# Auckland Cataract Study III: Refining Preoperative Assessment With Cataract Risk Stratification to Reduce Intraoperative Complications

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• PURPOSE: To assess intraoperative complications of phacoemulsification surgery in public teaching hospital settings using modified preoperative risk stratification systems.
• DESIGN: Prospective cohort study.
• METHODS: Preoperative risk stratification of 500 consecutive cataract cases using the New Zealand Cataract Risk Stratification (NZCRS) scoring system. Recommended allocation of higher-risk phacoemulsification procedures to experienced surgeons in public teaching hospital setting. MAIN OUTCOME MEASURE: Intraoperative complications relative to adherence to stratification recommendations.
• RESULTS: NZCRS classified 192 cases (38%) as high-risk, recommended for fellows or consultants (attendings). Primary surgeons were residents (n = 142, 28%), fellows (n = 88, 18%), and consultants (n = 270, 54%). Overall rate (N = 500) of any intraoperative complication was 5.0%. Where NZCRS scoring recommendations were observed (n = 448) the intraoperative complication rate was 4.5% but in "nonadherence" cases (n = 52 residents operating on higher-risk cases) this nearly doubled (9.6%). Postoperative complications occurred in 5.2%, primarily cystoid macular edema (3.7%). Postoperatively, mean unaided visual acuity was 6/12 (20/40) and best-corrected visual acuity improved from 6/20 (20/63) preoperatively to 6/10 (20/32) postoperatively ($P < .05$).
• CONCLUSIONS: The NZCRS system aids identification of higher-risk cataract cases and appropriate case-to-surgeon allocation and may increase surgeon awareness of risk factors. Compared to 2 previous studies under similar conditions in the same institution, the NZCRS system was associated with a 40% reduction in intraoperative complications (8.4% to 5%). The rate of posterior capsular tear was 0.6% ($P = .035$) compared to 2.6% in baseline phase and 1.4% in a prior risk stratification phase. Risk stratification seems to reduce intraoperative phacoemulsification complications in public teaching hospital settings. (Am J Ophthalmol 2019;197:114–120.


CATARACT SURGERY IS UNDOUBTEDLY THE MOST frequently performed ophthalmic surgical procedure in developed countries, including Australia and New Zealand, where approaching 200,000 procedures are performed annually. This demand for cataract surgery is only likely to increase with the increasingly aged population and higher expectations for visual function. Despite the overall success of contemporary phacoemulsification cataract surgery with favorable visual outcomes typically achieved in >95% of patients, a minority of cases still have surgical complications, which can lead to severe visual impairment.[1]

Studies such as the Auckland Cataract Study (1 and 2) have shown that public hospital intraoperative cataract complication rates, which were comparable with the contemporary international literature, have essentially halved since 2000.[2,3] Significantly, these risks of complications can be further reduced by the introduction of a simple cataract surgery risk stratification system.[3,4]

In 2016, Kim and associates reported a significant reduction of intraoperative complications by approximately 40%, following implementation of the UK-based Muhtaseb risk stratification system in New Zealand.[4] In an attempt to further reduce intraoperative complications, this risk-scoring system was refined, using contemporary data, for public teaching hospital centers and the New Zealand Cataract Risk Stratification (NZCRS) was developed. The present study primarily aimed to assess the effect of this NZCRS system on intraoperative complications of phacoemulsification cataract surgery, and related postoperative complications, in a major public hospital service in Auckland, New Zealand.

AJO.com Supplemental Material available at AJO.com.
Accepted for publication Sep 25, 2018.
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0002-9394/$36.00
https://doi.org/10.1016/j.ajo.2018.09.026

## METHODS

A PROSPECTIVE COHORT STUDY WAS CONDUCTED ON 500 consecutive cases of phacoemulsification cataract surgery, performed between April 20, 2017 to August 23, 2017, in the public hospital service in Greenlane Clinical Centre, Auckland District Health Board (ADHB), Auckland, New Zealand. The study protocol was approved by the ADHB research committee prior to implementation of the NZCRS system and adhered to the tenets of the Declaration of Helsinki. All consultant ophthalmic surgeons (attendings) in the Greenlane Clinical Centre agreed to participate via a departmental meeting and written communication.

All patients' clinical notes were reviewed on the day prior to surgery by a single investigator (J.H.), and using the NZCRS scoring system, an aggregated preoperative risk score was calculated for each case and documented in the patient clinical notes. The scoring system allocates 1-3 points for each ocular or patient factor, weighted depending on its potential risk for an intraoperative complication. The NZCRS system (Table 1) identifies a case as "high risk" and recommends allocation to senior surgeons—as a fellow- or consultant (attending)-only case—if it meets any of the 3 following criteria: (1) risk score of greater than 3, (2) the patient is effectively monocular (contralateral visual acuity ≤ 6/60 or as noted by surgeon), or (3) the eye has undergone a previous vitrectomy.

All other cases are classified as "low risk" and suitable for all levels of surgeons (ie, training residents, fellows, and consultants [attendings]). For all cases, a summary of the risk factors and the minimum level of surgeon required for that case was clearly documented by the investigator in the patient clinical notes prior to the planned surgery. Ophthalmic surgeons were asked to allocate cases appropriately according to the NZCRS recommendations; however, they retained the right to override the recommendation on clinical or other grounds (but were to record the reasons for so doing).

A standardized operation pro forma was incorporated into the clinical notes, where surgeons were asked to record their hand-written surgical note immediately following surgery. This enabled ease of reporting on intraoperative complications, with a check box for common intraoperative complications (anterior chamber/choroidal hemorrhage, anterior capsule tear, corneal incision retraction/wound leak, dropped nucleus, incomplete capsulorrhexis, iris prolapse, iris trauma, posterior capsule rupture, torn Descemet membrane, unplanned extracapsular cataract extraction, vitreous loss, zonule dehiscence), and a space was provided to document any other complications not included in the template. All cataract surgeries were performed as per standard ADHB protocol, with no change to intraoperative procedures or the supervision of training residents.

The investigators reviewed patients' clinical and surgical notes following their 4- to 6-week postoperative visit.

**TABLE 1.** New Zealand Cataract Risk Stratification System

| Risk Factor | Points |
|---|---|
| Dense/total/white/brunescent cataract/no fundus view | 3 |
| Pseudoexfoliation | 3 |
| Phacodonesis | 3 |
| Oral alpha-receptor antagonist[a] | 2 |
| Age > 88 years | 1 |
| Corneal scarring | 1 |
| High ametropia (>6 diopter myopia/hyperopia) | 1 |
| Posterior capsule plaque | 1 |
| Posterior polar cataract | 1 |
| Shallow AC (<2.5 mm) | 1 |
| Small pupil (<3 mm) | 1 |
| Miscellaneous risks assessed by surgeon (eg, poor position/cooperation) | 1 |
| Add all applicable points above for NZCRS score | |
| Fellow- or consultant (attending)-only case if: | |
| • NZCRS score > 3[a] and/or | |
| • Previous vitrectomy[a] and/or | |
| • Only eye[a] | |

AC = anterior chamber; NZCRS = New Zealand Cataract Risk Stratification.

[a]Modifications made to the validated Muhtaseb risk stratification system.

The main outcome measure was incidence of intraoperative complications, specifically considered in relation to NZCRS scoring. Postoperative complications and visual outcomes were also reviewed.

A visual acuity of counting fingers was converted to a Snellen equivalent of 6/60 (20/200) and hand movements was converted to 6/600 (20/2000) for analysis. Cases with visual acuities of light perception preoperatively were excluded from visual acuity analysis (2 eyes).

The outcome data in the current study, hereafter termed the "NZCRS phase", were collected in a format to be directly comparable to 2 previous cataract risk stratification studies performed by our group in the same teaching hospital under similar conditions: (1) a prospective observational study carried out in 2015, where the investigators calculated risk scores for 500 cases using the Muhtaseb system (however, the surgeons in this series were unaware of this score and no recommendations were made as to the level of surgeon to perform surgery)[5]; and (2) a second prospective study in 2016, where a further 500 cases were risk stratified using the Muhtaseb system; in this series surgeons were aware of the risk score and cases with a score of greater than 3 were allocated to senior surgeons (fellows/consultants [attendings]).[4] Hereafter, these 2 studies will be referred to as the "No intervention phase" (NIP) and "Muhtaseb intervention phase" (MIP), respectively.

To monitor for interrater reliability, 10% of cases from the current study (n = 50) were rescored using the NZCRS

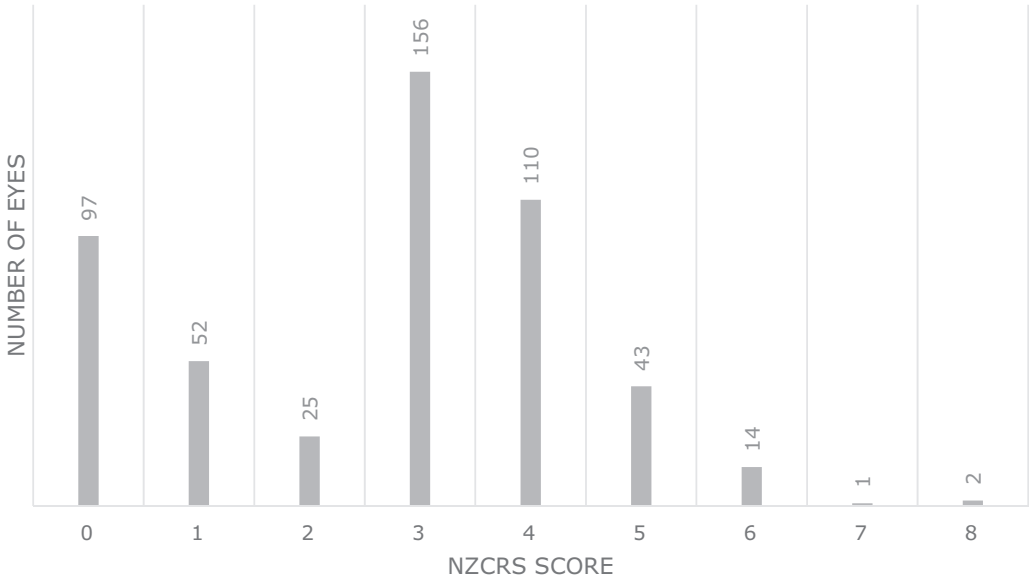


**FIGURE 1. New Zealand Cataract Risk Stratification (NZCRS) system score distribution (N = 500 eyes undergoing cataract surgery).**

system by an experienced scorer (B.K.), who had scored cases in the 2 previous cataract studies.

Statistical analysis was performed using SPSS version 25 (IBM SPSS Statistics for Windows, Version 25.0; IBM Corp, Armonk, New York, USA) with professional advice obtained from biostatisticians at the University of Auckland. $\chi^2$ tests were conducted for comparison of complication rates between the NIP, MIP, and NZCRS phases.[4,5] Logistic regression analyses were conducted to compare risk scores and complication rates, accounting for surgeon level and case mix.

*P* values of <.05 were considered statistically significant.

## RESULTS

FIVE HUNDRED EYES OF 494 PATIENTS WERE INCLUDED IN the study. The NZCRS risk score ranged from 0 to 8, with a median risk score of 3 (Figure 1). Of these, 170 cases had a risk score of greater than 3 and were allocated as high-risk cases. As per the NZCRS system, any case with a previous vitrectomy or only eye was also allocated as high risk regardless of the risk score. Therefore, in total, 38% of cases (n = 192) were identified as high-risk cases via the NZCRS system, and were allocated to fellows and consultants (attendings).

Of the 10% of cases (n = 50) scored independently by a second investigator, there was exact interrater agreement of NZCRS scores in 82% of cases and interrater agreement of NZCRS risk score within 1 risk factor in 98% of cases. Overall, there was interrater agreement of the suggested level of surgeon to perform the case in 90%.

The 500 cataract surgeries were performed by a total of 43 primary and assistant surgeons—13 residents, 6 fellows, and 24 consultants (attendings). In 31% of cases an assistant surgeon was present. Residents were the primary surgeon in 142 cases (28%), fellows in 88 cases (18%), and consultants (attendings) in 270 cases (54%).

The overall rate of any intraoperative complication with implementation of the NZCRS was 5.0%. These complications include iris prolapse (1.4%), iris trauma (1.2%), anterior capsule tear (1.4%), dropped nucleus (0.2%), posterior capsule tear with or without vitreous loss (0.6%), and zonule dehiscence (0.6%).

Of the cases that experienced a complication, residents were the primary surgeon in 36%, fellows in 12%, and consultants in 52% of cases. However, after case-mix adjustment with NZCRS scores, the difference in odds of a complication occurring among each level of surgeon group did not reach statistical significance (*P* =.392).

There was nonadherence to risk stratification guideline score in 52 cases, where residents in training were the primary surgeon in "high-risk" cases normally allocated to fellows and consultants (attendings) as per NZCRS. The clinical, or other, reasons for this nonadherence were not specifically documented by the supervising consultants (attendings). Notably, the intraoperative complication rate in this nonadherence group was 9.6%, with 2 cases of iris trauma, 1 iris prolapse, 1 zonule dehiscence, and 1 case of anterior capsule tear. Excluding these nonadherence cases (n = 52), the overall intraoperative complication rate in the current study was 4.5% (n = 448).

Ultimately, 482 out of the 500 NZCRS cases (96%) attended the 1-month-postoperative review. Of these cases, 5.2% had experienced postoperative complications, including cystoid macular edema (3.7%), transient corneal edema (1.0%), and ocular hypertension (0.4%). Ocular comorbidities such as glaucoma, diabetic retinopathy, and age-related macular degenerations were not excluded in assessing vision outcomes. Overall the mean unaided visual acuity improved from 6/38 (20/125) preoperatively to 6/12 (20/40) 1 month postoperatively, and best-corrected visual acuity (BCVA) from 6/20 (20/63) preoperatively to 6/10 (20/32) 1 month postoperatively ($P < .05$).

## DISCUSSION

SEVERAL PREOPERATIVE RISK STRATIFICATION SYSTEMS have been devised internationally, and previous studies have demonstrated that a scoring system is effective in identifying cases at higher risk of intraoperative complications.[6–10] In New Zealand, Kim and associates reported in this journal the utility of cataract surgery risk stratification, and observed a significant reduction of intraoperative complications after implementation of the UK-based Muhtaseb risk stratification system.[4] Subsequently it was suggested that a modified risk stratification system (NZCRS), refined specifically for public hospitals training residents and fellows, could potentially lead to a further reduction of intraoperative complications.

The NZCRS system was developed through modification of the Muhtaseb system,[6] which has previously been validated overseas.[11–13] Three additional measures and 1 higher-risk (score >3) parameter were added to the 11 established in the Muhtaseb system to develop the NZCRS system. Firstly, the NZCRS adds 2 points to the score for oral alpha-antagonists, based on the odds ratio of developing an intraoperative complication as reported by the UK Cataract National Dataset.[7] Notably, oral alpha-antagonists and the association with floppy iris syndrome has only become widely recognized as a new risk factor since the Muhtaseb system was developed in 2004.[14,15] Secondly, any eye that has undergone a prior vitrectomy becomes a fellow/consultant (attending) case regardless of the risk score in NZCRS. Prior studies have shown previous vitrectomy to be associated with increased intraoperative complications such as posterior capsular rupture, dropped nucleus, and retained lens fragments.[16,17] Finally, "only eye" patients are allocated to a fellow/consultant regardless of the score. This was added to the NZCRS system to incorporate patient functioning factors, following input from New Zealand cataract surgeons who took part in the previous phases of the Auckland Cataract Studies.

Owing to the additional measures incorporated into the NZCRS scoring system, a higher proportion of patients may be systematically identified as "high risk" compared to the Muhtaseb system. We believe the NZCRS system may provide a better guide to surgeons as to anticipated difficulties and aids in the identification of higher-risk cases. However, it is important to note that a case with "no risks" identified via the NZCRS system inevitability still comes with surgical risk. Also, the case may be more complex than anticipated owing to risks that unmask intraoperatively but that were unidentifiable at the time of preoperative assessment (eg, poor intraoperative pupil dilation, clouding of the cornea, increased positive pressure, mobile patient, and inadequate anaesthetic control).

In this prospective series of a cumulative 1500 patients undergoing cataract surgery in 3 phases, the current NZCRS study group had a higher proportion of high-risk cases, with 192 cases (N = 500) compared to 37 and 33 cases in the NIP (N = 500) and MIP (N = 500) phases, respectively (Figure 2). Therefore, for the purposes of comparison, all cases in the current study were retrospectively rescored using the Muhtaseb system to identify whether the seemingly large number of high-risk cases in the NZCRS study phase was primarily attributable to the different scoring system used or to a true difference in case mix. We confirmed a genuinely higher proportion of higher-risk cases in the presented NZCRS study, with 146 cases being identified as high risk, even when rescored using the established Muhtaseb system (76% of NZCRS higher-risk cases). Interestingly, in the NZCRS phase, a higher proportion of cases were operated on by less experienced surgeons, with 142 cases operated on by residents compared to the 2 previous studies (93 cases in NIP, 100 cases in MIP phase, $P < .05$) (Figure 3). Thus, in theory, this greater proportion of high-risk cases and greater proportion of training residents operating as the primary surgeon would be associated with an overall larger number of intraoperative complications in this latest phase of the Auckland Cataract Study.

The overall intraoperative complication rate following implementation of the NZCRS system was 5%. This was a 40% reduction of complications compared to the 8.4% reported in the baseline prior to active implementation of any risk stratification system in the same teaching hospital (NIP, 2015). In comparison to outcomes with active implementation of the Muhtaseb risk stratification system (MIP, 2016), although the *overall* complication rate remained unchanged at 5%, there was a reduction in the *severity* of complications, with a reduction in posterior capsule rupture from 7 to 3 cases, vitreous loss from 2 to 0 cases, and dropped nucleus from 2 cases to 1 case (Table 2).

Posterior capsule tear is a potentially serious intraoperative complication that may be associated with dropped nucleus, vitreous loss, and sight-threatening postoperative complications such as retinal detachment and cystoid macular edema.[18–20] In the UK Cataract National Database of 55 567 cases, the rate of posterior capsule tear was reported at 1.9%.[21] In New Zealand, studies have reported posterior

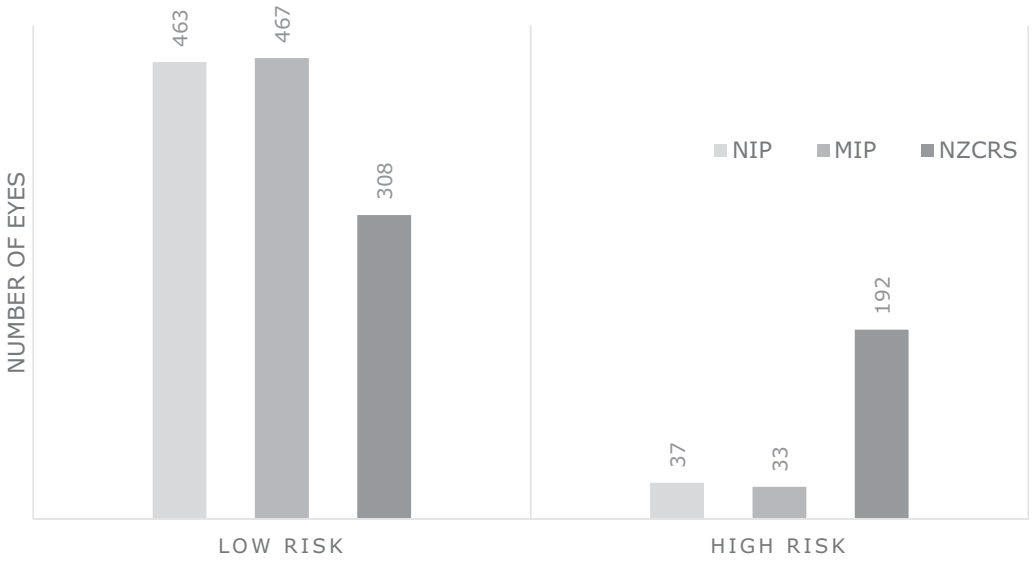


**FIGURE 2. Proportion of high-risk and low-risk cataract surgery cases in the current and prior phases: "no intervention phase" (NIP; N = 500); "Muhtaseb intervention phase" (MIP; N = 500); New Zealand Cataract Risk Stratification (NZCRS; current) phase (N = 500).**

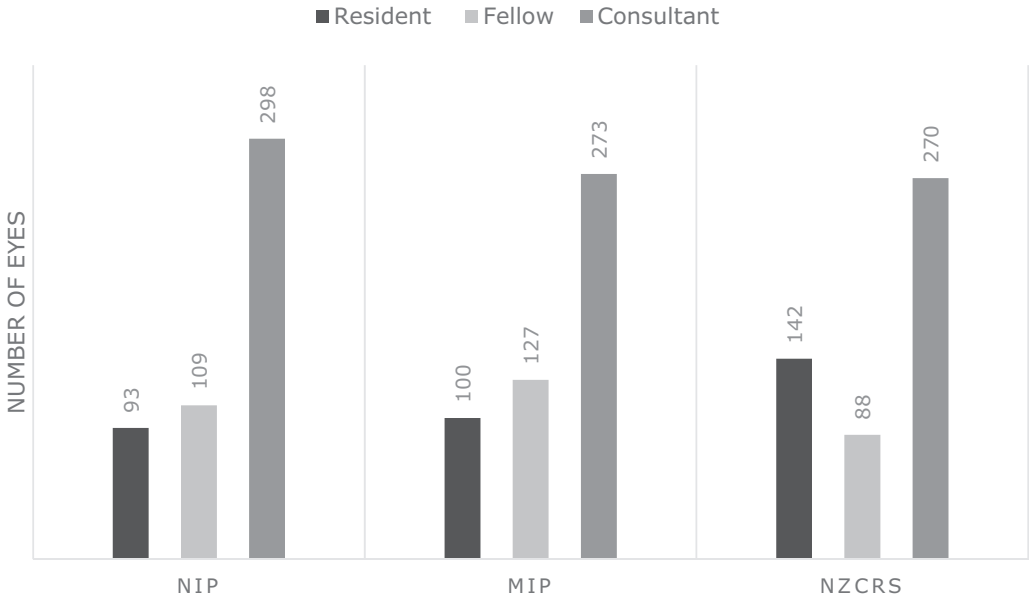


**FIGURE 3. Primary surgeon performing phacoemulsification in current New Zealand Cataract Risk Stratification study (NZCRS; N = 500) compared to earlier "no intervention phase" (NIP; N = 500) and "Muhtaseb intervention phase" (MIP; N = 500) cataract studies.**

capsule tear rates of 2.9%–3.3% owing to a different case mix with significantly higher prevalence of glaucoma, diabetic retinopathy, and advanced cataract compared to the UK.[22,23] At our institution we observed a significant reduction of posterior capsule tear rates, from 2.6% (13 cases) prior to risk stratification to 1.4% (7 cases) with the Muhtaseb system, then a further reduction to 0.6% (3 cases) with the current NZCRS system ($P = .035$) (Table 2).

Although this study was designed to primarily address intraoperative complications, obviously, postoperative outcomes were of interest to the investigators. Almost all patients (96%) returned for a 1-month-postoperative assessment. Of these cases, 5.2% experienced a

**TABLE 2.** Intraoperative Complications in Current New Zealand Cataract Risk Stratification Study Compared to Earlier "No Intervention Phase" and "Muhtaseb Intervention Phase" Prospective Cataract Studies

| | NIP (N = 500) 2015 | MIP (N = 500) 2016 | NZCRS (N = 500) 2017 | *P* Value |
|---|---|---|---|---|
| Intraoperative complications (total) | 8.4% | 5.0% | 5.0% | .035 |
| Iris prolapse | 2.6% | 1.4% | 1.4% | .257 |
| Iris trauma | 1.0% | 1.4% | 1.2% | .845 |
| Anterior capsule tear | 1.6% | 0.4% | 1.4% | .158 |
| Dropped nucleus | 0.2% | 0.4% | 0.2% | .778 |
| Posterior capsule tear ± vitreous loss | 2.6% | 1.4% | 0.6% | .035 |
| Zonule dehiscence | 1.6% | 0.6% | 0.6% | .165 |
| Vitreous loss | 0.2% | 0.4% | 0.0% | .367 |

MIP = "Muhtaseb intervention phase"; NIP = "no intervention phase"; NZCRS = New Zealand Cataract Risk Stratification study.

postoperative complication, most commonly cystoid macular edema (3.7%), followed by corneal edema (1.0%) and ocular hypertension (0.4%). In comparison to previous phases, total postoperative complications reduced (Kim BZ, personal communication, September 2018) from 8.1% in the baseline (NIP) phase to 6.1% in the Muhtaseb phase (MIP) ($P = .434$),[4] and were lowest at 5.2% in the current NZCRS phase. However, this downward clinical trend did not reach statistical significance. Interestingly, similar rates of cystoid macular edema were observed across all 3 phases (3.5% NIP vs 3.8% MIP vs 3.7% in NZCRS). In a consecutive series that included eyes with age-related macular degeneration, diabetes, and glaucoma, the mean unaided visual acuity improved from 6/38 (20/125) preoperatively to 6/12 (20/40) 1 month postoperatively. BCVA improved from 6/20 (20/63) preoperatively to 6/10 (20/32) 1 month postoperatively ($P < .05$). These data are comparable with previous NIP and MIP cataract studies, of similar size and population mix, that reported mean postoperative BCVA of 6/9 (20/30). Of the 3 cases complicated by posterior capsular tear, 1 case had BCVA of 6/120 (20/400) at 1 month owing to aphakia, another had BCVA of 6/12 (20/40), and 1 did not attend 1-month follow-up.

Although a reduction in complications was observed following introduction of the NZCRS system, another factor that may have contributed to the improved outcome is the Hawthorne effect (ie, modification of behavior in subjects who are aware they are being observed or studied).[24] Also, the risk scores clearly documented in the clinical notes for each case may have served as a prompt for increased surgical caution in all surgeons.

A limitation of this study is that all cases were risk scored by a single investigator (J.H.) entirely based on the information documented in the patient clinical notes. Any risk factors that may have been identified by the surgeons but not clearly documented would not have been picked up during risk scoring, leading to potential under-scoring of the actual risk. All ophthalmic surgeons in our institution were provided a list of risk factors included in the NZCRS system, and were asked to clearly document any risks present at the time of their preoperative assessment clinic; however, the level of documentation was variable. This barrier may be overcome by asking surgeons to fill in the scoring system themselves, at the time of preoperative clinical examination.

In this study, to retain clinical independence, the ultimate choice of which particular level of surgeon would operate on cataract cases with a higher risk score lay with the senior surgeon of the team. There was nonadherence to the NZCRS recommendations in 52 cases, where residents operated on "higher-risk" cases. Reasons for departure from these guidelines were not fully recorded, but typically it was felt the case was within the resident's skill set. Since these cases were associated with a higher rate of intraoperative complications (9.6% in nonadherence group vs 4.5% in adherence group), a greater level of direct supervision of the resident surgeon by the senior surgeon may be required in such cases. Also, inevitably in a teaching hospital, there may be more than 1 surgeon operating on a particular case. One third of cases in this study were performed in the presence of an assistant or supervising secondary surgeon. Although standardized operation note templates with tick boxes were included for reporting of intraoperative complications, there was occasional difficulty in deciphering from the operation note regarding to which surgeon the complication was attributable. Furthermore, the outcome of cataract surgery may have been team dependent, where the full responsibility of a complication cannot be attributed to 1 particular surgeon. Owing to these difficulties, all intraoperative complications in this study were assigned to the primary surgeon.

In conclusion, in this third phase of 3 prospective studies, we report a significant reduction of intraoperative complications after implementation of the NZCRS system. This is despite a higher proportion of high-risk cataract cases and a higher proportion of training residents operating as the primary surgeon, compared to earlier NIP and MIP phases of this study. We believe the NZCRS system aids in the identification of high-risk cases, provides objective guidance for appropriate case-to-surgeon allocation, and possibly increases surgeon awareness of risk factors that may aid in addressing potential operative difficulties. Notably, in clinical override "nonadherence" cases, where residents operated on "higher-risk" cases (N = 52), the intraoperative complication rate was more than double (9.6%) than in the cases where the NZCRS guidance was adhered to (4.5%, N = 448). This highlights the value of this relatively simple scoring system in trainee case allocation in a public hospital system. Going forward, the

NZCRS system ultimately requires further validation and its day-to-day practicability needs to be assessed. This could simply be pursued through a longitudinal clinical study, wherein surgeons use the NZCRS system to score and allocate patients themselves, without intervention from the investigators.

FUNDING/SUPPORT: JINA V. HAN WAS FUNDED BY AN UNRESTRICTED HEALTH RESEARCH SCHOLARSHIP (MAURICE AND PHYLlis Paykel Trust) at the University of Auckland, Auckland, New Zealand. Financial Disclosures: The following authors have no financial disclosures: Jina V. Han, Dipika V. Patel, Henry B. Wallace, Bia Z. Kim, Trevor Sherwin, and Charles N.J. McGhee. All authors attest that they meet the current ICMJE criteria for authorship.

Other Acknowledgments: The authors sincerely thank all patients, surgeons, nurses, and administrative staff at Greenlane Clinical Centre, ADHB, for their participation and support in this study. The authors thank the biostatisticians at the Department of Epidemiology and Biostatistics, University of Auckland, for their expert statistical advice.

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