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COMPARATIVE ANALYSIS OF ENDOTHELIAL CELL LOSS IN MATURE CATARACTS FOLLOWING PHACOEMULSIFICATION AND MANUAL SMALL INCISION CATARACT SURGERY

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ABSTRACT

Background: Corneal transparency depends on the corneal endothelium's structural soundness and functionality. The range of corneal endothelial cell count (ECC) in the adult population is 2000–2500 cells/mm2. ECC continues to decline with age.

Purpose: To compare the structural and functional endothelial cell (EC) changes in mature cataracts after phacoemulsification (PKE) and small incision cataract surgery (SICS).

Methods: In the current Prospective double-masked observational study a total of 200 eyes of 200 patients between 60 & 90 years of age with senile cataracts of nuclear sclerosis grade IV and above were enrolled. Patients were randomly assigned into two groups of 100 eyes each in Group A (SICS) & Group B (PKE). Corneal EC count and central corneal thickness (CCT) were done preoperatively and postoperatively on day 7 and day 30.

Results: The mean EC loss on postoperative day 7 in Group A was 14.54% and in Group B was 7.92% which was statistically significant. Though EC count improved in both the groups at 30 days post-operative visit, significantly more EC loss continued in Group A. The mean increase in CCT on postoperative day 7 in Group A was 3.04%, and in Group B was 1.69% which was statistically significant. On postoperative day 30, CCT improved in both groups and the difference was not statistically significant.

Conclusion: In the case of mature cataracts, PKE done by direct chop technique leads to lesser EC loss and thinner corneas postoperatively as compared to SICS.

Keywords: Endothelial Cell, Specular Microscope, Pachymetry, Mature Cataract, Phacoemulsification, Small Incision Cataract Surgery.

INTRODUCTION

Both structural integrity and function of the corneal endothelium are pivotal for corneal transparency. In the adult population, corneal endothelial cell count (ECC) ranges from 2000 to 2500 cells/mm^2.[1] With aging ECC continues to decrease. All surgical procedures involving maneuvers in the anterior chamber lead to loss of ECC.[2] Both Phacoemulsification (PKE) and small incision cataract

surgery(SICS) are well-established techniques for treating cataracts.[3] In PKE, the nucleus is divided into pieces and consumed by ultrasonic energy that causes thermal harm to the corneal endothelium.[4] In SICS, the whole nucleus is prolapsed into the anterior chamber and delivered through the scleral tunnel. This corneolenticular touch leads to loss of ECC.[5] Endothelial cell number and function can be measured by using a specular microscope and pachymetry. Preoperative factors that determine EC loss are the age of the patient, density of the cataract, axial length, pupillary dilatation, and anterior chamber depth.[6] Intraoperative factors like incision size, descemet membrane detachment, toxic intracameral medications, and PKE technique also determine EC loss.[7] Few studies reported that PKE had significantly more EC loss than SICS at 1 & 6-week intervals.[5,8,9] Few studies had found that SICS was associated with significantly more EC loss as compared to PKE at 1 & 6-week intervals.[10,11]The difference in the findings could be because of different grades of cataracts, surgical techniques, or advanced age. So, the study was planned to evaluate EC changes in mature cataracts following PKE & SICS where known influencers were similar.

METHODS

Institutional ethics committee approval was taken on 17 March 2022 vide protocol number IEC/OPHTHA/2022/0457. A prospective study was conducted at a multi-specialty hospital in eastern India from April 2022 to April 2024. It was double-masked as both the participants and investigators were oblivious to the treatment group. Patients were explained about both procedures and also informed that they would undergo one of these two procedures. After giving written consent in the local language, they were enrolled in the study. Patients were assured that they could withdraw from the study anytime and it would not affect the quality of care. A total of 200 patients between 60 and 90 years with senile cataracts of nuclear sclerosis IV & above (LOCS Grading) were enrolled in the study.

Exclusion Criteria

- Pseudoexfoliation.
- Corneal scar
- EC count <1500 cells/mm²
- Anterior Chamber (AC) depth <2.0 mm
- Phacomorphic or phacolytic Glaucoma
- Prior intraocular surgery
- Surgical time >15 min
- Surgical complication
- Maximum pupillary dilatation < 6 mm
- Retinal detachment

In all patients uncorrected visual acuity and best corrected visual acuity (BCVA) were recorded. Intraocular pressure (IOP) was measured by a Goldman applanation tonometer. After confirming open angle status, pupils were dilated by putting a single tropicamide 0.8% with phenylephrine 5% eye drop (Sunways, Mumbai, India) in both eyes every 10 minutes for 30 minutes. The dilated pupillary size was measured by the height of the slitbeam and the lens was classified according to the Lens opacities classification system (LOCS). After two independent examiners classified the cataract as nuclear sclerosis grade IV or above, they were included in the study.

200 eyes of these 200 patients were randomly assigned into two groups- SICS (Group A) and PKE (Group B). We used computer-generated number allocation for randomization. In all patients, ECC and central corneal thickness (CCT) was measured preoperatively and postoperatively on days 7 and 30. ECC and CCT were autocalculated from the central 3mm corneal image in a specular microscope (Topcon, Tokyo, Japan). Anterior chamber depth and keratometry were done using IOL Master (Carl Zeiss, Oberkochen, Germany). Immersion ultrasound A Scan was done to measure axial length and ultrasound B scan (Appasamy, Chennai, India) was done to confirm retinal attachment in case of no retinal view. IOL power was calculated in all patients by using the Sanders, Retzlaff, Kraff-T (SRK-

T) formula. Optometrists who did pre and post-operative checkups and data collection were masked about group allotment.

Surgical Technique (SICS)

2 ml of 0.5% bupivacaine and 4 ml of 2% lignocaine mixed with 150 IU of hyaluronidase were given to achieve peribulbar anesthesia. All surgeries were done by an expert surgeon (RB). After taking standard sterile precautions, a peritomy was done superiorly. A 6 mm scleral tunnel was created by using a crescent blade (Medinova, Hyderabad, India) at a 2 mm distance behind the limbus. The anterior chamber was entered with a 2.8 mm keratome (Medinova, Hyderabad, India). In all the cases staining of the anterior capsule was done by injecting 0.06% w/v Trypan blue (Aurolab, Madurai, India) intracamerally. Ophthalmic viscosurgical device (OVD), hydroxypropyl methylcellulose (HPMC) 2% w/v (Aurolab, Madurai, India) was used to maintain the AC. Continuous curvilinear capsulorhexis (CCC) was made by either a 26 gauge cystitome or a capsulorhexis forcep. [Figure 1] In the case of capsulorhexis runaway in hypermature cataract, a cut was given to the opposite side and capsulorhexis was completed with a capsulorhexis forceps. Gentle hydrodissection was done at per surgeon's discretion. A Sinskey hook was used to dial and bring the nucleus into the AC. The nucleus was taken out through the scleral tunnel by viscoexpression technique using the same OVD. Cortical matters were removed by Simcoe cannula. A single-piece PMMA IOL (Aurolab, Madurai, India) was implanted inside the capsular bag. The anterior chamber was formed by hydration through the side port. The scleral tunnel was not sutured. Conjunctiva was apposed with cautery.

Surgical Technique (PKE)

All surgeries were done by an expert surgeon (PPM) under peribulbar anesthesia. The main incision was given temporally by a 2.8 mm keratome (Medinova, Hyderabad, India). A side port incision was given at 6 o'clock in the right and 12 o'clock in the left eye. The anterior capsule was stained by injecting intracamerally 0.06% w/v Trypan blue (Aurolab, Madurai, India). To maintain the AC, HPMC was used in all the cases. CCC was performed by a forceps. Hydrodissection was performed at per surgeon's discretion. A sharp chopper was used to crack the nucleus by employing the direct chop technique using a PKE machine (Oertli, Berneck, Switzerland). [Figure 2] Multilevel chopping was performed to achieve a complete crack of the posterior plate. Nuclear fragments were consumed maintaining tip-down position. The following phaco parameters were used: maximum vacuum 400 mmHg, aspiration flow rate 40 ml per minute, 80 percent power in pulse mode and bottle height 100 cm above the patient's eye. Absolute PKE time was noted in all the cases. A coaxial irrigation aspiration probe was used in all the cases to aspirate the cortical matter. A foldable monofocal hydrophobic acrylic lens (Appasamy Associates, Chennai, India) was implanted in the capsular bag with the help of an injector. On postoperative day 1, patients were advised topical Moxifloxacin 4 times/day and topical Prednisolone acetate 1% w/v six times daily tapered over 4 weeks. Intraocular pressure was measured by a noncontact tonometer on postoperative days 7 and 30.

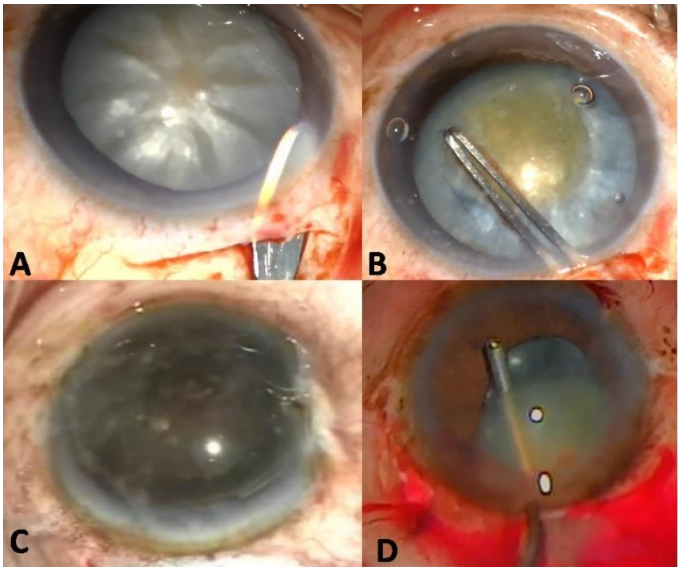

Figure 1: Scleral tunnel being made [A]. Capsulorhexis is done with a forceps [B]. A Sinskey hook is used to bring the nucleus into the anterior chamber [C]. The nucleus was delivered through the tunnel by the viscoexpression technique [D]

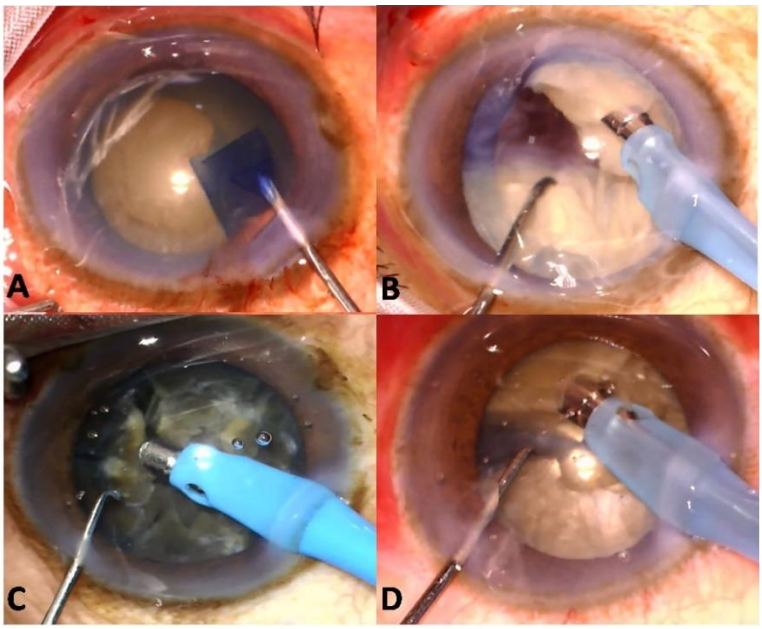

Figure 2: Capsulorhexis being done with a cystitome [A]. Multilevel chopping was performed till a complete crack of the posterior plate was achieved [B]. The nucleus is divided into multiple pieces [C]. Nuclear fragments were emulsified maintaining tip-down position

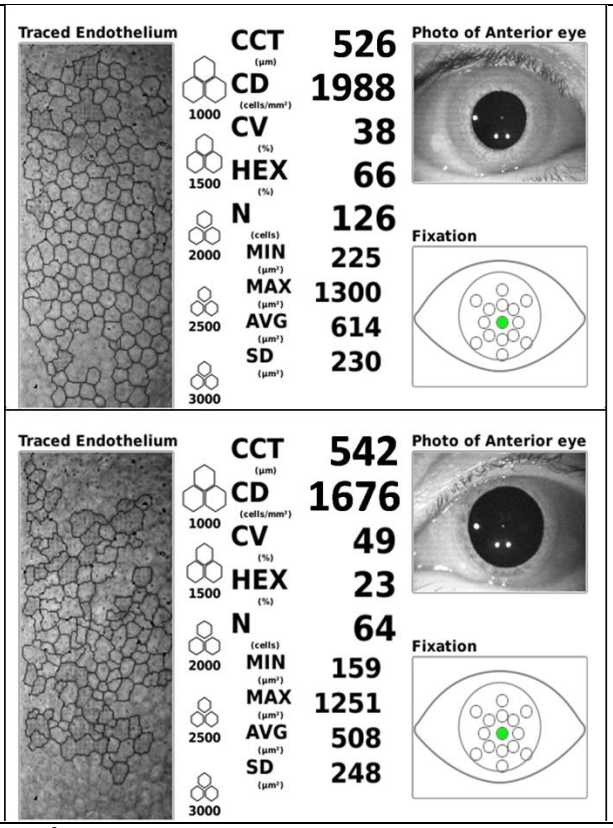

Figure 3: Pre(Above) and 7th-day post-operative(Below) specular microscopy of a patient in the SICS group

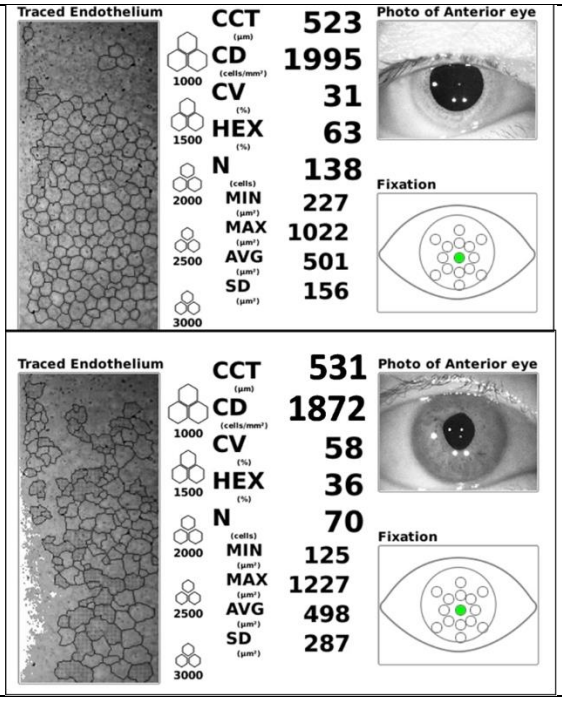

Figure 4: Pre(Above) and 7th-day post-operative(Below) specular microscopy of a patient in the Phacoemulsification group

RESULTS

All the continuous parameters were measured as mean ± standard deviation. In any group, pre and post-operative results were compared by using the paired t-test. Across the group, comparison was made by using the unpaired t-test. P value < 0.05 was considered statistically significant.

Preoperative: The Mean age in group A was 78+/- 11 years and in group B was 82+/- 16 years. (P value- 0.30). Both the groups were comparable in terms of grades of cataracts. (Table 1)
Postoperative Day 7: Significant EC loss was noted in both groups as compared to their preoperative value (P value- 0.001).[Figure 3 & 4] There was a decrease in cell density of 326+/- 17 cell/mm^2 (14.54%) in Group A and 168+/-32 cell/mm^2(7.92%) in Group B.(Table 2) Significantly more EC loss was noted in Group A as compared to Group B.(P value- 0.0001) Mean increase in CCT was 16+/- 7 μm in Group A and 9+/-4 μm in Group B . Corneas were thicker in Group A as compared to Group B. (P value- 0.006)
Postoperative day 30: EC count improved in both the groups, though significantly more EC loss persisted in Group A. (P value- 0.003) No significant difference in CCT was observed in the group. (P value- 0.095)

Category	**SICS**		**PKE**	
	Number of patients	**Percentage**	**Number of patients**	**Percentage**
NS IV	37	37.37%	31	31.63%
NS V	29	29.29%	34	34.69%
Hypermature	26	26.26%	22	22.45%
Morgagnian	7	7.07%	11	11.22%
Total	99	100%	98	100%

Table 1: Grade of cataracts and their distribution in the two groups

	Group A		**Group B**		
	EC Count	**EC loss (%)**	**EC Count**	**EC loss (%)**	**P value**
Preop	2296+/- 281		2284 +/- 305		0.773
Postop Day 7	1962+/- 287	326+/- 17 (14.54%)	2103+/- 205	168+/- 32 (7.92%)	0.0001
Postop Day 30	2058 +/- 267	256+/-24 (10.36%)	2164+/- 224	132+/-17 (5.25%)	0.003
	CCT	CCT change (%)	CCT	CCT change (%)	
Preop	526+/- 32		531 +/- 26		0.227
Postop Day 7	544+/- 12	16+/-7(3.04%)	538+/- 18	9+/- 4(1.69%)	0.006
Postop Day 30	541+/- 23	11+/- 3(2.09%)	536+/- 19	8+/-5(1.50%)	0.095

Table 2: Changes in the endothelial cell count & central corneal thickness in the two groups

DISCUSSION

SICS is a popular technique for cataract management in the developing world as it is faster and relatively inexpensive.[12] PKE has the advantage of reduced astigmatism and faster recovery.[13] Any intraocular surgery should be aimed to reduce damage of the corneal endothelium.[14] PKE was reported to cause 4%–25% endothelial cell loss.[15] Total ultrasonic energy, pupillary dilatation, different techniques of PKE, the Surgeon's experience, and the plane of phacoemulsification decide the loss of EC.[16] Earlier studies had reported that SICS had 4%–17% with endothelial cell loss.[17] Corneolenticular contact time, technique of nucleus delivery, grade of cataract, and pupillary dilatation are the factors that determine EC loss during SICS.[18]
In our study, age was comparable in both groups. Previous studies have reported that ECC decreases with age but CCT does not directly correlate with age.[1] 80.78% of patients in Group A and 92.08% of patients in Group B achieved BCVA of >6/18 at 1 month. Visual outcome after PKE was significantly better than SICS. Earlier studies had found similar results.[5] However, this finding of our study can be flawed as we could not see the fundus clearly before surgery. So, preoperatively both the groups were not comparable in terms of visual potential.
In our study, SICS had significantly more EC loss as compared to PKE at both 7 and 30-day postoperative checkups. Ganekal S et al[10] compared EC loss after SICS & PKE in 100 patients in each group. They found SICS had significantly more EC loss as compared to PKE (Direct chop

technique). Kumar R et al[5] compared endothelial changes after PKE & SICS in 100 patients in each group. They found that SICS had significantly less EC cell loss as compared to PKE (Divide & conquer technique). Differences in the findings could be because of the different grades of cataracts included in the study and the PKE technique. Guedes J et al[19] conducted a systemic review and meta-analysis on 9 studies and concluded that the direct chop technique had significantly less EC loss as compared to the divide and conquer technique.

In our study during 1-week postoperative visit, SICS group had thicker corneas as compared to PKE group. Perone et al[20] conducted a study on 85 patients post-PKE. They found that mean CCT increased 1.8% on day 4 and 0.1% on day 15. Deshpande et al[21] conducted a study on 101 patients who underwent PKE and SICS. They found that the mean increase in CCT in the SICS group was 18 µm on day 7 and 5 µm on day 30. Both the study results are comparable with our findings. At 30 days post-operative period, the difference in CCT was not statistically significant. Salvi et al[22] found that post-PKE, CCT increased by 6.44% on day 1 which reached near its preoperative levels after 1 week. In our study prolonged time needed to come to near preoperative values could be because of harder grades of cataracts included in the study. 2 patients in the PKE group with hypermature cataracts developed radial tears in the anterior capsule during capsulorhexis. They were converted to SICS and hence excluded from the study. 3 patients in the SICS group had persistent corneal edema at 30 days postoperative period. They were treated with topical prednisolone at reduced frequency till the edema resolved and were followed at monthly intervals. In 2 cases edema resolved at 2 months and in 1 case it required 3 months to completely resolve. The preoperative EC count of these 3 patients were 1682, 1724 & 1748 cells/mm^2. Given the finding, we recommend that PKE with direct chop technique may be a safer option in patients of mature cataracts with an EC count less than 1800.

However, we have certain limitations in our study. Here only one technique of PKE was compared with one technique of nucleus delivery in SICS. Different techniques may alter the outcome. We used dispersive OVD in all cases. Cohesive or adaptive OVD may have different outcomes. Though we planned 3 monthly follow-ups for 6 months in both groups, low turnover of the participants (<20%) precludes assessment of long-term changes in these eyes. Gharaee H et al[23] in their study had found that no significant change in the EC count occurs after 1 month of cataract surgery.

CONCLUSION

Both PKE and SICS are safe modes of cataract surgery leading to excellent visual outcomes. SICS with low-cost logistics can be employed while dealing with a mass number of cataract surgeries. PKE with direct chop technique may be preferred over the viscoexpression technique of SICS in mature cataracts. Mature cataracts with an EC count of less than 1800 cells/mm^2 are vulnerable to persistent corneal edema post-SICS.

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