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Royal College of Ophthalmologists' National Ophthalmology Database study of cataract surgery: report 8, cohort analysis of the relationship between intraoperative complications of cataract surgery and axial length

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ABSTRACT

Objectives To describe the relationships between axial length and intraoperative complications in patients undergoing cataract surgery.

Design Cohort analysis of the Royal College of Ophthalmologists' National Ophthalmology Database (RCOphth NOD).

Setting 110 National Health Service Trusts in England, Health Boards in Wales, Independent Sector Treatment Centres and Guernsey.

Participants 820 354 patients, aged 18 years or older, undergoing cataract surgery. Eligible operations were those from centres with at least 50 operations with a recorded axial length measurement and age at surgery between 1 April 2010 and 31 August 2019.

Interventions Phacoemulsification where the primary intention was cataract surgery alone.

Outcome measures Posterior capsule rupture (PCR) and other recorded intraoperative complications.

Results 1 211 520 eligible operations were performed by 3210 surgeons. The baseline axial length was <21 mm (short eyes) for 17 170 (1.4%) eyes, 21–28 mm (medium eyes) for 1 182 513 (97.6%) eyes and >28 mm (long eyes) for 11 837 (1.0%) eyes. The median age at surgery was younger for patients with long eyes than those with short or medium eyes. The rate of any intraoperative complication was higher for short eyes than medium or long with complication rates of 4.5%, 2.9% and 3.3%, respectively (p<0.001). PCR occurred in 1.40% surgeries overall, and in 1.53%, 1.40% and 1.61% of short, medium and long eyes, respectively (p=0.043, not significant at the 1% level).

Conclusions Overall PCR rates for cataract surgery in RCOphth NOD contributing centres are lower than previously reported and there is little change in PCR rates by axial length. Short eyes were more likely to have an intraoperative complication than medium or long eyes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This analysis is from the largest Royal College of Ophthalmologists' National Ophthalmology Database dataset to date and the findings are representative of those anticipated in English, Welsh and Guernsey ophthalmic departments with data from traditional National Health Service hospitals and the independent sector.

⇒ The results for each intraoperative complication including the subdivision of posterior capsule rupture are influenced by small event rates in a large sample.

⇒ Almost half of patients had cataract surgery on both eyes, which introduces patient-level correlation that impacts on the statistical comparisons.

⇒ There may also be reporting bias as clinicians are required to select the presence of ocular copathologies and also report the occurrence of surgical complications.

INTRODUCTION

Cataract surgery is one of the most commonly performed operations with almost half a million surgeries performed by the National Health Service (NHS) in England in 2019–2020.[1] Both first and second eye cataract surgery are cost-effective, and have significant indirect societal and healtheconomic advantages including greater social inclusion and participation, improvements in mental health, reducing falls and incidence of road traffic accidents.[2–6]

The Royal College of Ophthalmologists' National Ophthalmology Database (RCOphth NOD) was established over a decade ago in the UK to provide a national audit service allowing comparisons of surgery outcomes and complication rates between units and surgeons, and also for research. A number of RCOphth NOD analyses have been published for cataract surgery including

visual outcomes, complication rates,[7] copathology proportions[8] and equity of access[9] to cataract surgery. A previous analysis of cataract surgery complications by axial length published in 2015[8] found that overall posterior capsule rupture (PCR) rates (a significant intraoperative complication and one of the main benchmark outcomes) showed little change with ocular axial length except in eyes with axial length <20.0 mm where the risk of PCR was 1.9 times higher and 3.6% overall.[8]

This RCOphth NOD analysis using a sixfold larger dataset (over 1.2 million operations compared 180 thousand) aims to assess the relationship between axial length and intraoperative complications in contributing centres representative of English, Welsh and Guernsey ophthalmological departments undertaking cataract surgery.

In this analysis, PCR has been further subdivided into PCR without vitreous loss (PCR no VL), PCR with VL (PCR +VL), zonule dialysis with VL (ZD +VL) and PCR with ZD with VL (PCR +ZD + VL).

METHODS

The RCOphth NOD receives anonymised data from participating NHS Trusts in England, Health Boards in Wales, Independent Sector Treatment Centres and one centre in Guernsey providing NHS and publicly funded cataract surgery. The data are recorded on electronic medical record systems (EMR) or in-house databases and were submitted annually for cataract operations using phacoemulsification to treat patients aged 18 years or older, where the primary intention was cataract surgery alone. Combined procedures, 'cataract +other' surgery, were excluded, unless the 'other' surgery formed part of the cataract operation (eg, an operative manoeuvre to increase the size of the pupil). Further information on audit eligible cataract operation can be found on the RCOphth NOD audit website (www.nodaudit.org.uk).

Eligible operations were those that were performed between 1 April 2010 and 31 August 2019 satisfying the eligibility criteria that apply to the RCOphth NOD Cataract Audit, from any contributing centre with at least 50 eligible operations. Operations were excluded if there was no recorded axial length measurement, if the measurement was <18 mm or >40 mm or if there was no age at surgery recorded.

The data were recorded on the Medisoft EMR system (Medisoft Ophthalmology, Medisoft Limited, Leeds, UK, www.medisoft.co.uk), the Open Eyes EMR system (www.openeyes.org.uk) or 'in-house' data collection systems compliant with the National Cataract Dataset (https://www.rcophth.ac.uk/standards-publications-research/audit-and-data/clinical-data-sets/cataract-national-data-set/).

Axial length was categorised as <21 mm (short eyes), 21–28 mm (medium eyes) and >28 mm (long eyes) and also reported in 1 mm increments. Comparisons for ocular conditions and intraoperative complications across the axial length groups were performed using the Pearson χ^2 test, and a significance level of 1% used to ascertain statistically significant differences.

The EMR systems require the surgeon recording the operation note to specifically indicate a 'yes/no' response to whether a surgical complication occurred. At all centres, the EMR record (or its printed copy for the

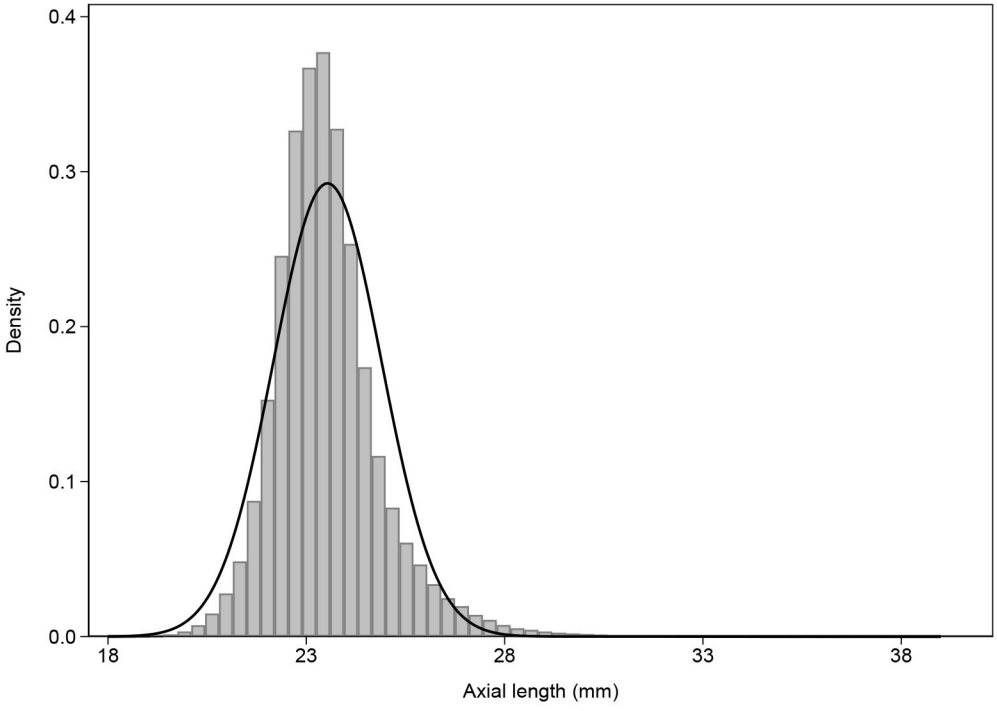

Figure 1 Histogram of baseline axial length for 1 211 520 eyes undergoing cataract surgery.

Table 1 Operating grade of surgeon and ocular copathology or known risk factor for PCR for short, medium and long eyes

	Baseline axial length				
N (column %)	Short (<21 mm)	Medium (21–28 mm)	Long (>28 mm)	Total	P value
Number of operations/eyes	17 170	1 182 513	11 837	1 211 520	N/A
Grade of operating surgeon					
Consultant surgeon	13 063 (76.1)	795 566 (67.3)	9053 (76.5)	817 682 (67.5)	<0.001
Career grade non-consultant surgeon	1305 (7.6)	114 332 (9.7)	813 (6.9)	116 450 (9.6)	
More experienced trainee surgeon	2510 (14.6)	229 581 (19.4)	1828 (15.4)	233 919 (19.3)	
Less experienced trainee surgeon	292 (1.7)	43 034 (3.6)	143 (1.2)	43 469 (3.6)	
Individual copathology/known PCR risk factor (n column %)					
Age-related macular degeneration	1749 (10.2)	122 641 (10.4)	684 (5.8)	125 074 (10.3)	<0.001
Glaucoma	2593 (15.1)	102 793 (8.7)	786 (6.6)	106 172 (8.8)	<0.001
Diabetic retinopathy	867 (5.0)	72 439 (6.1)	184 (1.6)	73 490 (6.1)	<0.001
Brunescent/White/Mature cataract	1094 (6.4)	55 275 (4.7)	537 (4.5)	56 906 (4.7)	<0.001
Corneal pathology	898 (5.2)	45 759 (3.9)	375 (3.2)	47 032 (3.9)	<0.001
Other macular pathology	397 (2.3)	30 792 (2.6)	561 (4.7)	31 750 (2.6)	<0.001
Previous vitrectomy surgery	79 (0.5)	20 843 (1.8)	875 (7.4)	21 797 (1.8)	<0.001
Amblyopia	1547 (9.0)	17 925 (1.5)	818 (6.9)	20 290 (1.7)	<0.001
No fundal view/vitreous opacities	368 (2.1)	18 499 (1.6)	177 (1.5)	19 044 (1.6)	<0.001
Pseudoexfoliation/phacodenesis	210 (1.2)	12 501 (1.1)	70 (0.6)	12 781 (1.1)	<0.001
Other retinal vascular pathology	185 (1.1)	12 176 (1.0)	74 (0.6)	12 435 (1.0)	<0.001
Uveitis/synechiae	288 (1.7)	9421 (0.8)	84 (0.7)	9793 (0.8)	<0.001
Optic nerve/CNS disease	94 (0.5)	5459 (0.5)	51 (0.4)	5604 (0.5)	0.227
Previous trabeculectomy surgery	92 (0.5)	5294 (0.4)	40 (0.3)	5426 (0.4)	0.045
Fuch's endothelial dystrophy	56 (0.3)	2278 (0.2)	6 (<0.1)	2340 (0.2)	<0.001
Inherited eye disease	74 (0.4)	1607 (0.1)	35 (0.3)	1716 (0.1)	<0.001
Other unspecified ocular copathology	3066 (17.9)	82 312 (7.0)	1276 (10.8)	86 654 (7.2)	<0.001

CNS, central nervous system ; PCR, posterior capsule rupture.

paper notes) constitutes the medicolegal documentation of the patient's operation record.

PCR was defined as in the RCOphth NOD[10] and is subdivided into PCR without VL (PCR no VL), PCR with VL (PCR +VL), ZD with VL (ZD +VL) and PCR and ZD with VL (PCR +ZD +VL).

Recorded intraoperative complications of canalicular trauma, corneal perforation, decentred IOL, epithelial abrasion, infusion cannula in subretinal/suprachoroidal space, operation cancelled, pain, retinal haemorrhage, vitreous haemorrhage and wound leak were all included in the 'unspecified other' due to small frequencies.

The grade of operating surgeon was categorised as consultant surgeons, career grade non-consultant surgeons (associate specialists, staff grades and trust doctors), more experienced trainee surgeons (fellows, registrars and specialty trainees/registrars years 3–7), and less experienced trainee surgeons (senior house officer, specialty trainee/registrars years 1–2 and foundation doctors years 1 and 2).

The lead clinician and Caldicott Guardian (responsible nominee for data protection) at each centre provided written approval for anonymised data extraction. Anonymised database analyses of this type do not require ethical permission due to being viewed as audit or service evaluation (see http://www.hra.nhs.uk/research-community/before-you-apply/determinewhether-your-study-is-research/). This study was conducted in accordance with the Declaration of Helsinki, and the UK's Data Protection Act.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Within the study period, 1 211 520 RCOphth NOD eligible cataract operations were performed on eyes with an axial length measurement between 18 and 40 mm and a recorded age at surgery from 110 centres with at least 50 eligible operations. The operations were performed on 595 786 (49.2%) left eyes and 615 734 (50.8%) right eyes from 820 354 patients, where the median number of operations per centre was 7330 (range: 53–42 637).

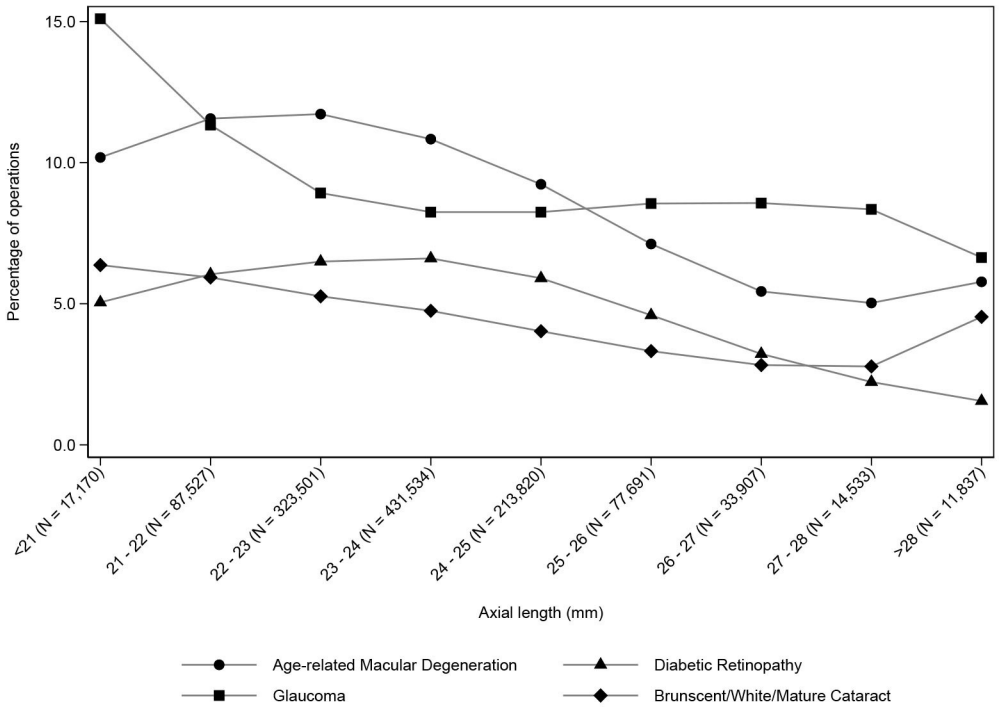

Figure 2 Prevalence rates for age-related macular degeneration, diabetic retinopathy, glaucoma and brunescent/white/mature cataract over 1 mm increments of axial length, for 1 211 520 eyes undergoing cataract surgery.

The operations were performed by 3210 surgeons, 1049 of whom had data for >1 grade, where 1505 consultant surgeons performed 817 682 (67.5%) operations, 486 career grade non-consultant surgeons performed 116 450 (9.6%) operations, 1704 more experienced trainee surgeons performed 233 919 (19.3%) operations and 564 less experienced trainee surgeons performed 43 469 (3.6%) operations.

Patient demographics

Of the 820 354 patients, 349 749 (42.6%) were male, 470 605 (57.4%) were female and 391 166 (47.7%)

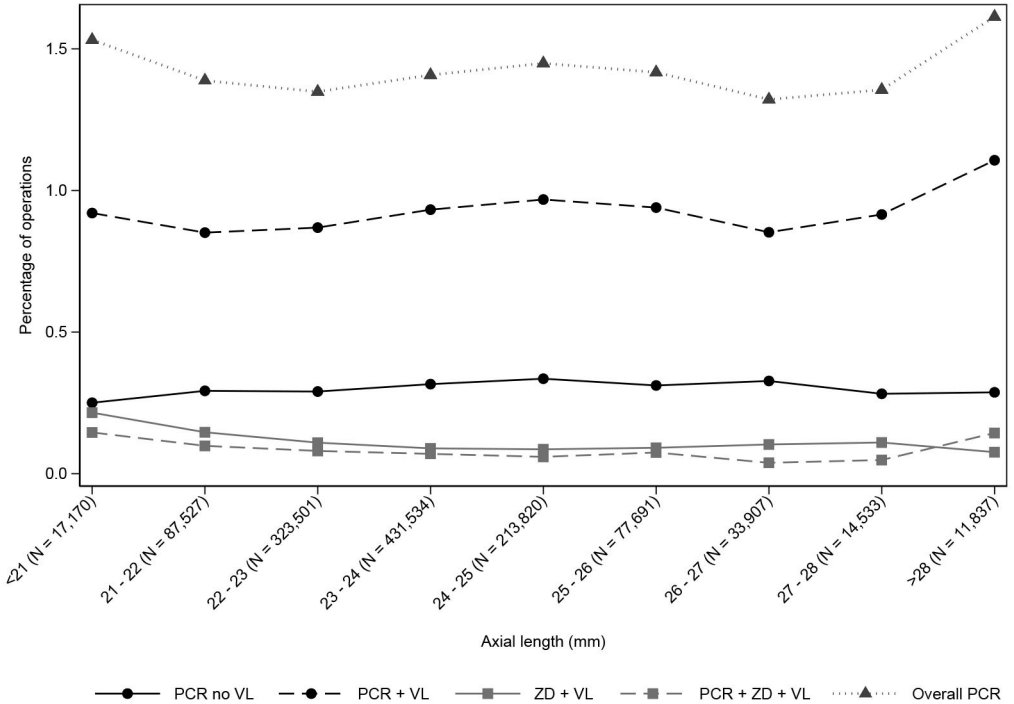

Figure 3 Posterior capsular rupture rates for 1 mm increments of axial length, for 1 211 520 eyes undergoing cataract surgery, where PCR is separated into constituent parts. PCR, posterior capsule rupture; ZD, zonule dialysis; VL, vitreous loss.

Table 2 Recorded intraoperative complications of cataract surgery for short, medium and long eyes

Intraoperative complications n (column %)	Baseline axial length				
	Short (<21 mm)	Medium (21–28 mm)	Long (>28 mm)	Total	P value
Number of operations/eyes	17 170	1 182 513	11 837	1 211 520	**N/A**
Number of eyes with					
No complication	16 400 (95.5)	1 147 866 (97.1)	11 452 (96.7)	1 175 718 (97.0)	<0.001
Any complication	770 (4.5)	34 647 (2.9)	385 (3.3)	35 802 (3.0)	
Individual complications					
Overall PCR*	263 (1.53)	16 497 (1.40)	191 (1.61)	16 951 (1.40)	0.043
PCR no VL	43 (0.25)	3669 (0.31)	34 (0.29)	3746 (0.31)	<0.001
PCR +VL	158 (0.92)	10 801 (0.91)	131 (1.11)	11 090 (0.92)	
ZD +VL	37 (0.22)	1174 (0.10)	9 (<0.10)	1220 (0.10)	
PCR +ZD + VL	25 (0.15)	853 (<0.10)	17 (0.14)	895 (<0.10)	
Overall zonule dialysis†	137 (0.8)	4996 (0.4)	57 (0.5)	5190 (0.4)	<0.001
Corneal epithelial abrasion	88 (0.5)	3238 (0.3)	35 (0.3)	3361 (0.3)	<0.001
Zonule dialysis no VL	75 (0.4)	2969 (0.3)	31 (0.3)	3075 (0.3)	<0.001
Torn iris/damage from the phaco	103 (0.6)	2849 (0.2)	9 (<0.1)	2961 (0.2)	<0.001
Endothelial damage/Descemet's tear	47 (0.3)	1299 (0.1)	7 (<0.1)	1353 (0.1)	<0.001
Lens exchange required/other IOL problems	38 (0.2)	1038 (<0.1)	32 (0.3)	1108 (0.1)	<0.001
Corneal oedema	34 (0.2)	956 (<0.1)	10 (<0.1)	1000 (<0.1)	<0.001
Hyphaema	18 (0.1)	599 (<0.1)	6 (<0.1)	623 (<0.1)	0.008
Iris prolapse/trauma	27 (0.2)	580 (<0.1)	4 (<0.1)	611 (<0.1)	<0.001
Phaco burn/wound problems	12 (<0.1)	553 (<0.1)	6 (<0.1)	571 (<0.1)	0.377
Choroidal/suprachoroidal haemorrhage	12 (<0.1)	315 (<0.1)	6 (<0.1)	333 (<0.1)	0.001
Anterior capsular tear	5 (<0.1)	188 (<0.1)	4 (<0.1)	197 (<0.1)	0.130
Other	102 (0.6)	5301 (0.4)	68 (0.6)	5471 (0.5)	0.002

*PCR was defined as in the RCOphth NOD (www.nodaudit.org.uk) and is subdivided into PCR without vitreous loss (PCR no VL), PCR with VL (PCR +VL), ZD with VL (ZD +VL) and PCR and ZD with VL (PCR +ZD +VL). The RCOphth NOD publicly reports PCR results to two decimal places.
†The overall ZD group includes ZD +VL, PCR +ZD +VL and ZD no VL.
PCR, posterior capsule rupture; RCOphth NOD, Royal College of Ophthalmologists' National Ophthalmology Database; VL, vitreous loss; ZD, zonule dialysis.

patients had cataract surgery to both their eyes during the analysis period, including 1275 patients who had immediate simultaneous bilateral cataract surgery (ISBCS).

ISBCS surgery was performed on 468 (36.7%) male patients and 807 (63.3%) female patients. The median age at surgery was 74.0 years (range; 22.5–100.2 years), 143 (11.2%) patients were unable to lie flat, 115 (9.0%) were unable to cooperate with the surgery and 205 (16.1%) had diabetes mellitus.

First treated eye surgery was performed on 715 952 patients (excluding ISBCS patients), where 304 642 (42.6%) patients were male and 411 310 (57.4%) patients female. The median age at surgery was 76.2 years (range: 18.0–117.5 years), 12 403 (1.7%) patients were unable to lie flat, 19 389 (2.7%) were unable to cooperate with the surgery and 135 525 (18.9%) had diabetes mellitus.

Second treated eye surgery was performed on 493 018 patients (excluding ISBCS patients), where 201 938 (41.0%) patients were male and 291 080 (59.0%) patients female. The median age at surgery was 77.2 years (range: 18.0–113.2 years), 7301 (1.5%) patients were unable to lie flat, 12 959 (2.6%) were unable to cooperate with the surgery and 98 749 (20.0%) had diabetes mellitus.

Axial length

The method of axial length measurement was optical for 1 100 064 (90.8%) eyes, ultrasound for 73 971 (6.1%) eyes and not recorded for 37 485 (3.1%) eyes, with similar proportions of methods used for small, medium and large eyes. The axial length measurements were approximately normally distributed around a mean of 23.5 mm and an SD of 1.4 mm, although with an extended right tail (figure 1). The median baseline axial length measurement was 23.4 mm (IQR: 22.7–24.1 mm). The baseline axial length was <21 mm (short eyes) for 17 170 (1.4%) eyes, between 21 and 28 mm (medium eyes) for 1 182 513 (97.6%) eyes and >28 mm (large eyes) for 11 837 (1.0%) eyes.

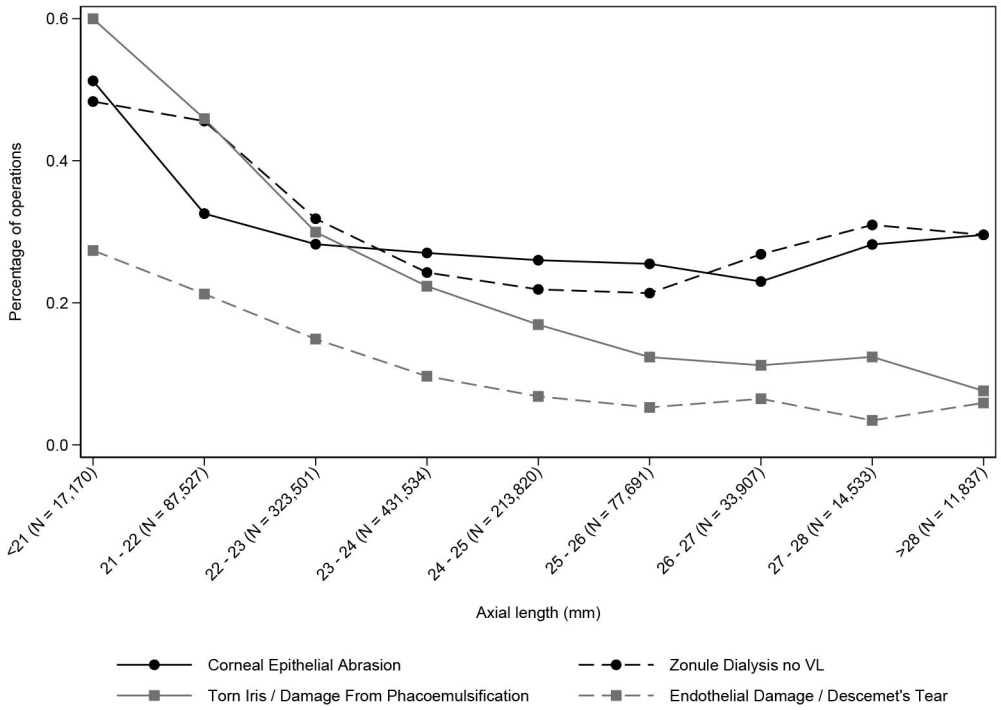

Figure 4 Complication rates for 1 mm increments of axial length, for 1 211 520 eyes undergoing cataract surgery. VL, vitreous loss.

The axial length measurements of the eyes operated on by each grade of surgeon were very similar, with a median for each grade of 23.4 mm and an IQR of around 22.7–24.2 mm (for each grade). Only less experienced trainee surgeons did not perform operations on eyes with an axial length <19 mm. In respect to the overall proportion of operations performed by each grade of surgeon, consultant surgeons performed a higher proportion of operations in short or long eyes than in medium eyes, with the opposite for the other three grades of surgeons (table 1).

The median age at surgery was approximately 8–9 years and 10–13 years younger for patients with long eyes than patients with short eyes and medium eyes respectively; median age for first eye surgery 66.3 vs 75.7 and 76.3 years, median age for second eye surgery 67.1 vs 75.8 and 77.3 years, median age for left eye ISBCS 61.7 vs 69.9 and 74.7 years and median age for right eye ISBCS 61.8 vs 71.5 and 74.7 years for long vs short and medium eyes, respectively (online supplemental table 1).

Ocular copathology and known PCR risk factors

The prevalence of glaucoma and unspecified other copathology were approximately 2–3 times higher in short eyes than in medium or long eyes. Age-related macular degeneration, pseudoexfoliation/phacodenesis and other retinal vascular pathology were approximately two times more prevalent in short or medium eyes than in long eyes. The prevalence of diabetic retinopathy was higher in short or medium eyes than long eyes. A brunescent/white/mature cataract, corneal pathology and uveitis/synechiae were more prevalent in short eyes than medium or long eyes. The prevalence of amblyopia was lower in medium eyes than short or long eyes. A higher percentage of long eyes had previously undergone vitrectomy surgery, and other macular pathology was more prevalent in long eyes than short or medium eyes (table 1). All individual ocular copathology and known PCR risk factors showed a statistically significant difference at the 1% level between short, medium and long eyes except for optic nerve/CNS disease (p=0.227) and previous trabeculectomy surgery (p=0.045). For the four most common copresent eye diseases in eyes undergoing cataract surgery, the prevalence variation over the axial length range is illustrated in figure 2.

Operative complications

The proportion of eyes that experienced any intraoperative complication was higher for short eyes than medium or long eyes, with complication rates of 4.5%, 2.9% and 3.3%, respectively (p<0.001).

The proportion of eyes that experienced PCR was 1.53%, 1.40% and 1.61% for short, medium and long eyes, respectively (p=0.043, not significant at the 1% level). When PCR was separated into constituent parts, the slightly higher trend observed for short and long eyes were due to the cases of ZD +VL and PCR +VL, respectively, and not PCR no VL or PCR +ZD + VL, the rates for which were fairly stable across the axial length range (figure 3).

A higher proportion of short eyes experienced corneal epithelial abrasion, ZD no VL, torn iris/damage from the phaco, endothelial damage/Descemet's tear, corneal oedema or iris prolapse/trauma than medium or long eyes. A lower proportion of medium eyes experienced

Table 3 Intraoperative complication rates for first and second eye surgery by patient's factors, for the five most frequently recorded complications, excluding ISBCS patients

Row percentage	Posterior capsule rupture	Corneal epithelial abrasion	ZD no VL	Torn iris/ damage from the phaco	Endothelial damage/ Descemet's tear
First eye surgery (N=715 952)	**1.5**	**0.3**	**0.3**	**0.3**	**0.1**
Grade of operating surgeon					
Consultant Surgeon (N=488 177)	1.2	0.3	0.3	0.2	0.1
Career grade non-consultant surgeon (N=67 373)	1.5	0.3	0.3	0.3	0.1
More experienced trainee surgeon (N=136 091)	2.3	0.3	0.4	0.4	0.2
Less experienced trainee surgeon (N=24 311)	2.7	0.6	0.4	0.4	0.2
Able to lie flat					
Yes (N=7 03 549)	1.5	0.3	0.3	0.3	0.1
No (N=12 403)	2.0	0.3	0.4	0.3	0.1
Able to cooperate					
Yes (N=6 96 563)	1.5	0.3	0.3	0.3	0.1
No (N=19 389)	1.6	0.3	0.3	0.3	0.1
Age at surgery					
<70 (N=199 130)	1.4	0.3	0.3	0.1	<0.1
70–74 (N=123 281)	1.4	0.3	0.3	0.2	<0.1
75–79 (N=147 788)	1.4	0.3	0.3	0.2	0.1
80–84 (N=138 095)	1.4	0.3	0.3	0.3	0.1
85–89 (N=80 522)	1.8	0.3	0.3	0.5	0.2
≥90 (N=27 136)	2.2	0.2	0.4	0.6	0.2
Gender					
Male(N=304 642)	1.6	0.3	0.3	0.3	0.1
Female(N=411 310)	1.4	0.3	0.3	0.2	0.1
Second eye surgery (N=493 018)	**1.3**	**0.3**	**0.3**	**0.2**	**0.1**
Grade of operating surgeon					
Consultant Surgeon (N=327 480)	1.0	0.2	0.2	0.2	0.1
Career grade non-consultant surgeon (N=48 945)	1.4	0.3	0.3	0.2	0.1
More experienced trainee surgeon (N=97 481)	2.0	0.3	0.4	0.3	0.2
Less experienced trainee surgeon (N=19 112)	2.4	0.6	0.3	0.4	0.2
Able to lie flat					
Yes (N=485 717)	1.4	0.3	0.2	0.2	0.1
No (N=7301)	1.5	0.3	0.3	0.4	0.2
Able to cooperate					
Y (N=480 059)	1.3	0.3	0.3	0.2	0.1
No (N=12 959)	1.5	0.3	0.3	0.3	0.2
Age at surgery					
<70 (N=117 851)	1.2	0.3	0.2	0.1	<0.1
70–74 (N=83 457)	1.1	0.3	0.2	0.2	<0.1
75–79 (N=106 543)	1.2	0.3	0.2	0.2	0.1
80–84 (N=103 102)	1.4	0.3	0.3	0.3	0.1
85–89 (N=61 448)	1.5	0.3	0.3	0.4	0.2
≥90 (N=20 617)	1.9	0.2	0.4	0.5	0.2
Gender					
Male(N=201 938)	1.3	0.3	0.2	0.3	0.1
Female (N=291 080)	1.2	0.3	0.3	0.2	0.1

ISBCS, immediate simultaneous bilateral cataract surgery; VL, vitreous loss; ZD, zonule dialysis.

lens exchange required/other IOL problems than short or long eyes, otherwise the proportion of short, medium or long eyes with individual intraoperative complications were very similar. All individual intraoperative complications showed a statistically significant difference at the 1% level between short, medium and long eyes except for phaco burn/wound problems (p=0.377) and anterior capsular tear (p=0.130, table 2).

The rates of corneal epithelial abrasion, ZD no VL, torn iris/damage from the phaco and endothelial damage/Descemet's tear were higher for shorter eyes and generally decrease as the axial length increases, except for corneal epithelial abrasion and ZD no VL, which did increase again for axial length measurements >26 mm (figure 4).

For the five most frequently recorded intraoperative complications (excluding ISBCS patients), the proportion of eyes that experienced these were similar or lower for second treated eye surgery than for first treated eye surgery for each grade of operating surgeon and in respect to the patients age, gender, ability to lie flat and ability to cooperate with the surgery, with exceptions for the patients ability to lie flat or cooperate for torn iris/damage from the phaco and the patients ability to cooperate for endothelial damage/Descemet's tear (table 3).

DISCUSSION

In this analysis of more than 1.2 million eyes undergoing cataract surgery in England, Wales and Guernsey, there was little change in PCR rates by axial length with rates of 1.53%, 1.40% and 1.61% for short, medium and long eyes, respectively. The overall PCR rate for this much larger RCOphth NOD dataset was 1.40% and lower than 1.95% reported in the previous RCOphth NOD analyses[7] with recent single year analyses having even lower rates – 1.14% in the 2018–2019 report.[10]

Additionally, there are differences in how intraoperative complications such as zonular dialysis may translate to the overall PCR headline rates, for example, zonular dialysis without VL was more common in short eyes (zonular dialysis without VL is not considered to be 'PCR'), however, the rates of zonular dialysis with VL were similar across groups, which again may reflect surgeon experience at managing intraoperative complications as consultant surgeons performed a higher proportion of operations in short (and long eyes). Multivariate analysis would be needed to investigate potential interactions of specific PCR risk factors. Also the 0.4% zonular dialysis no VL rate for eyes with an axial length <21.0 mm in this RCOphth NOD analysis was much lower than expected with a rate of 4.9% (5/103) reported in a 2013 analysis of outcomes in eyes with microphthalmos and nanophthamos[11] (defined as axial length <21.0 m). This RCOphth NOD analysis excluded eyes with axial lengths <18 mm and reports on a vastly larger sample of eyes with an axial length <21 mm. There is a lot of variability in the definitions of nanophthalmos and microphthalmos with values of <20.0 mm and <21.0 mm now being accepted based on the lower 2 and lower 3 SD from population values.[12 13] Consequently 'short' eyes in this RCOphth NOD analysis include both microphthalmos and nanophthalmos.

In this RCOphth NOD analysis the rates of brunescent/white/mature cataracts were approximately a third higher in short eyes than medium or long eyes. In the previous RCOphth NOD analysis,[8] eyes with brunescent/white/mature cataracts were more common in both very short (<20 mm) and very long axial lengths (>30.0 mm), suggesting surgeons may now be more comfortable intervening at early stages of cataract development in long eyes than previously. This is also supported by the median age at surgery being approximately 8–9 years younger for patients with long eyes than patients with short eyes and 10–13 years younger for patients with medium eyes. Rates of ocular copathologies differed by axial length group with glaucoma and age-related macular degeneration being more common in short eyes. This finding was similar to that in a previous RCOphth NOD analysis.[8]

This analysis is from the largest RCOphth NOD dataset to date, however, the results for each intraoperative complication including the sub-division of PCR are influenced by small event rates in a large sample. In this analysis, 47.7% patients had both eyes undergo cataract surgery, which introduces patient-level correlation that impacts on the statistical comparisons. This is further complicated by potential ocular level correlation from certain ocular conditions that can develop as bilateral disease, and the possibility that age-related ocular conditions are more prevalent in second treated eyes. The comparator groups formed from the axial length measurements are affected by the 5196 (1.3%) patients with data for both eyes who did not have both eyes in the same axial length group, that is, one short eye and one medium eye. It is not possible to account for all the sources of variation between centres, patients and possible correlations, consequently the interpretation of p values require caution as they are likely to be too low, especially for some covariates with extremely low event rates. It is possible that not all recorded first treated eye operations were the patients actual first eye surgery, as the patients could have their first eye surgery prior to a centre adopting an electronic data collection system, or performed in a different centre, and at present the RCOphth NOD cannot link patients' data if collected at different centres. There may also be reporting bias as clinicians are required to select the presence of ocular copathologies and also report the occurrence of surgical complications.

Overall, this RCOphth NOD analysis is from the largest dataset of more than 1.2 million cataract surgeries and the findings are representative of those anticipated in English, Welsh and Guernsey ophthalmic departments with data from traditional NHS hospitals and the independent sector. Overall PCR rates are lower than previously reported and showed little change by axial length. The rate of any intraoperative complication was higher for short eyes than medium or long eyes and was mainly driven by zonule weakness, iris trauma or endothelial/

Descemet's membrane damage, and not anterior capsule tears (or PCR). Detailed multivariate analysis is needed to investigate for interactions of specific PCR risk factors.

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NHS Trusts in England: Barking, Havering and Redbridge University Hospitals NHS Trust; Barnsley Hospital NHS Foundation Trust; Barts Health NHS Trust; Blackpool Teaching Hospitals NHS Foundation Trust; Bolton NHS Foundation Trust; Bradford Teaching Hospitals NHS Foundation Trust; Buckinghamshire Healthcare NHS Trust; Calderdale and Huddersfield NHS Foundation Trust; Chesterfield Royal Hospital NHS Foundation Trust; County Durham and Darlington NHS Foundation Trust; East Kent Hospitals University NHS Foundation Trust; East Lancashire Hospitals NHS Trust; East Suffolk and North Essex NHS Foundation Trust; East Sussex Healthcare NHS Trust; Epsom and St Helier University Hospitals NHS Trust; Frimley Health NHS Foundation Trust; George Eliot Hospital NHS Trust; Gloucestershire Hospitals NHS Foundation Trust; Great Western Hospitals NHS Foundation Trust; Guy's and St Thomas' NHS Foundation Trust; Hampshire Hospitals NHS Foundation Trust; Harrogate and District NHS Foundation Trust; Imperial College Healthcare NHS Trust; Isle of Wight NHS Trust; James Paget University Hospitals NHS Foundation Trust; Kettering General Hospital NHS Foundation Trust; King's College Hospital NHS Foundation Trust; Kingston Hospital NHS Foundation Trust; Leeds Teaching Hospitals NHS Trust; Liverpool University Hospitals NHS Foundation Trust; London North West University Healthcare NHS Trust; Manchester University NHS Foundation Trust; Mid and South Essex NHS Foundation Trust*; Mid Cheshire Hospitals NHS Foundation Trust; Moorfields Eye Hospital NHS Foundation Trust**; Norfolk and Norwich University Hospitals NHS Foundation Trust; North Cumbria Integrated Care NHS Foundation Trust; North Middlesex University Hospital NHS Trust; North West Anglia NHS Foundation Trust; Northampton General Hospital NHS Trust; Northern Lincolnshire and Goole NHS Foundation Trust; Nottingham University Hospitals NHS Trust; Oxford University Hospitals NHS Foundation Trust; Portsmouth Hospitals University NHS Trust; Royal Berkshire NHS Foundation Trust; Royal Cornwall Hospitals NHS Trust; Royal Devon University Healthcare NHS Foundation Trust; Royal Free London NHS Foundation Trust; Royal Surrey County Hospital NHS Foundation Trust; Royal United Hospitals Bath NHS Foundation Trust; Salisbury NHS Foundation Trust; Sandwell and West Birmingham Hospitals NHS Trust; Sheffield Teaching Hospitals NHS Foundation Trust; Sherwood Forest Hospitals NHS Foundation Trust; South Tees Hospitals NHS Foundation Trust; South Warwickshire NHS Foundation Trust; Southport and Ormskirk Hospital NHS Trust; St Helens and Knowsley Teaching Hospitals NHS Trust; Surrey and Sussex Healthcare NHS Trust; The Dudley Group NHS Foundation Trust; The Hillingdon Hospitals NHS Foundation Trust; The Mid Yorkshire Hospitals NHS Trust; The Newcastle upon Tyne Hospitals NHS Foundation Trust; The Princess Alexandra Hospital NHS Trust; The Rotherham NHS Foundation Trust; The Shrewsbury and Telford Hospital NHS Trust; Torbay and South Devon NHS Foundation Trust; United Lincolnshire Hospitals NHS Trust; University Hospital Southampton NHS Foundation Trust; University Hospitals Birmingham NHS Foundation Trust; University Hospitals Bristol and Weston NHS Foundation Trust; University Hospitals Coventry and Warwickshire NHS Trust; University Hospitals Dorset NHS Foundation Trust; University Hospitals Plymouth NHS Trust; University Hospitals Sussex NHS Foundation Trust; University Hospitals of Morecambe Bay NHS Foundation Trust; Warrington and Halton Teaching Hospitals NHS Foundation Trust; Wirral University Teaching Hospital NHS Foundation Trust; Wrightington, Wigan and Leigh NHS Foundation Trust; Wye Valley NHS Trust; Yeovil District Hospital NHS Foundation Trust; University health boards in Wales: Aneurin Bevan University Local Health Board; Cardiff & Vale University Local Health Board; Cwm Taf Morgannwg University Local Health Board; Hywel Dda University Local Health Board; Guernsey: Medical specialists group Guernsey; Independent sector treatment centres: The following sites from Practice Plus Group: Emersons Green NHS Treatment Centre; North East London NHS Treatment Centre; Peninsula NHS Treatment Centre; Rochdale Ophthalmology; SH Devizes NHS Treatment Centre; Shepton Mallet NHS Treatment Centre; Southampton NHS Treatment Centre; St Marys NHS Treatment Centre; Will Adams NHS Treatment Centre; The following sites from SpaMedica: Birkenhead; Birmingham; Bolton; Bradford; Chelmsford; Liverpool; Manchester; Newcastle Under Lyme; Newton-le-Willows; Sheffield; Skelmersdale; Wakefield; Widnes; St. Stephens Gate Medical Practice; *Since this analysis was conducted two centres have merged to form the organisation named above. **Including data from Croydon Health Services NHS Trust and data from the Bedford Hospital within Bedfordshire Hospital NHS Foundation Trust as these are part of the same governing authority for ophthalmology.

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Ethics approval Anonymised database analyses of this type do not require ethical permission due to being viewed as audit or service evaluation (see http://www.hra.nhs.uk/research-community/before-you-apply/determinewhether-your-study-is-research/).

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