ± 7.6 secs and in grade 3, it was found to be 79.2 ± 9.9 secs.

A posterior chamber monofocal foldable acrylic hydrophobic single-piece IOL was implanted in the capsular bag in all cases Postoperatively, all patients were advised topical moxifloxacin hydrochloride 0.5% QID for 2 weeks, prednisolone acetate 1.5% six times/day in tapering doses over the next 4 weeks and ketorolac tromethamine 0.4%, four times/day for 4 weeks. All patients were followed up on the 1, 7, 15 and 28 postoperative days.

Statistical analysis was performed using the statistical package for social science system SPSS [version 17.0; SPSS Inc., Chicago, IL, USA]. Continuous variables, values over time within the groups were analyzed and presented as mean \pm SD, and categorical variables were presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using Student's t test, for within the group comparisons, paired t test was used to compare the significant change at different time points from baseline values.

Results

Table 1 illustrates that out of the total 108 patients, there were 18 males (33.3%) and 36 females (66.7%) in the linear group and there were 25 males (46.3%) and 29 females (53.7%) in the torsional group. A female dominance was seen among the study subjects.

Table 2 shows that in the linear group, the maximum patients (44.4%) belonged to age group 61 - 70 years and minimum patients (16.7%) belonged to age group 40 - 50 years. The mean age was 58.72 ± 7.83 (SD) years. In the torsional group, the maximum patients (51.9%) belonged to age group 61 - 70 years and minimum patients (11.1%) belonged to age group 40 - 50 years. The mean age was 60.54 ± 7.06 (SD) years.

Table 3 shows that the trend of corneal endothelial cell loss was never found to be statistically significant, between the linear and torsional group at any postoperative visit POD 1 [p = 0.089], POD 7 [p = 0.094], POD 15 [p = 0.081] and at

POD 28 [p = 0.077]. On POD 28, the endothelial cell loss was less in patients who underwent surgery by torsional phacoemulsification technique (97.41 ± 28.61) as compared to those who underwent by linear technique (99.04 ± 26.09). Table 4 and Figure 1 shows that the change in central corneal thickness was not found to be statistically significant between linear and torsional groups at POD 1 [p = 0.0716], POD 7 [p = 0.623], POD 15 [p = 0.497] and at POD 28 [p = 0.591]. On POD 28, the change in central corneal thickness was less in patients who underwent surgery by torsional phacoemulsification technique (26.80 ± 11.07) as compared to those who underwent surgery by linear technique (27.37 ± 6.76). The highest CCT was observed on POD1 in both groups and gradual recovery was attained at follow up visits.

Table 1: Gender wise distribution of subjects

Sex	Phaco Technique			
	Linear		Torsional	
	Frequency	%	Frequency	%
F	36	66.7%	29	53.7%
M	18	33.3%	25	46.3%
Total	54	100%	54	100%

Table 2: Age wise distribution of study subjects

Age Groups	Phaco Technique			
	Linear		Torsional	
	Frequency	%	Frequency	%
40 - 50 yrs	9	16.7%	6	11.1%
51 - 60 yrs	21	38.9%	20	37.0%
61 - 70 yrs	24	44.4%	28	51.9%
Total	54	100%	54	100%
Mean ± SD	58.72 ± 7.83		60.54 ± 7.06	

Table 3: Comparison of endothelial cell count between linear and torsional group

Endothelial Cell Count	Phaco Technique		P Value
	Linear	Torsional	
	Mean ± SD	Mean ± SD	
Baseline	2262.02 ± 290.11	2372.06 ± 370.56	0.089
POD 1	2134.63 ± 278.18	2238.63 ± 357.33	0.094
POD 7	2144.61 ± 276.78	2253.65 ± 360.02	0.081
POD 15	2154.59 ± 279.96	2262.02 ± 290.12	0.083
POD 28	2162.98 ± 282.31	2274.65 ± 361.88	0.077

Table 4: Comparison of central corneal thickness between linear and torsional group

CCT	Phaco Technique		P Value
	Linear	Torsional	
	Mean ± SD	Mean ± SD	
Baseline	505.8 ± 29.09	509.46 ± 33.17	0.543
POD 1	542.2 ± 29.18	544.37 ± 32.49	0.716
POD 7	539.91 ± 28.57	542.78 ± 31.81	0.623
POD 15	536 ± 27.23	539.93 ± 32.43	0.497
POD 28	533.17 ± 27.83	536.26 ± 31.74	0.591

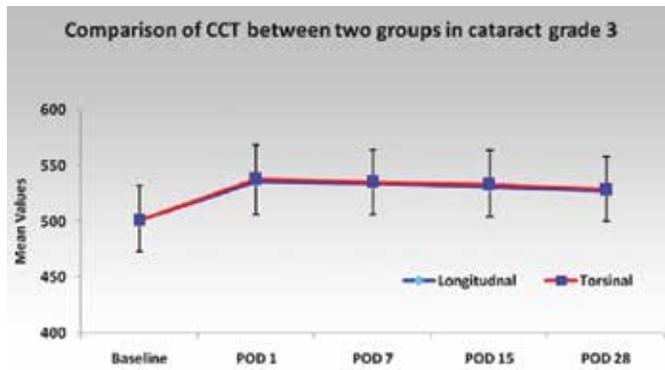


Figure 1: Shows comparison of central corneal thickness between linear and torsional phacoemulsification in Grade- III lens nuclear opacity

Table 5 and Figure 2 demonstrates that in only 4 patients (7.4%) in the linear group and 4 patients (7.4%) in the torsional group, the postoperative inflammation which was cells 1+ and flare 1+ was noticed. Patients with postoperative inflammation in the torsional group on POD1 had BCVA of 6/9 whereas the patients in linear group on POD1 had BCVA of 6/12. No patients on subsequent follow up on POD 7, 15 and 28 showed signs of any postoperative inflammation.

Table 5: Inflammation after cataract surgery

Post op Inflammation	Phaco Technique			
	Linear		Torsional	
	Frequency	%	Frequency	%
Cells 1+, Flare 1+	4	7.4%	4	7.4%
Nil	50	92.6%	50	92.6%
Total	54	100%	54	100%

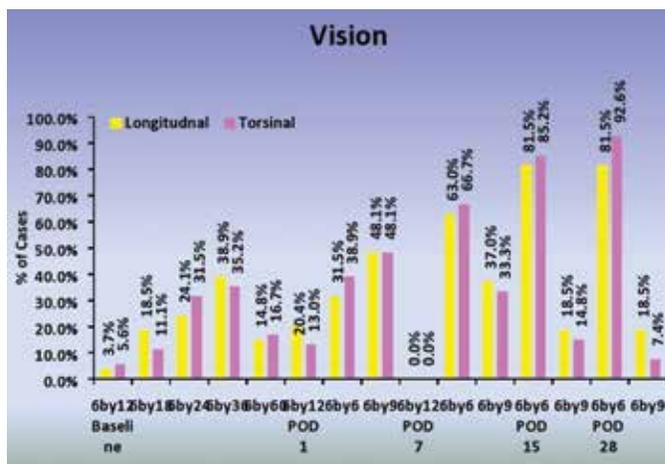


Figure 2: Comparing pattern of pre and postoperative vision in terms of percentage amongst linear and torsional phacoemulsification

Discussion

Cataract surgery is the most frequently performed operation in patients over 65 years of age.¹⁷ A technological tectonic shift has taken place in the techniques of cataract extraction. Modern cataract surgery aims at early visual rehabilitation of the patient in a minimally invasive manner. The pioneering work of Kelman has evolved into the current techniques of

phacoemulsification. The phacoemulsification ultrasound probe delivers energy into the eye that is used to break up the cataract to facilitate emulsification and aspiration. It accomplishes this by vibrating at a fixed frequency when the foot pedal is depressed to position 3. To increase the amount of ultrasound power, the machine simply increases the stroke length of the probe. Traditionally the probe delivers power only in a longitudinal manner, with the phaco needle moving forward and back. Recent innovations in phaco technology also allow for the delivery of power through a lateral motion. Delivering ultrasound power through lateral motion can increase cutting efficiency by reducing repulsion of lens material. It is important to use as little ultrasonic phaco energy as possible during the cataract surgery. The ultrasonic energy can damage the corneal endothelial cells, with excessive damage leading to corneal decompensation. The basic power settings are continuous, pulse, and burst. In the continuous power setting, energy delivery is continuous with variations in power, controlled by the amount of foot pedal depression. The range of programmability of the pulse and burst phacoemulsification settings has expanded considerably. While previous generations of phaco platforms had pulse rates of up to 20 pulses per second, the newer-generation machines have the ability to deliver up to 120 pulses per second. Similarly, the older machines had burst widths as narrow as 30 milliseconds, while the new platforms are able to deliver burst widths as fine as just 4 milliseconds. The advantage of this upgraded range of programmability is the smoothness and precision of power delivery.

Good, fast and stable visual rehabilitation is the goal of cataract surgery, and BCVA is one of the best parameters to evaluate the quality and efficiency of a surgical technique. Our study showed no statistically significant difference in the two techniques in terms of BCVA on day 1, 7, 15 or 28, however the difference in the two groups was wider on postoperative day 1 and subsequently narrowed down with time. This suggests that the torsional mode has a better visual outcome in the early postoperative phase. This pattern of visual rehabilitation after surgery is probably attributable to the corneal injury and its recovery.¹⁸ Mohamed A Fakhry and Malak I El Shazly¹⁹ also showed no statistical significance in BCVA when comparing torsional and linear mode post operatively. When comparing the postoperative inflammation between the groups, our study showed no statistically significant difference in terms of quantum of inflammation or the number of patients having inflammation, however in the patients who had postoperative inflammation, an interesting pattern was observed. In the torsional group, all patients with postoperative inflammation had a BCVA of 6/9, whereas all patients in the linear group with postoperative inflammation had a BCVA of 6/12. This difference in BCVA in patients having postoperative inflammation can be attributed to less fluid turbulence and surge due to the precise fluidic control system in the torsional phaco technique which is not present in the linear phaco technique.

Postoperative corneal thickness and edema are indirect methods to predict endothelial changes.²⁰ The central corneal thickness (CCT) is considered to be a reliable measure of a

transient corneal edema. In the present study, the change in CCT on postoperative day 1 in the torsional group was 6.85% whereas in the linear group, it was 7.20%. On measurement on postoperative day 28, the change in CCT in the torsional group was 5.00% whereas in the linear group, it was 5.41%. Although this difference between the two techniques was not statistically significant but the change in CCT was less in the torsional group as compared to the linear group on postoperative day 1 and day 28 showing better safety and efficacy of the torsional technique over the linear technique. In a recent study published in 2018, it was concluded that with torsional phacoemulsification with respect to longitudinal, the percentage of patients who can reach excellent BCVA is remarkably increased.²¹

In the present study, we compared the corneal endothelial cell changes on postoperative day 1, 7, 15 and 28 in group A and B with the data collected pre-operatively to assess the damage caused to the corneal endothelium by performing cataract surgery with the help of phacoemulsification machines. As per the findings of the study, there is a statistically significant difference in the corneal endothelial cell count on all postoperative days individually in the two groups' namely torsional phacoemulsification and linear phacoemulsification, but when the two are compared with each other the difference was not statistically significant. In the torsional group the difference in the endothelial cell count on postoperative day 1 from baseline was 5.6% and the difference was exactly the same i.e. 5.6% in the linear group, but when compared on postoperative day 28, the torsional group showed a difference of 4.4% from baseline whereas in the linear group, the difference was 4.1%. Atas et al,²² in their study conducted in Turkey, showed similar results wherein the percentage of endothelial cell loss 30 days after surgery was 7% in the longitudinal group and 6% in the torsional group respectively which was not statistically significant. Below is the comparative study table.

Comparative Study

	Fakhry and El Shazly ¹⁹	Atas et al ²²	Sorrentino et al ²¹	Current Study
Corneal Endothelium Cell Loss	No Statistical Difference	No Statistical Difference	Torsional < Longitudinal	No Statistical Difference
Central Corneal Thickness	No Statistical Difference	No Statistical Difference	Torsional < Longitudinal	No Statistical Difference
Best Corrected Visual Acuity	No Statistical Difference	No Statistical Difference	Torsional > Longitudinal	No Statistical Difference

Conclusion

As we stand today with the evolution of technology, the pressure on ophthalmologists to give early and perfect visual rehabilitation to patients undergoing cataract surgery has increased manifold. This has led to increased expectations of patients from ophthalmologists, which has made many believe that cataract surgery is now a refractive surgery. In the present study, we have compared the two latest techniques of cataract surgery and tried to decipher the advantages of one technique over the other. On comparing the two techniques, we conclude that the

torsional technique gives faster visual recovery than the linear technique although this advantage is narrowed down with the passage of time. In terms of endothelial cell loss and postoperative corneal edema, the torsional technique shows slightly better results although not statistically significant inferring that the torsional technique is safer and has more efficacy than the linear technique.

All the patients in the present study were divided in two groups of nuclear opacity grade 2 and nuclear opacity grade 3 and it was concluded that in these groups, there was no statistically significant difference in terms of endothelial cell loss, postoperative corneal edema and postoperative inflammation between the two techniques.

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