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Evaluating the outcomes of manual small incision cataract surgery for advanced cataract in New Zealand

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Abstract

Purpose: To evaluate patient demographics, visual and keratometric outcomes, and complications of manual small incision cataract surgery (mSICS) to treat advanced cataract in New Zealand.
Study design: A total of 289 eyes undergoing consecutive mSICS by a single surgeon in Rotorua Eye Clinic in New Zealand between January 2011 and October 2015 were prospectively included.
Methods: Patient demographics, visual and keratometric outcomes including corrected distance visual acuity (CDVA) and vector analysis of surgically induced astigmatism (SIA), were analysed. Predicted and observed risk-adjusted surgical complications were compared.
Results: The mean patient age at time of surgery was 73.6 years. New Zealand European constituted the single largest ethnic group at 51.6% (*n* = 149). Māori were the second largest ethnic group at 35.6% (*n* = 103). Overall, 88.2% (*n* = 255) of patients achieved postoperative CDVA of 6/12 or better at 4 weeks following surgery. The mean postoperative logMAR CDVA was 0.17 ± 0.37 SD (6/9 + 2 Snellen equivalent). The mean SIA magnitude was 0.99 D (SD = 0.76 D). Preoperative risk of posterior capsule rupture was 5.2% but no cases were observed. Iris prolapse was noted in 1 case (0.4%) and endophthalmitis in 2 cases (0.7%).

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Conclusions: This is the largest study of mSICS in a developed country to date. mSICS is a safe and effective technique for advanced cataract extraction in a developed country with excellent visual outcomes. The incidence of posterior capsular rupture was below the predicted rate; however, endophthalmitis was higher than expected for a cohort of this size.

Keywords: advanced cataract, manual small incision cataract surgery, New Zealand

Menilai hasil pembedahan katarak insisi kecil manual (mSICS) di New Zealand

Abstrak

Tujuan: Untuk mengkaji demografi, keratometri dan hasil penglihatan dan komplikasi kaedah pembedahan katarak insisi kecil (mSICS) bagi merawat penyakit katarak di New Zealand.
Bentuk kajian: Sejumlah 289 pesakit yang menjalani pembedahan katarak secara insisi kecil (mSICS) oleh seorang pakar mata di Klinik Mata Rotorua di New Zealand dari bulan Januari 2011 sehingga bulan Oktober 2015 telah dikaji.
Kaedah kajian: Demografi pesakit, hasil keratometri, tahap ketajaman penglihatan dan analisis vektor kadar astigmatisme yang disebabkan oleh pembedahan telah dikaji. Ramalan dan pemerhatian risiko pembedahan yang diselaraskan telah dibandingkan.
Keputusan kajian: Min purata umur pesakit pada waktu pembedahan adalah 73.6 tahun. Kumpulan etnik terbesar merupakan orang berketurunan New Zealand Eropah dengan 51.6% (n = 149). Māori, dengan 35.6% (n = 103) merupakan kumpulan etnik kedua terbesar. Secara keseluruhannya 88.2% (n = 255) dari pesakit-pesakit ini mencapai ketajaman penglihatan tahap 6/12 atau lebih bagus pada 4 minggu selepas pembedahan. Min purata ketajaman penglihatan selepas pembedahan menggunakan kaedah logMAR adalah 0.17 ± 0.37 SD (6/9 +2 dengan kaedah Snellen). Min purata astigmatisme selepas pembedahan adalah 0.99 D (SD = 0.76 D). Walaupun risiko pecah kapsul posterior sebelum pembedahan adalah 5.2% malah tiada kes yang dilaporkan. Komplikasi iris pula terdapat dalam 1 kes (0.4%) dan endoftalmitis dalam 2 kes (0.7%).
Kesimpulan: Ini merupakan kajian terbesar mSICS yang melibatkan negara maju setakat kini. Kaedah pembedahan katarak mSICS terbukti teknik selamat dan efektif untuk pembedahan penyakit katarak lanjut di negara maju dan menghasilkan tahap penglihatan yang amat baik. Kadar komplikasi pecah kapsul

posterior adalah rendah dari dijangka. Walaubagaimanapun, kadar endoftalmitis lebih tinggi dari dijangka untuk kohort saiz sebegini.

Kata kunci: katarak, New Zealand, pembedahan katarak insisi kecil manual

Introduction

Manual small incision cataract surgery (mSICS) is a variation of extracapsular cataract extraction and was first described more than 20 years ago.[1] This technique involves a significantly smaller primary incision, no sutures, and reduced surgically induced astigmatism (SIA) compared to traditional extracapsular cataract extraction.[2] As with phacoemulsification, mSICS can also be safely conducted under topical anaesthesia with intracameral lignocaine if required.[3] The excellent outcomes, relatively low cost, and minimal surgical equipment required for mSICS have made this technique popular for treating cataract in many developing countries.[2,4-6]

While mSICS generally produce similar visual outcomes and complications when compared with phacoemulsification,[5] in most developed countries, phacoemulsification remains the gold standard technique for cataract extraction with approximately 90% of cataracts in Western countries removed using this technique.[6]

There may be circumstances where mSICS has advantages over phacoemulsification, in particular for the removal of advanced cataract. Large studies in the United Kingdom and elsewhere have demonstrated that brunescent cataract increases the risk of surgical complications using phacoemulsification by up to 400% or more.[7-9] These findings are consistent with observations of phacoemulsification-related complications in New Zealand.[10] In contrast, for the removal of brunescent, white, or black cataracts, mSICS is a reportedly safe and effective surgical technique with a reduced incidence of posterior capsular rupture when compared with phacoemulsification.[11,12]

With such widespread predominance of phacoemulsification, mSICS is often overlooked as a valid technique for cataract extraction in developed countries. The current prospective study evaluates the visual and keratometric outcomes as well as the complications of 289 consecutive mSICS procedures for advanced cataracts performed by a single surgeon in New Zealand. The preoperative predicted risk of posterior capsular rupture for this study cohort was compared with the actual observed incidence.

Methods

This clinical audit was approved by the Te Whatu Ora Lakes Research and Ethics Committee and conducted adhering to the institutional research guidelines and the NZ National Ethical Standards for Health and Disability Research and Quality Improvement. Prior to surgery, informed consent was obtained from all patients. Visual outcomes were collected prospectively as part of continuous clinical audit for patients undergoing cataract surgery. Ethnicity was self-reported or obtained through pre-existing hospital records.

In 2013, Rotorua was a rural town with a population of 65,000 and included 23,000 inhabitants of self-reported Māori ethnicity.[13] Ophthalmic care for Rotorua at the time of the current study was delivered exclusively by the Rotorua Eye Clinic under the Lakes District Health Board with a staff of 3 ophthalmologists and 1 ophthalmology resident. Eligibility for publicly funded cataract surgery in New Zealand is assessed on a weighted combination of visual acuity, cataract morphology, and patient-reported quality of life. These are combined to produce a clinical prioritisation and assessment criteria (CPAC) score. The local district hospitals set out their own CPAC score threshold based on the demand and capacity, and those that meet the threshold are waitlisted for surgery.

A total of 289 consecutive mSICS completed by a single surgeon at Rotorua Eye Clinic between January 2011 and October 2015 were included. Indications for mSICS included patients with advanced cataract, defined as the presence of a white or brunescent cataract, or cataract that was graded as greater than nuclear 4 (colour and opalescence) in the operative eye according to the Lens Opacity Classification System (LOCS) III.[14] Patients with dislocated or subluxated lens, inadequate zonular support, underlying ocular inflammatory conditions, systemic disorders with bleeding diathesis, and those who declined surgery were excluded from receiving mSICS. Analysis of keratometric, visual, and clinical outcomes was completed by an independent investigator.

The preoperative surgical assessment included a full ophthalmic and medical history and slit-lamp examination. Visual acuity was measured under standardised conditions using Snellen and logarithmic minimum angle of resolution (logMAR) scales. Visual acuity values of count fingers (CF), hand motion (HM), and light perception (LP) were converted to 2.0, 2.3, and 2.7, respectively, on the logMAR scale.

Preoperative biometry, including keratometry and axial length measurements, was completed using partial coherence laser interferometry with the IOLMaster 500 (Carl Zeiss Meditec, Jena, Germany). In patients where the IOLMaster was unable to record axial length, contact ultrasound biometry with the Tomey AL-1000 (Tomey Corp. Nagoya, Japan) was conducted. Ultrasound data were manually entered into the IOLMaster for intraocular lens (IOL) power calculations using the SRK/T formula and A-constant of 118.9. All patients received the Tecnis ZCB00 aspheric

acrylic IOL (Abbott Medical Optics, Santa Ana, CA, USA). An appropriate IOL power was selected with a spherical equivalent target of -0.25 dioptres (D).

mSICS was completed with sub-Tenon's local anaesthesia and ocular surface was prepared with povidone-iodine solution. The surgical technique included the reflection of a temporal conjunctival flap followed by construction of a temporal 'frown' scleral-tunnel incision located 1.5 mm from the limbus and extending into the clear cornea and anterior chamber with a 6.5-mm wide incision. Dual 1.4-mm paracentesis incisions were created at 90° and 270° and were sufficient to allow passage of a Simcoe cannula. Healon GV (Abbott Medical Optics) ophthalmic viscosurgical device (OVD) was used to stabilize the anterior chamber and a 5–6 mm continuous curvilinear capsulorrhexis was completed in the anterior lens capsule. Hydrodissection and subluxation of the lens into the anterior chamber was followed by Simcoe cannula assisted delivery of the lens via the temporal wound and removal of residual cortical remnants. IOL placement was within the intact capsular bag and suture-less closure of the eye was completed following removal of residual OVD. All patients received prophylactic intracameral cefuroxime, 1 mg in 0.1 ml at the end of the surgery, and the ocular surface was cleaned with povidone-iodine solution prior to removing the sterile drape.

A regime of topical steroid eye drops (prednisolone acetate 1%) and non-steroidal anti-inflammatory eye drops (diclofenac sodium 0.1%) was commenced 4 times daily on day 1 following surgery and continued for 1 month in total. No additional topical antibiotic eye drops were given. Postoperative assessments were completed at weeks 1 and 4. Autorefraction and postoperative keratometry with the Nidek ARK-30 autorefractor (Nidek Co. Aichi, Japan) was conducted. Corrected distance visual acuity was assessed by an optometrist following the 4-week postoperative visit.

Surgically induced astigmatism (SIA) was calculated using pre- and postoperative keratometry values (obtained from autorefractor) and vector analysis as described elsewhere.[15,16] Risk of posterior capsule rupture for the mSICS groups were calculated using adjusted odds ratios for clinical risk factors as outlined in the UK Cataract National Dataset.[7]

Three patients with missing data/lost to follow-up were removed from analysis. Microsoft Excel v16.62 (Microsoft Corporation, Redmond, WA, USA) and R v4.1.2 software (R Core Team, Vienna, Austria) were used for descriptive analysis, paired *t*-test, Welch 2 sample *t*-test, and production of tables and figures. $P < 0.05$ was considered statistically significant.

Results

Over the 4 years and 9-month duration of the study, a total of 292 mSICS procedures were completed. This accounted for 30% of the total amount of cataract operations completed by the surgeon at Rotorua Eye Clinic over this period. Of these, 289 were included for analysis. In total, 30 (10.3%) patients received bilateral mSICS. Eligibility for second eye surgery was determined by recalculation of CPAC score. There were 176 (60.9%) (*n* = 176) females and 113 (39.1%) males.

The mean patient age at time of surgery was 73.6 years. Demographic data, including distribution of age at time of surgery and ethnicity, are summarized in Tables 1 and 2. New Zealand European constituted the single largest ethnic group at 51.6% (*n* = 149) of the total patients. Māori were the second largest ethnic group at 35.6% (*n* = 103) of the total patients. The mean age at time of surgery for Māori patients was 67.7 years and that of New Zealand European patients was 76.9 years ($p = 5.8\ e^{-9}$). Seventy-nine (76.7%) Māori patients had preoperative CDVA of 6/60 or worse compared to 62 (41.6%) New Zealand European patients.

Inability to record an axial length using partial coherence laser interferometry required contact ultrasound measurements of axial length in 38.4% (111 eyes) of the patients undergoing mSICS.

Standard graphs for reporting visual and refractive outcomes are displayed in Figures 1 and 2.[17] Preoperative uncorrected distance visual acuity (UDVA) in the operating eye had a mean logMAR acuity of 1.44 ± 0.80 SD (approximately 3/90 + 2 Snellen equivalent). Preoperative CDVA ranged from 6/9 to LP with a mean logMAR CDVA of 1.35 ± 0.85 SD (approximately 3/60 - 2 Snellen equivalent). One patient had CDVA of 6/9 (UDVA of 6/12); however, clinically had nuclear LOCS III grade 5 cataract and met the threshold for publicly funded surgery. The proportion of eyes with CDVA of 6/60 was 54.7% (*n* = 158) prior to surgery and 3.8% (*n* = 11) following surgery. Overall, 88.2% (*n* = 255) of all patients achieved postoperative CDVA of 6/12 or better. The mean postoperative logMAR CDVA was 0.17 ± 0.37 SD (approximately 6/9 + 2 Snellen equivalent) and UDVA was 0.25 ± 0.27 SD (approximately 6/12 + 2 Snellen equivalent) at 4 weeks following surgery. There was significant improvement in CDVA following the surgery with a change in logMAR of 1.18 (95% CI 1.09 to 1.29, $p = 2.2e^{-16}$).

Mean absolute surgically induced astigmatism magnitude (SIAm) was 0.98 D ± 0.76 SD. Mean absolute SIAm for the right eye was 0.87 D ± 0.64 SD. Mean absolute SIAm for the left eye was 1.11 D ± 0.86 SD. At 4 weeks following surgery, 94.8% (*n* = 274) of eyes were within 1.0 D of their target spherical equivalent and 87.5% (*n* = 253) were within 0.5 D.

A total of 4 cases (1.4%) had either intraoperative or postoperative complications. Intraoperative iris prolapse occurred in 1 patient (0.4%). No other intraoperative complications were observed. The mean probability of posterior capsule rupture for this study cohort was calculated to be 5.2% based on the risk stratifica-

Table 1. Distribution of New Zealand European and Māori patients as a function of age at time of surgery

Age (y)	Number (%)	Cumulative %	NZ European (%)	Cumulative %	Māori (%)	Cumulative %
0–29	3 (1.0)	1.0	1.3	1.3	1.0	1.0
30–39	2 (0.7)	1.7	0.0	1.3	2.0	2.9
40–49	4 (1.4)	3.1	0.0	1.3	3.9	6.9
50–59	21 (7.3)	10.4	4.0	5.4	12.7	19.6
60–69	62 (21.5)	31.8	14.1	19.5	32.4	52.0
70–79	88 (30.4)	62.3	32.2	51.7	32.4	84.3
80–89	98 (33.9)	96.2	41.6	93.3	15.7	100.0
90+	11 (3.8)	100	6.7	100	0.0	100.0
Total	**289**		100		100	

Table 2. Ethnicity of patients undergoing manual small incision cataract surgery

Ethnicity	Number (%)
NZ European	149 (51.6)
Māori	103 (35.6)
Other European	18 (6.2)
Pacific	6 (2.1)
Asian	2 (0.7)
Indian	2 (0.7)
Chinese	1 (0.3)
Not specified	8 (2.8)
Total	**289 (100)**

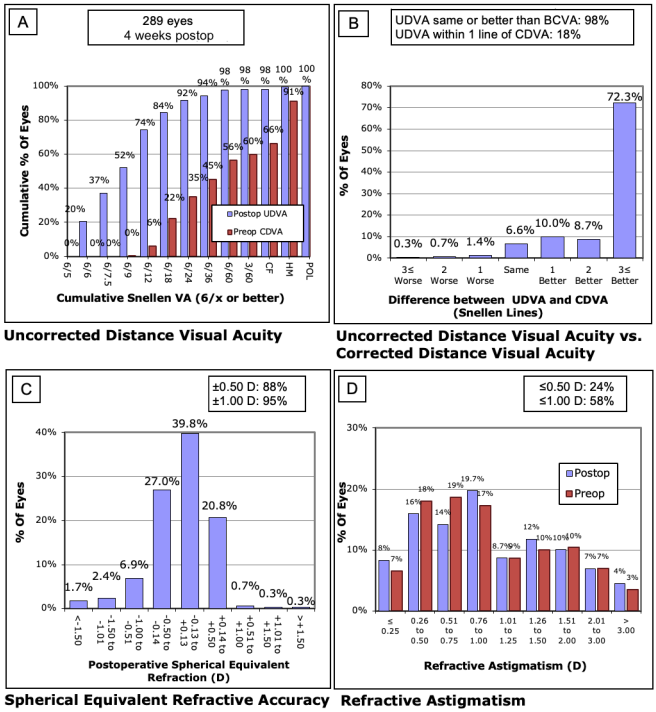

Fig. 1. Standard graphs for reporting refractive surgery outcome and astigmatism. BCVA: best-corrected visual acuity; UCVA: uncorrected visual acuity.

tion from the UK National Cataract Dataset.[7] There were no observed cases of intraoperative posterior capsule rupture. Postoperative endophthalmitis was observed in 2 patients (0.7%). The first patient developed endophthalmitis 13 days following surgery. The aqueous tap grew *Staphylococcus aureus* while there was no growth from the vitreous tap after 10 days of incubation. The patient later developed retinal detachment which was repaired with a scleral buckle. The final CDVA was 6/9.5 in the affected eye. The second patient had underlying bilateral moderate non-proliferative diabetic retinopathy and associated diabetic maculopathy. He developed endophthalmitis 21 days following surgery. Vitreous tap cultured *Streptococci* sensitive to ceftazidime, amoxicillin, and ciprofloxacin. The affected eye was slow to improve hence underwent pars plana vitrectomy. He subsequently developed significant retinal vascular occlusion and the final CDVA was HM. Postoperative cystoid macular oedema was detected in 1 patient (0.3%). No patients had persistent corneal oedema at 4 weeks, and none developed pseudophakic bullous keratopathy. Postoperative complications such as wound leaks, secondary high intraocular pressure, or suprachoroidal haemorrhage were not observed.

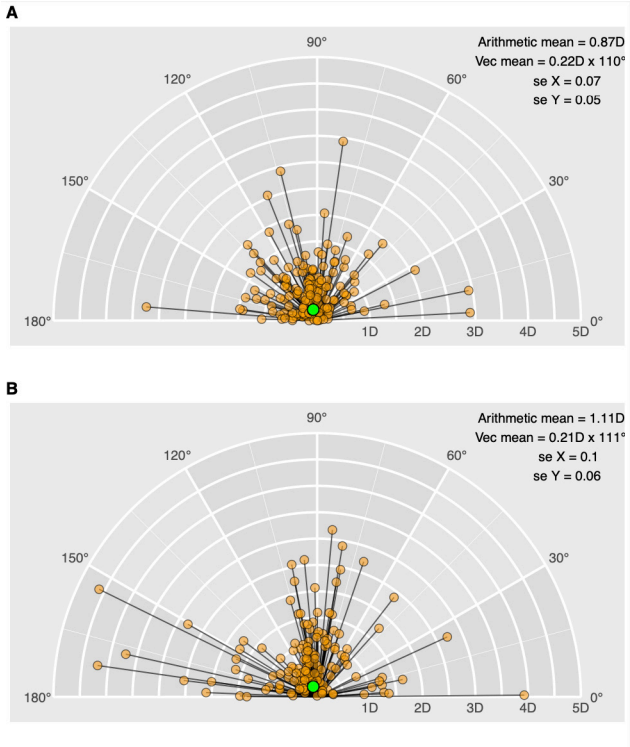

Fig. 2. Surgically induced astigmatism vectors (polar diagram) for the *(A)* right eye and *(B)* left eye. Temporal scleral incisions measured at least 6.5 mm in width and were positioned 1.5 mm from the limbus extending to clear cornea at the endothelium. The arithmetic mean: mean of the surgically induced astigmatism vector. Vec mean: centroid location with standard errors in x (se X) and y (se Y) axes.

Discussion

Phacoemulsification is the gold standard surgical technique for routine cataract surgery in developed countries and generally produces excellent results.[10] Patients with advanced cataract have a relatively high risk of phacoemulsification-related complications when compared with patients presenting with less advanced cataract.[7-9] Less is known, however, about which surgical techniques can be used to safely reduce the risk of surgical complications without compromising visual outcomes in these patients.

mSICS is a variation of extracapsular cataract extraction that has been used predominantly in developing countries.[5,6,18,19] Although mSICS was described more recently than phacoemulsification, the application of mSICS is largely confined to developing countries despite comparable visual outcomes, similar incidence of complications, and improved cost effectiveness when compared with phacoemulsification.[4,18,20] As far as the authors are aware, only 4 studies have reported visual outcomes and complications following mSICS for advanced cataract in developed countries.[21-24] The results were comparable to reported outcomes of phacoemulsification; however, all were relatively small studies. The current study summarizes results from 289 consecutive mSICS cataract extractions, all completed by a single surgeon in New Zealand. To our knowledge, this is the largest study to date evaluating the visual outcome and complications of mSICS in treatment of advanced cataract in a developed country.

As expected, due to the indications used for selecting patients for mSICS, more than half the total eyes had preoperative baseline CDVA of 6/60 or worse. Despite this, 88.2% (n = 255) of total patients achieved postoperative CDVA of 6/12 or better. The visual outcomes from the current study are comparable to those reported following mSICS for advanced cataract.[19,20,25] There was a significantly higher proportion of eyes achieving CDVA of 6/12 or better compared to those reported in Australia, Singapore, and the United Kingdom.[21,23,24]

Although postoperative CDVA is reported to be similar with phacoemulsification and mSICS,[18] studies have demonstrated that phacoemulsification is associated with less SIA than mSICS.[5,26] SIA in mSICS is increased with superior incisions when compared to temporal incisions.[27] Using exclusively temporal incisions, the magnitude of SIA reported in the current study is consistent with other reports in the literature for mSICS and phacoemulsification.[20,25]

Previous studies have described similar rates of iris prolapse and posterior capsular rupture in mSICS and phacoemulsification.[11,20,28] It is well established that dense cataracts are associated with a higher risk of surgical complications, including iris prolapse.[7,29] In the current study, there was 1 (0.4%) reported case of intraoperative iris prolapse. This patient had preoperative CDVA of HM and a large, dense cataract. Iris prolapse secondary to elevated vitreous pressure was noted intraoperatively and the wound was sutured. The results of the current study suggest mSICS

is associated with a significantly reduced incidence of posterior capsule rupture when compared with phacoemulsification in patients with advanced cataract. Risk stratification based on the UK National Cataract Dataset[7] predicted 15 cases (5.2%) of posterior capsule rupture for this study cohort. No case of posterior capsule rupture was observed in the current study cohort.

Adverse outcomes noted in the current study were like those previously reported for mSICS or phacoemulsification.[19,20,22] However, the 2 cases (0.7%) of endophthalmitis were higher than expected.[30,31] Despite this, 1 case achieved a final CDVA of 6/9.5. Apart from the patients being male and presence of diabetic retinopathy in 1 patient, no other risk factors for endophthalmitis were identified.[30] This study used routine intracameral cefuroxime prophylaxis, incisions were scleral rather than corneal, and an acrylic IOL was used in all cases. These factors are all associated with a lower risk of endophthalmitis.[30,31] The reason for the high rate of endophthalmitis reported in the current study is unclear and warrants further investigation.

The baseline demographics, including ethnicity, age at time of surgery, and presenting CDVA highlight some issues that warrant further investigation. Māori patients required cataract surgery at a much earlier age than non-Māori ethnicities. It is unclear why this disparity exists but may in part be related to the higher incidence of diabetes and associated diabetic cataract,[32,33] underrepresentation at screening,[34] and shorter life expectancy of Māori people in New Zealand.[35] Further research is required to identify why this population is presenting relatively late with advanced cataract when compared with non-Māori populations.

The current study has confirmed that mSICS produces comparable results to phacoemulsification in respect to visual and keratometric outcomes in a developed country. Perhaps most importantly, despite the high predicted preoperative risk of posterior capsule rupture, the actual incidence observed was zero.

mSICS has been reported to be a faster and less expensive technique with similar visual outcomes and safety profile to phacoemulsification in developing countries.[4] Other studies suggest additional benefits of mSICS, including reduced risk of a dropped nucleus, the ability to safely use a ‘can-opener’ capsulotomy if required, and the ability to combine mSICS with other procedures, such as trabeculotomy.[36.37] Results from the current study support the use of mSICS for the niche group of patients presenting with advanced cataract that are known to have a higher risk of adverse outcomes using phacoemulsification.

There are limitations to the current study. Given the selection of patients with advanced dense cataract for mSICS, the baseline characteristics would differ from the average cataract population that undergo phacoemulsification in developed countries. These factors include presenting CDVA, the severity/type of cataract present, and axial length/biometry calculation technique. It is worth noting, the visual and keratometric outcomes in this study group remained comparable to that of internationally reported outcomes of routine phacoemulsification, and the incidence of capsule rupture was lower. The outcomes were also comparable to

the studies that evaluated mSICS in advanced cataract populations in developed countries including Australia, the United States, the United Kingdom, and Singapore.[21-24]

Another limitation to note is the relatively short period of follow-up. Follow-up for most comparable studies typically ranges from 6 weeks to 6 months. Due to the nature of a public hospital setting with high service demand yet few specialists, the patients in this study were not routinely seen again after their 1-month postoperative visit. Given the short follow-up, the incidence of posterior capsular opacification, typically high in mSICS,[25] and other late complications remain unknown. Furthermore, different devices were used to measure the keratometry pre- and postoperatively, which may have affected the reliability of the keratometric measurements and refractive outcomes in this study. However, given several studies have shown no statistical differences in the measurements between these keratometry devices,[38-42] this effect is likely to be negligible.

Further work is required in the form of a randomised controlled trial to definitively investigate the role of mSICS for treatment of dense cataracts in the setting of developed countries. It would be useful to characterise other parameters of interest, such as endothelial cell count, pachymetry, and corneal topography. Although reports suggest endothelial loss is similar with phacoemulsification and mSICS, there are few studies that have directly looked at this parameter and have not specifically investigated endothelial loss in the subpopulation with advanced dense cataract.[43-45]

As cataract extraction is the most frequently performed operation in many countries worldwide, small improvements in surgical results can impact large numbers of patients. mSICS may prove to be an invaluable part of the surgical toolkit in developed countries to treat advanced cataract while ensuring visual results comparable to that of phacoemulsification cataract surgery.

Declarations

Ethics approval and consent to participate

This clinical audit was approved by the Te Whatu Ora Lakes Research and Ethics Committee and conducted adhering to the institutional research guidelines and the NZ National Ethical Standards for Health and Disability Research and Quality Improvement. Prior to surgery, informed consent was obtained from all patients.

Competing interests

The authors report there are no competing interests to declare.

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