

# Corneal Endothelial Cell Damage During Manual Small Incision Cataract Surgery

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## ABSTRACT

**Introduction:** In maintenance of transparency in cornea, the corneal endothelium plays a major role and cataract surgery has influence on endothelial cell change. In this study, we tried to analyse endothelial behaviour post small incision cataract surgery using specular microscope and its clinical relevance.

**Materials and Methods:** 100 cataractous eyes of 100 patients underwent MSICS with posterior chamber intraocular lens implantation. Preoperative and post-operative corneal endothelial cell density and other morphometric parameters like average cell size, co-efficient of variation of cell size and hexagonality of the cells were analysed using specular microscope. Change in these parameters over follow-up period were recorded and correlated with clinical outcomes.

**Results:** Of the 100 patients, the mean endothelial cell density before undergoing operation was  $2681.28 \pm 322$  (SD) which was reduced to  $2506.31 \pm 296$  (SD),  $2435.26 \pm 292$  (SD) at 1 week and  $2403.26 \pm 290$  (SD) at 1 month, finally  $2392.08 \pm 290$  (SD) at 3 months. The mean reduction of endothelial cell density at every stage of follow up was statistically significant ( $p < 0.05$ ). The mean CV of cell size before operation was  $33.28 \pm 4.8$  (SD) %. On the 1st postoperative day, it increased to  $36.15 \pm 4.6$  (SD) %. After 1 month  $36.17 \pm 3.8$  (SD) %. The change in the mean CV on the 1st postoperative day was significant ( $p < 0.05$ ). After that, further changes in mean CV were not significant over time.

**Conclusions:** There is a statistically significant reduction in the CECD following MSICS which is clinically not significant, because none of the cases developed corneal decompensation postoperatively.

**Key Words:** Corneal endothelial cell density, corneal decompensation, Endothelial cell loss, Manual small incision cataract surgery, Specular microscopy

corneas.<sup>2</sup>

Mild stress to endothelium may result in endothelial cell size and shape changes, while greater stress may result in cell loss as well as irreversible alterations in the endothelial cytoskeleton.<sup>6</sup> Sources of stress may be metabolic (from hypoxia or hyperglycemia), toxic (from drugs or preservatives), injury (from trauma or surgery) or alterations in pH or osmolarity. The corneal endothelial cell layer cannot regenerate after injury. Repair processes involve enlargement of residual cells, amitotic nucleus division, migration, and the rosette phenomenon, which leads to a reduction in cell density, a proportional increase in mean cell size, and disruption of the normal hexagonal cell pattern. Endothelial injury may occur during cataract surgery due to a number of factors, such as corneal distortion, irrigating fluid, ricocheting of nuclear fragments and intraocular lens contact.

The aim was to study the changes in the corneal endothelial cell density and morphometric parameters following MSICS. **Materials and Methods:** This prospective study included 100 cases having either unilateral or bilateral senile cataract who visited our hospital for treatment between January 2011 and September 2011. After taking detailed history and doing general, systemic and ocular examination, each case was subjected to Specular microscopy of the cataractous eye 1 day before the surgery (MSICS) for determining the central corneal endothelial cell density and other morphometric parameters like average cell size, minimum cell size, maximum cell size, coefficient of variation of cell size and hexagonality. A single surgeon performed all the surgeries which were uneventful. The surgeon was not aware about the identity of the case among other patients on each operative day. After surgery, each case was again subjected to Specular microscopy on the first postoperative day for recording the same endothelial parameters. All cases were discharged on the 1<sup>st</sup> postoperative day with topical antibiotic-steroid combination eye-drops for 6 weeks,

## INTRODUCTION

One of the most important functions of cornea is to maintain its transparency for optimal clarity of vision. Of all the factors that contribute to the maintenance of transparency in cornea, the corneal endothelium plays a major role. Corneal endothelium is a single layer of 400,000 to 500,000 cells forming a boundary between the corneal stroma and anterior chamber. The endothelial monolayer from young individuals consists of polygonal cells, 4 to 6 micrometer thick, with a diameter of approximately 20 micrometer.<sup>1</sup> At birth, the endothelial cell density is about 3000 to 4000/mm<sup>2</sup> which decreases gradually to about 2600/mm<sup>2</sup> in adult. The central endothelial cell density decreases at an average rate of 0.6% per year in normal

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gradually tapering the dose. All cases were followed up after 1 week, 1 month and 3 months for recording the endothelial parameters as described earlier. A single operator performed the specular microscopy of all the cases both preoperatively and during all the follow-up visits.

**Surgical technique:** 6 to 10 ml of anaesthetic solution was administered by two point peribulbar route. The solution was prepared as follows: 6-10 ml of 2% Lignocaine in 1:200,000 Adrenaline mixed with 1500 IU of Hyaluronic acid. Moderate intermittent pressure was applied until ocular akinesia was achieved. Eyelid and periocular skin were cleaned with spirit swab, followed by 5% povidone iodine solution which was also instilled in the conjunctival sac and kept for 3 minutes. Sterile draping was done including the lid margins. Frown shaped incision 5.5-7.5 mm in length was made superiorly 2mm behind the limbus. Capsulorhexis was done with a 26G bent needle through a sideport. Hydrodissection was performed using Ringer's Lactate solution. 2% hydroxypropyl methylcellulose was used as viscoelastic substance. Nucleus was delivered using sandwich technique. PMMA IOLs were implanted in the capsular bag. Duration of surgery ranged from 10 to 15 minutes, which was recorded as the duration from the time of sideport entry upto the completion of the viscoelastic washout from the anterior chamber following IOL implantation.

### Specular microscopy

Patient was seated comfortably in front of the Specular microscope, with his/her chin and forehead resting snugly on the chin-rest and forehead-rest of the microscope. Photography was done in 'Auto' mode and 'Low' flash level. Photography point was selected at the central cornea. The image was transferred to a personal computer (PC) installed with the 'Cell Count' software through a USB cord. The 'Cell Count' program was set at 'AutoAnalyze' mode. As the image got transferred to the PC, the data was automatically analyzed and its results were displayed on the screen. 3 sets of observation were made for each variable and the average value was taken during all measurements (Figure 1, Figure 2).

### Exclusion criteria

Patients with developmental cataract, traumatic cataract, complicated cataract, acquired or hereditary corneal pathology, glaucoma, past history of ocular trauma or systemic illness like Diabetes Mellitus were excluded from the study.

## RESULTS

The total number of cases enrolled for the study was 100; of which 54 (54%) were males and 46 (46%) were females. The mean age was  $64.12 \pm 8.58$  (SD) years ranging from 48 years to 86 years. The mean endothelial cell density (ECD) before undergoing operation was  $2681.28 \pm 322$  (SD) (Figure 3). On the first postoperative day, the mean ECD of the operated eyes reduced to  $2506.31 \pm 296$  (SD) which was statistically significant ( $p < 0.05$ ). After 1 week, the mean ECD was  $2435.26 \pm 292$  (SD) ( $p < 0.05$ ). After 1 month, the mean ECD was  $2403.26 \pm 290$  (SD) ( $p < 0.05$ ). After 3 months, the mean



Figure 1: Specular microscope

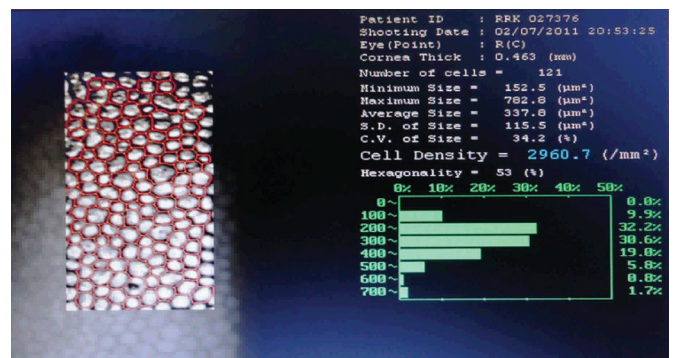


Figure 2: Endothelial cell count display on monitor

ECD was  $2392.08 \pm 290$  (SD) ( $p < 0.05$ ) (Figure 4). The mean reduction of endothelial cell density at every stage of follow up was statistically significant ( $p < 0.05$ ) [Table 1]. The effect of tunnel length and duration of surgery on the endothelial cells are shown in Table 2 and Table 3.

Preoperatively, the average cell size of the endothelial cells was  $402.31 \pm 45$  (SD)  $\mu\text{m}^2$ . On the first postoperative day, the average cell size was  $403.01 \pm 51.5$  (SD)  $\mu\text{m}^2$  which was statistically not significant ( $p = 0.84$ ). After 1 week, the average cell size was  $421.5 \pm 42.6$  (SD)  $\mu\text{m}^2$  ( $p < 0.05$ ). After 1 month, the average cell size was  $420.95 \pm 45$  (SD)  $\mu\text{m}^2$  ( $p < 0.05$ ). After 3 months, the average cell size was  $420.82 \pm 41.6$  (SD)  $\mu\text{m}^2$  ( $p < 0.05$ ). The change in the average cell size upto 1 week was significant. From 1 week to 1 month, the change in average cell size was not significant ( $p = 0.78$ ), and so also from 1 month to 3 month ( $p = 0.94$ ) [Table 1].

The mean Coefficient of variation (CV) of cell size before operation was  $33.28 \pm 4.8$  (SD)%. On the 1<sup>st</sup> postoperative day, the mean CV increased to  $36.15 \pm 4.6$  (SD)%. After 1 week, the mean CV was  $36.5 \pm 4.4$  (SD)%. After 1 month, the mean CV was  $36.17 \pm 3.8$  (SD)%. After 3 months, the mean CV was  $36.25 \pm 3.4$  (SD)%. The change in the mean CV on the 1<sup>st</sup> postoperative day was significant ( $p < 0.05$ ). After that, further changes in mean CV were not significant over time [Table 1]. The mean percentage of hexagonal cells before the operation

	Preoperative	1 <sup>st</sup> postoperative day	After 1 week	After 1 month	After 3 months
Endothelial Cell Density (cells/mm <sup>2</sup> )	2681.3	2506.3	2435.3	2403.3	2392.1
Endothelial cell loss (cells/mm <sup>2</sup> )		175	246	278	289.2
Average cell size (μm <sup>2</sup> )	402.31	403.01	421.5	420.95	420.82
CV (%)	33.28	36.08	36.5	36.17	36.25
Hexagonality (%)	54.79	53.02	51.79	51.64	51.37

**Table-1:** Endothelial parameters before and after operation

Tunnel length (mm)	No. of cases	Average cell loss±SD (per sq. mm) on 1 <sup>st</sup> postoperative day	Average cell loss±SD (per sq. mm) after 3 months
5.5	8	160.2±36.6	274.0±34.6
6	20	162.7±41.6	275.9±50.6
6.5	32	153.6±49.8	259.9±58.4
7	26	202.2±62.0	329.8±58.7
7.5	14	198.8±56.9	308.1±53.1

**Table-2:** Tunnel length vs endothelial cell loss

Duration of surgery (minutes)	No. of cases	Average cell loss±SD (per sq. mm) on 1 <sup>st</sup> postoperative day	Average cell loss±SD (per sq. mm) after 3 months
10	8	164.3±39.2	266.1±42.5
11	14	143.6±33.7	255.0±40.5
12	22	165.5±40.2	278.4±58.9
13	28	160.5±47.5	286.2±56.1
14	16	197.6±62.8	314.3±66.9
15	12	239.3±63.3	337.3±64.8

**Table-3:** Duration of surgery vs endothelial cell loss

was 54.79±6(SD)%. On the 1<sup>st</sup> postoperative day, the mean hexagonality of cells reduced to 53.02±5.5(SD)%. The mean hexagonality of cells after 1 week, 1 month and 3 months were 51.79±5(SD)%, 51.64±5.2(SD)% and 51.37±5.4(SD)% respectively [Table 1].

## DISCUSSION

Various studies in the recent and distant past have shown significant variations in the amount of corneal endothelial cell loss following cataract surgery. Some of the studies have specifically mentioned about the type of cataract surgery performed, while some others have not mentioned in detail about the factors which may have influence on the corneal endothelium.

In this study, The mean reduction of endothelial cell density at every stage of follow up was statistically significant ( $p < 0.05$ ). Parikshit Gogate et al<sup>7</sup>, found a mean endothelial cell loss of 11.1% and 15.3% after 1 week and 6 weeks respectively following SICS, and 13.2% and 15.5% after 1 week and 6 weeks respectively following phacoemulsification. Nanako Furuse et al<sup>8</sup> also found that 10 to 20% of cells were lost during the 3 months after the operation, and the number of cells remained stationary thereafter, similar findings were obtained by A C Sobottka Ventura et al<sup>9</sup>. These variations in the results of this study as compared with the past studies might be due to differences cases selection or surgical techniques employed. In

this study, it has been found that there is a reduction of 10.4% and 10.8% in the ECD at 1 month and 3 months postoperatively, compared to preoperative value, which means that the change is only 0.4% between 1 month and 3 months. So, it may be considered that the wound healing is almost complete at around 3 months after the surgery.

As such, studies concentrating on the duration of surgery could not be found exactly in the literature; but some studies have definitely suggested that patients with intraoperative complications, subsequently taking longer duration for its management, had a significantly higher percentage cell loss compared with those without complications. In this study, even though there were no significant intraoperative complications, variation in the duration of surgery was observed due to difference in time taken to perform various steps of the surgery, i.e. capsulorhexis, nucleus prolapse in anterior chamber, nucleus delivery, PCIOL implantation and so on. But the range of operative duration in this study was narrow (10-15 minutes), and the variation in the amount of cell loss corresponding to the operative duration was not significant statistically after 3 months. (Tble-2) In this study, variation in incision length was due to variation in the anticipated size of the cataractous nucleus according to its grading. This parameter was analyzed because, when the incision size is larger, the inner lip of the sclero-corneal tunnel is expected to be larger with subsequent greater injury to corneal endothelium. (Table-3) Though specific study on the size of incision has not been found in literature, some studies have suggested that endothelial cell loss correlates well with the degree of endothelial trauma.<sup>10</sup>

Due to compensatory enlargement of the cells, the mean endothelial cell area increased progressively in the postoperative period. In a study conducted by Christopher Wirbelauer et al<sup>11</sup> to characterize possible differences in endothelial cell changes after cataract surgery in patients with pseudoexfoliation syndrome (PSX), they found that the total increase in cell area was 70 μm<sup>2</sup> in the PSX group and 51 μm<sup>2</sup> in the control group ( $P < .001$  for both) after 6 months, without intergroup differences. Glasser DB et al<sup>12</sup> had emphasized that analysis of individual cell areas and shapes is a more sensitive indicator of endothelial damage or stress than ECD measurement. While a decline in ECD represents a history of endothelial cell loss, cellular pattern changes represent a healing response to previous or ongoing cell damage.<sup>13</sup>

The changes observed in the coefficient of variation of cell size and hexagonality of cells in this study are similar with the findings of Soichi Morikubo et al<sup>14</sup>, David B. Glasser et al<sup>15</sup>, Dennis S. C. Lam et al<sup>16</sup>. Changes in the morphometric parameters like increase in the average cell size and coefficient of variation of cell size (CV), and decrease in the hexagonality

of cells following surgery as observed in this study are justifiable in view of the corneal endothelial response to surgically induced trauma.

## CONCLUSION

There is a statistically significant reduction in the corneal endothelial cell density as well as variation in other parameters like cell size and coefficient of variation following small incision cataract surgery; which is clinically not significant, because none of the cases developed corneal decompensation postoperatively. The meticulous surgical technique and good cell counts pre-operatively had favoured post-operative outcomes though specular microscopy studies showed significant qualitative and quantitative endothelial cellular alterations.

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