Ultrasonic pachymeter: a little different role

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ABSTRACT

BACKGROUND

Ultrasonic pachymeter, though primarily used in refractive surgery and in glaucoma evaluation, can evaluate and compare the change in corneal thickness following extracapsular cataract extraction (ECCE), small incision cataract surgery (SICS) and phacoemulsification.

METHOD

Six hundred patients were included in study. Patients were divided into three groups. Group 1 (200 eyes), group 2 (200 eyes) and group 3 (200 eyes) underwent ECCE, SICS, and phacoemulsification, respectively. Corneal thickness was evaluated pre-operatively and postoperatively on day 1, day 2, day 7, day 15, and day 30 by ultrasonic pachymetry.

RESULTS

Mean pre-operative corneal thickness in central, superior, inferior, nasal, and temporal quadrants is $525.35 \pm 32.34 \mu\text{m}$, $592.23 \pm 35.39 \mu\text{m}$, $595.66 \pm 31.68 \mu\text{m}$, $589.29 \pm 38.07 \mu\text{m}$, and $581.19 \pm 42.31 \mu\text{m}$, respectively. Postoperatively, a highly significant ($P \leq 0.01$) increase in central corneal thickness was observed up to day 15 in ECCE, day 7 in SICS whereas it was up to day 2 in phacoemulsification. In superior quadrant, it is up to day 15 in ECCE and SICS whereas it is up to day 7 in phacoemulsification. In inferior quadrant, it was up to day 2 in all three techniques. In temporal quadrant, it is up to day 7 in ECCE and up to day 2 in SICS and phacoemulsification. In nasal quadrant, a highly significant ($P \leq 0.01$) increase in corneal thickness was observed up to day 7 in ECCE and SICS whereas it was up to day 2 in phacoemulsification.

CONCLUSION

Normal central corneal thickness is $525.35 \pm 32.44 \mu\text{m}$. At midperiphery, inferior cornea has maximum corneal thickness followed by superior, temporal, and nasal cornea. Postoperatively, pre-operative value of corneal thickness and visual rehabilitation is achieved earliest in phacoemulsification followed by SICS and ECCE.

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Key Words: corneal thickness; ECCE; phacoemulsification; SICS; ultrasonic pachymeter

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INTRODUCTION

Cataract surgery, either by phacoemulsification, small incision cataract surgery (SICS) or extracapsular cataract extraction (ECCE), leads to a certain amount of endothelial insult. This is best studied by a specular microscope, which delineates the extent of morphological and numerical changes in endothelial cells.¹ However, in clinical setting corneal thickness varies in direct proportion to the endothelial cell function.² Pachymetry involves measurement of corneal thickness, which is an indirect indication of the functional integrity of the corneal endothelium.³ In clinical setting, though endothelial insult is best studied by specular microscopy, ultrasonic pachymeter (Figures 1A and B) can be an useful alternative tool in assessing degree of endothelial insult.⁴ DGH 550 Ultrasonic pachymeter (DGH Technology Inc., Exton, PA, USA) assesses endothelial insult

Figure 1 (A) Ultrasonic pachymeter, (B) reading of ultrasonic pachymeter.

by measuring corneal thickness, i.e. greater the endothelial insult, the more, the corneal thickness is present. Ultrasonic pachymeter works on the principle of echo spike technique and offers certain advantages over specular microscopy, viz. ease of use, relatively less expensive, portable, and measurement not dependent on patients' fixation.

Ultrasonic pachymeter though frequently used in refractive surgeries like LASIK⁵ and in glaucoma evaluation,⁶ it can be an economical and simple alternative tool to specular microscope in assessing postoperative endothelial insult and thereby comparing different techniques of cataract surgery.

MATERIALS AND METHOD

A group of 600 patients were included in the study. All patients underwent pre-operative examination, which included recording of visual acuity by Snellen's visual acuity chart, slit lamp biomicroscopic examination of anterior segment including morphological features of the type of cataract including the grade of nuclear sclerosis, fundus examination by indirect ophthalmoscopy, IOP measurement by Goldmann's applanation tonometer, and pre-operative corneal thickness measurement by DGH 550 ultrasonic pachymetry.

All the surgeries were carried out by surgeons of equal experience in phacoemulsification, manual SICS and ECCE.

Phacoemulsification was performed in nuclear (NS I and NS II as per Lens Opacities Classification System II), cortical and posterior sub-capsular cataract by superior 3-mm corneal incision. Though phacoemulsification was confined to nuclear, cortical, and posterior sub-capsular cataracts only; however, cases were assigned consecutively for undertaking ECCE, SICS, and phacoemulsification without any bias whatsoever.

In phacoemulsification, after capsulorhexis, nucleus was sculpted with the four-quadrant technique and thereafter each piece was phacoemulsified in pulse mode (effective phaco time: 60 ± 15 seconds). Foldable intra-ocular lenses were inserted in all cases. Small incision cataract surgery was performed by making 6.5 mm sclerocorneal tunnel superiorly. Nucleus was delivered into anterior chamber by rotating technique and expressed out through the tunnel using wire vectis. Conventional ECCE was performed by making superior 8 mm limbal incision. Can opener technique was performed in all cases. Nucleus was expressed out from capsular bag by pressure counter pressure technique. Rigid intra-ocular lenses (IOLs) were implanted in all cases and limbal incision was closed by interrupted 10-0 monofilament polyamide suture. Two percent hydroxypropyl methylcellulose was used in all patients.

Patients were divided into three groups. Group 1 (200 eyes) underwent phacoemulsification, group 2 (200 eyes) underwent SICS, and group 3 (200 eyes) underwent ECCE. Corneal thickness was evaluated postoperatively on day 1, day 2, day 7, day 15, and day 30 by ultrasonic pachymetry and is measured at the sites as depicted in Figure 2.

Patients suffering from preexisting corneal disease, glaucoma, complication during surgery like posterior capsular rent

Figure 2 Sites of corneal thickness measurement.

and vitreous loss, uveitis, and extremes of age (<10 years and >70 years) were excluded from study.

The statistical analysis was carried out using Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 15.0 for Windows). For all quantitative variables, mean and standard deviation were calculated. Means were compared with analysis of variance for three groups. Within groups, comparisons were done using paired *t*-test. Statistical tests were two-sided and performed at a significance level of $\alpha=0.05$.

Infection was avoided postoperatively by using a new bottle of local anaesthetic (4% xylocaine) every day. Perfect cleaning protocol was maintained for the ultrasonic probe and probe tip as mentioned in DGH 550 ultrasonic pachymetry operator's manual. The protocol is, "To prevent patient to patient infection, after each patient, the ultrasonic probe is wiped with 70% isopropyl alcohol followed by immersion of probe tip in 70% isopropyl alcohol for 10 minutes. This tip is then rinsed in sterile distilled water before use." One drop of antibiotic eye drop was instilled into the conjunctival sac each time following the ultrasonic probe.

RESULTS

Pre-operative values of corneal thickness:

- Central cornea (CCT): $525.1 \pm 25.2 \mu\text{m}$
- Superior quadrant (SQ): $592.23 \pm 35.39 \mu\text{m}$
- Inferior quadrant (IQ): $595.66 \pm 31.61 \mu\text{m}$
- Temporal quadrant (TQ): $581.19 \pm 38.31 \mu\text{m}$
- Nasal quadrant (NQ): $589.29 \pm 38.07 \mu\text{m}$

From the above, it has been shown that corneal thickness is maximum in SQ and minimum in TQ. Postoperative evaluation and comparison of change in corneal thickness is as follows.

Central Cornea (CCT)

Pre-operative value of corneal thickness was achieved on day 30 in ECCE, day 15 in SICS, and day 7 in phacoemulsification. On day 7, a highly significant ($P \leq 0.01$) difference is observed in corneal thickness among all the three techniques. However, no significant ($P \geq 0.05$) difference in corneal thickness was observed on day 15 between phacoemulsification and SICS. This means, endothelial damage at central cornea was the least in phacoemulsification followed by SICS and then ECCE (Table 1).

Table 1 Evaluation and comparison of corneal thickness in central cornea.

Corneal thickness	ECCE (P)*	SICS (P)†	Phaco (P)#
Pre-operative	525.55±33.03 (≥0.05)	525.13±32.44 (≥0.05)	524.65±32.67 (≥0.05)
Day 1	751.17±9.41** (≤0.01)	689.80±5.96** (≤0.01)	630.83±6.62** (≤0.01)
Day 2	728.71±7.19** (≤0.01)	689.47±6.00** (≤0.01)	599.63±12.62** (≤0.01)
Day 7	630.56±6.91** (≤0.01)	584.11±19.65** (≤0.01)	529.04±7.31‡ (≤0.01)
Day 15	559.85±12.51** (≤0.01)	529.42±6.13‡ (≤0.01)	529.02±6.01‡ (≥0.05)
Day 30	529.70±6.05‡ (≥0.05)	529.63±6.21‡ (≥0.05)	529.29±5.87‡ (≥0.05)

ECCE: extracapsular cataract extraction, SICS: small incision cataract surgery.

*ECCE/SICS.

†ECCE/Phaco.

#SICS/Phaco.

 **Highly significant ($P \leq 0.01$) difference from pre-operative value.

 ‡No significant difference ($P \geq 0.05$) from pre-operative value.

Table 2 Evaluation and comparison of corneal thickness in superior quadrant.

Corneal thickness	ECCE (P)*	SICS (P)†	Phaco (P)#
Pre-operative	592.12±35.52 (≥0.05)	591.85±35.17 (≥0.05)	592.73±35.67 (≥0.05)
Day 1	789.89±5.95** (≤0.01)	769.80±5.96** (≤0.01)	750.43±5.94** (≤0.01)
Day 2	761.31±5.95** (≤0.01)	729.47±6.00** (≤0.01)	710.41±6.31** (≤0.01)
Day 7	630.07±6.04** (≤0.01)	649.51±6.21** (≤0.01)	609.61±5.81** (≤0.01)
Day 15	610.17±6.10** (≥0.05)	609.90±5.78** (≤0.01)	589.97±5.96‡ (≤0.01)
Day 30	590.28±5.80‡ (≥0.05)	589.31±5.78‡ (≥0.05)	589.32±6.21‡ (≥0.05)

ECCE: extracapsular cataract extraction, SICS: small incision cataract surgery.

*ECCE/SICS.

†ECCE/Phaco.

#SICS/Phaco.

 **Highly significant ($P \leq 0.01$) difference from pre-operative value.

 ‡No significant difference ($P \geq 0.05$) from pre-operative value.

Superior Quadrant (SQ)

Pre-operative value of corneal thickness was achieved earliest in phacoemulsification, i.e. on day 15, whereas it was achieved on day 30 in both ECCE and SICS. A highly significant difference ($P \leq 0.05$) in corneal thickness is observed on day 15 between phacoemulsification and ECCE and also between phacoemulsification and SICS. This means, among the techniques, phacoemulsification causes the least damage to corneal endothelium in SQ (Table 2).

Inferior Quadrant (IQ)

Pre-operative value of corneal thickness was achieved on day 7 in ECCE, SICS, and phacoemulsification. No statistically significant difference ($P \geq 0.05$) in corneal thickness was observed on day 7 among the techniques. This means, all the three techniques cause similar damage to corneal endothelium in IQ (Table 3).

Temporal Quadrant (TQ)

Pre-operative value of corneal thickness was achieved on day 15 in ECCE and on day 7 in SICS and phacoemulsification. On day 7, a highly significant ($P \leq 0.01$) difference in corneal thickness was observed between ECCE and SICS, and also between ECCE and phacoemulsification. However, no significant difference is observed between SICS and phacoemulsification on

day 7. This means, ECCE causes maximum damage to corneal endothelium in TQ (Table 4).

Nasal Quadrant (NQ)

Pre-operative value of corneal thickness was achieved on day 15 in ECCE and SICS and on day 7 in phacoemulsification. No significant ($P \geq 0.05$) increase in corneal thickness was observed on day 15 among the three different techniques. This means, endothelial damage was minimum in phacoemulsification in NQ (Table 5).

DISCUSSION

Ultrasonic pachymeter measures corneal thickness by echo spike technique. In today's scenario, it is primarily used in keratorefractive surgeries and in the evaluation of glaucoma.^{5,6} In this study, the use of ultrasonic pachymeter in making a comparison among ECCE, SICS, and phacoemulsification, is a rather different role and enables us to know about the technique that causes minimum endothelial insult and earliest visual rehabilitation.

Lesiewska⁷ observed that in majority of patients, the corneal thickness approximated the status existing before operation on the

Table 3 Evaluation and comparison of corneal thickness in inferior quadrant.

Corneal thickness	ECCE (P)*	SICS (P) [†]	Phaco (P) [#]
Pre-operative	595.81±32.37 (≥0.05)	595.53±31.42 (≥0.05)	596.09±31.67 (≥0.05)
Day 1	649.80±5.96* (≥0.05)	649.89±5.94* (≥0.05)	655.24±3.14* (≥0.05)
Day 2	649.71±5.96* (≥0.05)	649.74±5.89* (≥0.05)	650.20±5.96* (≥0.05)
Day 7	609.30±4.02 [†] (≥0.05)	608.59±5.63 [†] (≥0.05)	607.92±5.53 [†] (≥0.05)
Day 15	607.64±5.44 [†] (≥0.05)	607.71±5.47 [†] (≥0.05)	606.85±4.89 [†] (≥0.05)
Day 30	606.58±5.49 [†] (≥0.05)	607.03±5.81 [†] (≥0.05)	609.47±7.14 [†] (≥0.05)

ECCE: extracapsular cataract extraction, SICS: small incision cataract surgery.

*ECCE/SICS.

[†]ECCE/Phaco.[#]SICS/Phaco.**Highly significant ($P \leq 0.01$) difference from pre-operative value.[†]No significant difference ($P \geq 0.05$) from pre-operative value.**Table 4** Evaluation and comparison of corneal thickness in temporal quadrant.

Corneal thickness	ECCE (P)*	SICS (P) [†]	Phaco (P) [#]
Pre-operative	580.55±42.62 (≥0.05)	581.50±41.61 (≥0.05)	581.54±42.86 (≥0.05)
Day 1	789.89±5.94** (≤0.01)	729.58±6.06** (≤0.01)	710.42±6.20** (≤0.01)
Day 2	768.70±7.37** (≤0.01)	690.15±5.80** (≤0.01)	710.81±6.19** (≤0.01)
Day 7	630.07±6.04** (≤0.01)	581.40±5.98 [†] (≤0.01)	582.25±6.16 [†] (≥0.05)
Day 15	581.78±5.98 [†] (≥0.05)	581.82±5.97 [†] (≥0.05)	581.71±5.69 [†] (≥0.05)
Day 30	585.48±5.72 [†] (≥0.05)	584.42±6.15 [†] (≥0.05)	584.74±5.91 [†] (≥0.05)

ECCE: extracapsular cataract extraction, SICS: small incision cataract surgery.

*ECCE/SICS.

[†]ECCE/Phaco.[#]SICS/Phaco.**Highly significant ($P \leq 0.01$) difference from pre-operative value.[†]No significant difference ($P \geq 0.05$) from pre-operative value.**Table 5** Evaluation and comparison of corneal thickness in nasal quadrant.

Corneal thickness	ECCE (P)*	SICS (P) [†]	Phaco (P) [#]
Pre-operative	588.63±38.60 (≥0.05)	589.22±37.54 (≥0.05)	590.02±38.24 (≥0.05)
Day 1	750.15±5.91** (≤0.01)	709.82±5.93** (≤0.01)	699.90±6.47** (≤0.01)
Day 2	730.07±6.06** (≤0.01)	670.49±5.62** (≤0.01)	670.33±5.93** (≤0.01)
Day 7	689.40±5.87** (≤0.01)	629.97±5.73** (≤0.01)	589.64±6.07 [†] (≤0.01)
Day 15	589.55±6.35 [†] (≥0.05)	590.66±6.17 [†] (≥0.05)	589.36±6.31 [†] (≥0.05)
Day 30	589.80±6.14 [†] (≥0.05)	590.09±6.11 [†] (≥0.05)	590.00±5.96 [†] (≥0.05)

ECCE: extracapsular cataract extraction, SICS: small incision cataract surgery.

*ECCE/SICS.

[†]ECCE/Phaco.[#]SICS/Phaco.**Highly significant ($P \leq 0.01$) difference from pre-operative value.[†]No significant difference ($P \geq 0.05$) from pre-operative value.

seventh postoperative day whereas in our study, the central corneal thickness reaches the pre-operative level on seventh day in subjects who underwent phacoemulsification. However, in SICS and conventional ECCE, the pre-operative level of corneal thickness is achieved on the 15th and 30th day, respectively. This difference is attributed to the varying incision size and

varying intra-operative anterior chamber instability among the different techniques.

Ravlicio et al⁸ observed that a statistically significant increase in corneal thickness was observed up to day 30 and day 7 after surgery in the ECCE group and in individuals who underwent phacoemulsification, respectively. In our study, it has been

observed that a statistically significant increase in central corneal thickness was observed up to the seventh day after surgery in ECCE group whereas in the phacoemulsification group it is being observed up to the second day after surgery. This difference could be attributed owing to refinement in surgical technique and increased expertise.

Amon et al⁹ observed in their study that the individual undergoing 7.0 mm scleral-step incision showed a slightly higher increase in corneal thickness as compared to individuals undergoing 3.5 mm incision. Also in all cases, thickness in superior cornea had increased more than the central thickness. After one month, all eyes regained their pre-operative thickness. The study showed that neither of the two surgical techniques greatly influences the increase in corneal thickness and consequently, the prospective endothelial cell loss. A contradictory observation was made in our study in which it was observed that there is statistically significant difference in corneal thickness observed up to day 7 following SICS and up to day 2 following phacoemulsification technique. To conclude endothelial insult after cataract surgery as measured indirectly from corneal thickness by ultrasonic pachymeter is maximum after ECCE followed by SICS and then phacomulsification. Pre-operative value of corneal thickness is achieved earliest in phacoemulsification followed by SICS and ECCE. Also visual rehabilitation is achieved earliest in phacoemulsification followed by SICS and ECCE.

Intellectual Contributions of Authors

Study concept: Lt Col Alok Sati, Brig Deepak Kalra, VSM

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CONFLICTS OF INTEREST

None identified.

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