Cataract: past, present & future

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Case Scenario Links

Cataract Surgery Past Present Future

• Infant with an altered light reflex (Oph12)
• Gradual deterioration in visual acuity over time (Oph07)
  Type 2 diabetes mellitus (Endo11)
• 6 week check (Paed26)
• Family with a genetic disorder (MG02)
Cataract: blindness & visual impairment

- Cataract
- Uncorrected Refractive errors are the leading causes of Avoidable Visual Impairment.

Visual Impairment

- Diabetic Retinopathy 1%
- Childhood blindness 5%
- Other causes: 18%
- Age-related macular degeneration (AMD) 1%
- Glaucoma 2%

Cataract 32%

- Glaucoma 8%
- Childhood blindness 4%


Blindness

- Diabetic Retinopathy 1%
- Age-related macular degeneration (AMD) 5%
- Uncorrected Refractive Error 3%
- Corneal Opacities 4%

Cataract 51%

- Other causes 21%
- Trachoma 3%

- Unoperated Cataract and Glaucoma are the leading causes of Avoidable Blindness.

The blind leading the blind
By Pieter Bruegel the elder
Basic anatomy: Lens and anterior segment

Cross section of anterior segment of the human eye showing lens suspended by fine zonules

Ectopia lentis with upward luxation of the crystalline lens due to weakened & absent zonules (seen in lower pupil)
Simplified diagrammatic eye

Eye has 2 principal focusing structures

a) The cornea $\frac{2}{3}^{\text{rd}}$
   approximately 40 dioptres

b) The crystalline lens $\frac{1}{3}^{\text{rd}}$
   approximately 20 dioptres

c) If lens cataract is removed
   the focusing power (20D) needs to be replaced

d) Historically lens power replaced by spectacles,
in last 40 years mainly by intraocular lenses
Cataract assessment:
acuity, ophthalmoscope and slit lamp
Describing Cataract Anatomy

Anterior
- Anterior sub-capsular
- Cortical
- Nuclear

Posterior
- Posterior sub-capsular
The global burden of cataract

• 20 million blind globally - classified as <6/30 - 2010 (WHO)
• Additional 2 million new cases per annum
• 90% of blindness in developing world - 51% due to cataract
• >100 million severe visual impairment
• However only around 12 million cataract procedures per annum
Cataract - multiple aetiologies

- Congenital
- Inherited
- **Age-related (the majority)**
  - Metabolic – e.g. diabetes
  - Toxic – e.g. corticosteroids
  - Traumatic – e.g. irradiation
- Secondary – e.g. ant. uveitis

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Posterior polar cataract

Dense brunescent (advanced) cataract
Dehydrational crises: a major risk factor in blinding cataract

D C MINASSIAN,1 V MEHRA,2 AND J-D VERREY1

From the 1International Centre for Eye Health, Institute of Ophthalmology, 27–29 Cayton Street, London EC1V 9EJ, and the 2Chattisgarh Eye Hospital, Fafadhi, Raipur, MP, India

SUMMARY An earlier case control investigation has indicated a strong relationship between dehydrational crises and risk of presenile cataract. A second methodologically distinct case control study of risk factors in cataract has been carried out in a population very different in terms of environmental and sociocultural characteristics from the population investigated in the earlier study in Central India. The results strongly confirm the findings from the first study and indicate that an estimated 38% of blinding cataract may be attributable to repeated dehydrational crises resulting from severe life threatening diarrhoeal disease and/or heatstroke. The risk of blinding cataract was strongly related to level of exposure to dehydrational crises in a consistent and dose dependent manner, thus indicating a causal association. The findings are discussed in relation to possible sources of bias in the study, confounding in the data, and the steps that were taken to minimise their undesirable effects.
Breaking down barriers: a (R)evolution in cataract surgery
Cataract surgery: ancient to modern

Ancient Techniques

Couching

Current cataract extraction techniques

1. Intra-capsular – now mainly in developing world
2. Extra-capsular – some use in developed world
3. Phacoemulsification – most popular technique
Couching of cataract has ancient origins in India – similar techniques shown in illustration of Roger of Salernin in 12th Century Italy.
Origin of modern Cataract Surgery:
1750’s Extra-capsular cataract (ECCE) surgery

Dr Jacques Daviel, a French Ophthalmologist, first described the ECCE technique in 1752 – and a variation of this technique was the mainstay of cataract surgery until 1990’s.
Intra-capsular cataract extraction (ICCE)
the cataract (lens) is removed with the capsule

Still successfully performed in parts of developing world in 2020
Extra-capsular Cataract Surgery (ECCE)

the cataract is removed leaving the lens capsule
Intra-ocular lenses 1949

Sir Harold Ridley

Invented intra-ocular lenses (IOLs) and performed the first successful Surgery in Moorfields Eye Hospital, London, 1949
1970’s Iris-clip intra-ocular lenses

Iris clip lenses used when no capsular support e.g. after ICCE

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1980’s Intra-ocular lenses:
single piece anterior chamber IOLs & three piece posterior chamber IOL
1990’s: widespread acceptance of small incision phacoemulsification surgery

Use of high frequency ultrasound to emulsify cataract performed through a smaller incision (6mm verses traditional 10mm incision of ECCE procedures)
Phacoemulsification basics

Phacoemulsification (ultrasound) hand piece

- Driven electrically Piezoelectric crystal vibrates ultrasonically
- Frequency 25,000 – 60,000 Hz
- Phaco “needle” is hollow (0.9mm) with central aspiration port
- Needle surrounded by soft irrigation sleeve with two ports which maintains fluid in anterior chamber
- Phacoemulsification tip has both a “jackhammer” mechanical effect and a cavitation (acoustic) effect.
Superior scleral tunnel approach to phacoemulsification in 1990’s

In early 1990’s IOLs were typically **rigid** and therefore needed a larger (5-6mm) incision, further back on the sclera than contemporary incisions, and sutures.
Contemporary corneal Incision structure

1, 2 or 3 step corneal incisions
• Quick, no bleeding, single instrument, typically no suture
• Enables topical anaesthetic, popular – now 90% procedures
Late 1990’s Intra-ocular lenses: 
small incision phacoemulsification and the evolution of 
foldable or injectable Intraocular lenses

Folding or injecting the 6mm diameter IOL enables the incision size to be reduced to 3mm width for no-suture phacoemulsification with incisions moving from largely scleral to corneal based
Complexity of phacoemulsification technology
Injecting a single piece IOL via corneal incision
Complexity of phacoemulsification technology

Phacoemulsification video
Cataract Surgery: varied global rates
Cataract presentation in a New Zealand perspective: Auckland Cataract Studies 2000 - 2020
The Auckland Cataract Studies

- The first ACS provided a prospective snapshot of 500 patients with cataract, cataract services, and state of the art surgical techniques in a public hospital service in the year 2000
- Also highlighted public cataract waiting list issues and access to appropriate government funded care in a major metropolitan area (now resolved)
- Results published in a series of scientific publications in the British Journal of Ophthalmology and Clinical and Experimental Ophthalmology
## Evolution of NZ Cataract Prioritization Questionnaire

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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
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<tr>
<td>6/12</td>
<td>1</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>6/18</td>
<td>2</td>
<td>8</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
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<tr>
<td>6/24</td>
<td>9</td>
<td>9</td>
<td>15</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>6/36</td>
<td>10</td>
<td>10</td>
<td>16</td>
<td>22</td>
<td>29</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>6/60</td>
<td>11</td>
<td>11</td>
<td>17</td>
<td>23</td>
<td>35</td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>CF/HM</td>
<td>12</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>36</td>
<td>36</td>
<td>40</td>
</tr>
</tbody>
</table>

Clinical modifiers eg. ARMD, Diabetic retinopathy -10 to +20
Work and independence 0 to 10
Non-vision physical disability 0 to 10
Activities of Daily Life questionnaire 0 to 13
Driving 0 to 7

Mrs JW
11 1 5 0 0 7

Image used with patient permission

24pts
The Auckland Cataract Study 1: waiting for surgery in a developed country

Harbour Bridge Study (N=193)

Mean age 77.2 years
Mean wait 18.2 +/- 11.6
Mean BSCVA 6/36

Outcome
Still waiting 49%
Expedited Rx 4%
Private Surgery 21%
Deceased 12%
Declined Surgery 12%

The Waiting Game: The natural history of a cataract waiting list in New Zealand
Auckland Cataract Project: Associated Systemic Disease

The majority of those with significant cataract have General Health issues

- Hypertension 25%
- Cerebral vascular disease 12%
- Diabetes Melitus 11%
- Ischaemic Heart disease 10%

Rx
- Aspirin 42%
- Warfarin 6%

Pre-proliferative diabetic retinopathy

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Auckland Cataract Study 1

488 consecutive cataract operations

Moderately advanced cataracts with mean BSCVA of 6/48 (20/160)

Mean pre-op refraction  -0.49 +/- 1.03D

99.8% local anaesthesia (95% subtenons)

97.5% small incision phacoemulsification

Typically less than 30 minute procedure

Phacoemulsification outcomes (N=488)

Unselected, consecutive, moderately advanced cataracts treated in a tertiary public hospital by residents / consultants

Outcome:
- Mean BSCVA = 6/7.5 (20/25)
- Majority (88%) > 6/12 (20/40)
- Mean SphEq = -0.46+/-0.89D

Complications:
- 4.9% capsular tears
- 3.7% cystoid macular oedema
- 0.2% endophthalmitis
- 1.5% of eyes red’n in potential BSCVA due to surgery

The Auckland Cataract Study: co-morbidity, surgical techniques and clinical outcomes in a Public Hospital Service. Andrew Riley, Tahira Malik, Christina Grupcheva, Michael Fisk, Jennifer Craig, Charles McGhee. BJ O 2002
The Initial Auckland Study: Summary 1

Predominantly elderly, majority female population

Significant systemic illness and co-existing ocular diseases,

Relatively advanced cataracts and poor visual acuity

Majority (97.5%) phacoemulsification, local anaesthetic (mainly sub-Tenons anaesthesia), day-case surgery in 2000

Remaining 2.5% underwent extra-capsular cataract surgery
The Initial Auckland Study: Summary 2

Almost 90% achieved BSCVA of 6/12 (20/40) or better which meets the NZ & UK driver’s licence standard.

~5% of eyes had an adverse intra-operative event

However, only 1.5% of eyes exhibited poorer post-operative BSCVA than predicted based on overall eye health in 2000.
## ACS 2000: Complications Summary

### N=500 Intraoperative complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior capsule tear</td>
<td>24</td>
<td>4.9%</td>
</tr>
<tr>
<td>Iris prolapse / Iris trauma</td>
<td>21</td>
<td>4.3%</td>
</tr>
<tr>
<td>Wounds retraction/minor phaco burn</td>
<td>19</td>
<td>3.9%</td>
</tr>
<tr>
<td>Incomplete capsulorrhexis</td>
<td>11</td>
<td>2.2%</td>
</tr>
<tr>
<td>Dropped lens fragment</td>
<td>4</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Consultants 320 phacoemulsifications - 4.7% capsule tear
Registrars 168 phacoemulsifications - 5.4% capsule tear
Always consider knowledge in context of contemporary international evidence base

- **Posterior capsule rupture** 1.9 - 5.2%
- **Cystoid macular oedema** 1.0 - 5.7%


Auckland cataract Studies 2000 to 2020

Considering

- Contemporary trends and outcomes
- Registrar training and patient safety
- Risk stratification for cataract surgery
- Decreasing intra-operative complications
What’s new in IOL design?

Developments since ACS 2000

- Posterior capsule opacity & square edge
- Multifocal / accommodative IOLs
- Coloured IOLs & macular protection
- Correction of astigmatism
- Correction of spherical aberration
- Specialised IOLs for reconstruction
An Evidence based approach

Can we do better in assessing surgical risk for a patient?
Can we improve complication rates in a teaching hospital?
Audit: Cataract Surgery in Auckland 2002 to 2015
Can we make further improvements in a teaching hospital?

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2015</th>
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<tbody>
<tr>
<td>4.9%</td>
<td>Posterior capsule tear*</td>
<td>2.6%</td>
</tr>
<tr>
<td>3.8%</td>
<td>Cystoid macular oedema</td>
<td>3.5%</td>
</tr>
<tr>
<td>67.7%</td>
<td>UAVA 6/12 or better</td>
<td>73.9%</td>
</tr>
</tbody>
</table>

*May reflect better technology, less advanced cases, and improved training
PART 2:
Auckland Cataract Studies: Improving outcomes
Routine procedure & standard of care 2020

• Almost all cases ambulatory same-day surgery
• Anaesthesia typically sub-Tenons L.A. in DHBs
• Routine cases approx. 30 minutes theatre time
• Pad or shield overnight with day 1 and 28 review
• Post-op. Rx topical antibiotic (Chloramphenicol) for two weeks and topical steroid (Prednisolone or Dexamethasone) for four weeks
Auckland Cataract Study II
Risk stratification: Non-intervention phase (NIP)

• Preoperative data used to calculate individual risk scores (N=500) surgeon unaware of score

• Muhtaseb et al. and Butler T.K. risk scoring systems utilized

• Certain patient factors associated increased risk of intraoperative complications

Intraoperative complication rate per risk score in Auckland cataract Study IIA. Observational / NIP Phase


M-Score of >3 associated with an increasing risk of intraoperative complication
• Preoperatively scored a further 500 cases

• Suggested cases scoring >3 be performed by fellows/consultants
Complication rates per surgeon group
Auckland Cataract Study IIA (NIP) vs IIB (MIP)

• Note: complications ascribed to primary surgeon

• Case-adjusted odds ratios between groups not significantly different – registrars/ fellows/ consultants had similar complication rates, allowing for appropriate allocation

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Registrars</td>
<td>10.8%</td>
<td>7.0%</td>
<td>0.449</td>
</tr>
<tr>
<td>Fellows</td>
<td>6.4%</td>
<td>3.9%</td>
<td>0.554</td>
</tr>
<tr>
<td>Consultants</td>
<td>8.4%</td>
<td>4.8%</td>
<td>0.094</td>
</tr>
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</table>
Auckland Study II (MIP): Conclusions

1. **Risk scores** correlate with complication rates
2. **Fewer intraoperative complications with stratification**
3. Higher risk cases **appropriately allocated** senior surgeons
4. Lower risk cases also benefit from **increased awareness**?
5. ? “**Hawthorne effect**” altered behavior when studied

To assess New Zealand Cataract Risk Stratification system (NZCRS-1) on intraoperative complications of cataract surgery

Prospective cohort study

- 500 cases of phacoemulsification cataract surgery
- Public teaching hospital, Auckland, NZ
- 43 surgeons, 24 consultants 19 trainees*

*This indicates the number of trainees, not necessarily a diagnosis.
### NZ Cataract Risk Stratification (NZCRS)

**Please tick ALL that apply:**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Points</th>
<th>Risk factor</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense/total/white/ brunescent cataract /no fundus view</td>
<td>3</td>
<td>High ametropia (&gt;6D myopia/hyperopia)</td>
<td>1</td>
</tr>
<tr>
<td>Pseudoexfoliation</td>
<td>3</td>
<td>Posterior capsule plaque (1)</td>
<td>1</td>
</tr>
<tr>
<td>Phacodonesis</td>
<td>3</td>
<td>Posterior polar cataract (1)</td>
<td>1</td>
</tr>
<tr>
<td>Oral alpha-receptor antagonist</td>
<td>2</td>
<td>Shallow AC (&lt;2.5mm) (1)</td>
<td>1</td>
</tr>
<tr>
<td>Age &gt;88 years</td>
<td>1</td>
<td>Small pupil (&lt;3mm dilated) (1)</td>
<td>1</td>
</tr>
<tr>
<td>Corneal scarring</td>
<td>1</td>
<td>Miscellaneous risks assessed by surgeon (e.g. poor position/cooperation) (1)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total points:**

---

Please tick:

- Previous vitrectomy?  Yes [ ]  No [ ]
- Only eye?  Yes [ ]  No [ ]

If **total points >3 OR prev vit to OR only eye**, then fellow or SMO only case (tick below)

**Fellow or SMO ONLY case [ ]**
# NZCRS-1: Intraoperative complications

<table>
<thead>
<tr>
<th>Intraoperative complications (Total)</th>
<th>NZCRS (N=500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iris prolapse</td>
<td>1.4%</td>
</tr>
<tr>
<td>Iris trauma</td>
<td>1.2%</td>
</tr>
<tr>
<td>Anterior capsule tear</td>
<td>1.4%</td>
</tr>
<tr>
<td>Dropped nucleus</td>
<td>0.2%</td>
</tr>
<tr>
<td>Post. capsule tear ± vitreous loss</td>
<td>0.6%</td>
</tr>
<tr>
<td>Zonule dehiscence</td>
<td>0.6%</td>
</tr>
<tr>
<td>Vitreous loss</td>
<td>0.0%</td>
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</table>

NZCRS adherence (N=448) 4.5%

Non-adherence (N=52) 9.6%
Visual outcome NZCRS: 1 month

<table>
<thead>
<tr>
<th>NZCRS</th>
<th>Preoperative</th>
<th>Postoperative (4-6 weeks)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaided visual acuity</td>
<td>6/38</td>
<td>6/12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Best corrected visual acuity</td>
<td>6/20</td>
<td>6/10</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

No patients excluded on basis of co-morbidity e.g. glaucoma, AMD, diabetic retinopathy

Preceding NIP and MIP phases postoperative BCVA: 6/9 (20/30)
Intraoperative complications: 3-phase prospective Auckland Cataract Study (N=1500)

- NZ - No intervention (N=500)
  - Total 8.4%
  - PC tear 2.6% (13)

- NZ-Muhtaseb (N=500)
  - Total 5.0%
  - PC tear 1.4% (7)

- NZCRS-1 (N=500)
  - Total 5.0%
  - PC tear 0.6% (3)

(p = 0.035)

Phase 1: (NIP) risk score calculated but no intervention
Phase 2: (MIP) risk score calculated with intervention
Phase 3: NZCRS-1 risk score calculated with intervention
Auckland Cataract Study IV: NZCRS-2 standard of care phase

**Intraoperative complication rate**
- Registrar 5% (5/100 cases)
- Fellows 5.7% (2/35 cases)
- Consultants 2.2% (8/365 cases)

**Mean NZCRS-2 risk score per group**
- Registrar 0.81
- Fellows 1.6
- Consultants 1.6
Comparing Auckland Cataract Studies II-IV: intraoperative complications (N=2000)

**NZ - No intervention (N=500)**
- Total 8.4%
- PC tear 2.6% (13)

**NZ-Muhtaseb (N=500)**
- Total 5.0%
- PC tear 1.4% (7)

**NZCRS-1 (N=500)**
- Total 5.0%
- PC tear 0.6% (3)

**NZCRS-2 (N=500)**
- Total 3.0%
- PC tear 0.8% (4)

Phase 1: (NIP) risk score calculated but no intervention
Phase 2: (MIP) risk score calculated with intervention
Phase 3: NZCRS-1 risk score calculated with intervention
Phase 4: NZCRS-2 risk score calculated with intervention but no oversight

(p= .035)

(p<0.05)
Risk stratification with NZCRS

• **Does stratification work?**
  • 64% reduction of intraoperative complications (8.4% to 3.0% p<0.05)
  • Reduced severity of complications (PCR 2.6% to <1.0%)

• **Practical in day-to-day clinical setting?**
  • Good *utilisation* initial setup phase (80.5%)
  • Excellent *adherence to stratification* (99%)
NZCRS Risk Stratification Summary

- **Reduction of intraoperative complications** with NZCRS
  - Despite **higher proportion** of **high risk cases/trainees**

- **Preoperative risk stratification**
  - **identification** of high risk cases
  - **appropriate allocation** of case
  - **Increased awareness** of risk factors
  - Enables comparison of case complexity in training assessments
Summary: Auckland Studies 2000-2020

- Prospective study of more than 3000 patients
- Almost all patients undergo phacoemulsification cataract surgery with local anesthesia.
- Despite co-existing eye disease majority achieved 6/12 meeting the NZ driving standard.
- 5% of of eyes experienced adverse intra-operative event however only 1.0% visually significant
- 3% will develop cystoid macular oedema (most common post-operative complication)
- Only 1.0 - 1.5% of eyes exhibit poorer post-operative BSCVA than anticipated.
- Severe post-operative complications endophthalmitis and retinal detachment were uncommon
- Cataract stratification enables best allocation of patient to surgeons and decreases complications

The End

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