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What was known before

Large datasets on cataract outcomes are limited by incomplete collection of key primary outcome indicators, which in turn may affect the quality of the data.

What this study adds

This study demonstrates that fully paperless ophthalmology units can be achieved in the NHS and that these have the ability to produce comprehensive cataract surgery outcome data.

The comprehensiveness of the data and the absence of selection bias mean that these data can be used with confidence in benchmarking and audit.

Going paperless: Improved cataract surgery outcome data quality in a new fully electronic unit

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Abstract

Objectives: To report outcome data on the first 5,000 consecutive cataract cases at a new paperless eye unit and benchmark against the Royal College of Ophthalmologists' National Ophthalmology database (RCOphth NOD).

Methods: Using the in-built audit tool of the electronic medical records system, data from all cataract operations performed between 1st April 2014 and 13th January 2017 were compiled.

Results: 5,008 cases were recorded of which the overall intra-operative complication rate was 2.4%, the most common being posterior capsular rupture – 1.14%. Follow-up data on post-operative complications were recorded in 98.6% of cases. Pre-operative visual acuity and post-operative visual acuity was measured in 98.0% of cases. 40.8% of eyes achieved a visual acuity of 6/6 or better and 90.7% achieved 6/12 or better.

Conclusions: A dataset of over 5,000 consecutive cataract operations was obtained in this eye department. The recording of pre-operative and post-operative visual acuity in 98% of cases compare very favourably to the RCOphth NOD Audit Report 2017 where pre-operative and post-operative visual acuity were recorded in only 57.1% of operations. Despite this difference, the outcome measures from this unit and RCOphth NOD were very similar, validating the results of the RCOphth NOD audit reports. Significantly, when applying the RCOphth NOD audit criteria for measuring post operative visual acuity, approximately 15% of cases were excluded from the dataset; reducing the completeness of the dataset. Paperless ophthalmology units are feasible in today's NHS and can produce near complete cataract datasets; this can ultimately lead to more comprehensive and reliable aggregate cataract outcome data.

Introduction:

Cataract surgery is the most common surgical procedure in the UK, where 330,000 cataract operations are performed per year in the English National Health Service (NHS) in the UK (1). In recent years there has been increasing emphasis on publication of aggregate and

individual surgical outcome data in cataract surgery (2). Publication of surgical outcomes is an important driver of quality improvement and helps patients to make informed decisions about their care.

The primary dimensions of data quality have been defined as completeness, uniqueness, timeliness, validity, accuracy and consistency (3). In many reports on cataract outcomes to date there appears to be actual or potential data quality issues both in terms of the accuracy (representativeness) of the data and the completeness of the dataset. Although some databases have been able to capture a large number of operations, the results have been limited by incomplete collection of key primary outcome indicators, which in turn may affect the quality of the data. In addition, when outcome databases are dependent on input of data that is separate from the clinical record there is selection bias and potential loss of representativeness of the data.

The European Registry of Quality Outcomes for Cataract and Refractive Surgery (EUREQUO) reported outcomes on 523,921 cataract extractions but long-term follow-up data (7 to 60 days) were available in only 46% of cases (4). The Royal College of Ophthalmologists' National Ophthalmology Database (RCOphth NOD) aims to provide robust evidence on cataract surgery outcomes and in its first report has audited the outcomes of 75,827 cataract operations in 34 centres in England (2). However, the results drawn from this first report indicate that data on pre-operative and post-operative visual acuity (VA) were recorded in the database in only 52.7% of cases. In the second RCOphth NOD audit report in 2017 this figure improved to 57.1% of cases (5). An estimate of the proportion of cataract operations performed in each participating centre that was included in the RCOphth NOD audit report ranged from 7.7% to 99.9% (overall 73%).

In the case of RCOphth NOD, the incompleteness of the dataset is due partly to the time-based definition of post-operative visual acuity (only cases with an acuity measured at between 2 weeks to 4 months post-surgery are included). A more important factor is the fact that, although many ophthalmology units in the UK use electronic medical records (EMR), very few use EMR *exclusively.* The ongoing partial use of paper records is the main reason for data leaching from multicentre electronic datasets such as the RCOphth NOD through the patients' cataract pathways. The NHS in England plans to be paperless by 2023

(6). In 2014 Moorfields Eye Hospital NHS Foundation Trust established a new paperless ophthalmology unit at Croydon University Hospital. We present outcomes data on the first 5,008 consecutive cataract surgery cases performed at this new unit.

Our specific aims were:

1) To benchmark our cataract surgery results against the RCOphth NOD results using the RCOphth NOD definition of post-operative visual acuity in order to assess the representativeness of our data
2) To investigate whether including data from patients seen and discharged within 2 weeks of surgery made a material difference to the visual outcomes
3) To report outcomes on this more inclusive and almost complete dataset of 5,008 consecutive cases

Methods:

Moorfields Eye Centre at Croydon University Hospital uses a single electronic medical records (EMR) system to record cataract encounters (Medisoft Ophthalmology, Medisoft Limited, Leeds, UK).

All cataract operations were performed between 1st April 2014 and 13th January 2017. These dates represent the opening date of the new eye unit and the date at which the 5,000th cataract operation was performed.

All duplicate records and records not belonging to patients (eg test patients) were removed by Medisoft technical staff. Thereafter, the in-built audit tool in the EMR was used to acquire data. The search was conducted on the 12th Dec 2017.

Baseline data on demographics, pre-operative visual acuity (VA), ocular co-morbidities and whether the surgery was on a first or second eye were collected. Outcome data on intra-operative complications, post-operative complications, post-operative VA and deviation from predicted post-operative refraction were collected. Pre-operative VA data was defined as the better value of uncorrected distance visual acuity (UDVA) or corrected distance visual acuity (CDVA). Post-operative 'best-measured' VA was defined as the best

CDVA measurement when present and the best measurement of UDVA or pinhole VA when CDVA was absent. Post-operative VA data were acquired in two ways: first, using the RCOphth NOD timescale of 2 weeks to 4 months post-surgery and second, using a more inclusive timescale of 1 day to 6 months post-surgery.

Results:

5,008 cataract operations were recorded between 1st April 2014 and 13th January 2017 at Moorfields Eye Centre at Croydon University Hospital. 2,902 (57.9%) were female and 2,106 (42.1%) were male and the mean age was 73.6 years. 41.2% of operations were performed by consultants, 38.6% by career grade non-consultant surgeons, 15.5% by experienced trainees and 4.7% by less experienced trainees.

The presence or absence of ocular co-pathology was documented in 100% of cases. 3,519 (70.3%) operations were in patients with no recorded ocular co-pathology and 1,489 (29.7%) were in patients with recorded ocular co-pathology.

Intra-operative Complications

The intra-operative complication rate was 2.4% (119 cases), the most common being posterior capsular rupture (PCR) which occurred in 1.14% of cases (see Table 1). The RCOphth NOD uses the definition of PCR to include PCR with and without vitreous loss *and* zonular rupture with vitreous loss.

Post-Operative Complications

Follow-up data on post-operative complications were recorded in 4,938 (98.6%) of operated eyes. The overall post-operative complication rate was 9.8%, the most common being post-operative uveitis (129 cases, 2.6%) and cystoid macular oedema (99 cases, 2.0%) see Table 2.

Visual Acuity

The pre-operative VA was recorded in 4,927 (98.4%) out of 5,008 cases.

Overall, 4,906 eyes (98%) had documented VA before and after cataract surgery. Using the RCOphth NOD time criteria of measuring post-operative VA between 2 weeks to 4 months post-surgery, 4,156 (83%) eyes had documented visual acuity before and after cataract surgery. 15% of cases were reviewed and discharged within 2 weeks of surgery.

Overall, 2,004 (40.8%) of patients achieved a post-operative VA of 6/6 or better and 4,449 (90.7%) achieved 6/12 or better after surgery (see Table 3). There was broad agreement in visual outcomes between our comprehensive data, our data limited to RCOphth NOD time criteria for post-operative acuity and the RCOphth NOD data (Table 4).

Discussion:

This single-centre study provides a high-quality dataset of over 5,000 consecutive cataract operations from a new ophthalmology unit. The completeness of these data compares favourably with previous reports using data from EMR in the UK, not least because this dataset includes 100% of the cataract operations performed in our unit within these dates. In the RCOphth NOD Audit Report 2017 no pre-operative VA data were recorded in 19.5% of cases and no post-operative complication data were recorded in 64.4%. Pre-operative and post-operative VA data were recorded in only 57.1% of cases (5). Incompleteness of visual acuity data has been a historical problem in national datasets in the UK (1, 2, 7) and the RCOphth NOD audit report 2017 acknowledges that "*completeness of pre-operative VA and post-operative VA outcome remain variable and an area for improvement in many centres.*" We anticipate that the increasing adoption of paperless EMR will bring about this improvement. In the meantime, our (98% complete) data appear to validate the benchmarks for visual acuity outcomes reported in the RCOphth NOD audit reports. One way of improving the completeness of VA outcome would be to include data on all patients. This would require a change in the time-based definition of post-operative visual acuity defined by RCOphth NOD. We note an approximate 15% loss of post-operative VA data in our cases when adhering to RCOphth NOD criteria for reporting post-operative VA. Our data

suggests that including data on all patients would not materially change the visual acuity outcomes.

When analysing intra-operative complications, this study found a posterior capsule rupture rate of 1.14%, which compares well with the 1.5% and 1.8% PCR rate from RCOphth NOD 2017 and 2016 respectively. Of note, our dataset is comprehensive and we have not excluded cataract cases which RCOphth NOD defines as ineligible in its statistical analysis plan. The overall rate of post-operative complication was 9.8% in this study with post-operative uveitis and corneal oedema accounting for 4.2%. Although our rate of major intra-operative complication (posterior capsule rupture) was lower than that recorded in the RCOphth NOD, our rate of recorded post-operative less serious complications (9.8%) was higher than the 5.8% reported in RCOphth NOD 2016 and lower than the 11.4% reported in RCOphth NOD 2017. These differences between our results and those of the RCOphth NOD and between successive RCOphth NOD reports raise an interesting issue about the definition of complications and recording in electronic records. At the first post-operative review, our electronic record forces documentation of the presence or absence of the findings listed in Table 2. Corneal oedema and post-operative uveitis, for example, are present in almost all patients at some point after cataract surgery and whether these are recorded as a complication depends both on the timing of post-operative review and the ability or inclination of the clinician reviewing the patient to distinguish between complication and normal post-operative course. Many of our patients were reviewed at 1-2 weeks post-surgery rather than the usual 3 weeks and this may account for some of the reported cases of corneal oedema and post-operative uveitis. Similarly, recorded rates of cystoid macular oedema will depend on whether patients have post-operative optical coherence tomography scans of the retina and whether cystoid macular oedema is defined clinically or tomographically. In order to accurately benchmark rates of post-operative complications, these complications need to be defined.

In some units in the UK patients are followed up by community opticians and not seen by the operating unit post-operatively. This is a further reason for loss of electronic data during the cataract pathway. Our centre invites all of our patients to attend for post-operative review after cataract surgery and records data exclusively electronically. Hence we have been able to record follow up in 98.6% of operations and record post-operative VA

in 98.0% of operations. This represents an almost complete dataset. We attribute the small data loss to non-attendance for follow up, inability to record VA (learning difficulties/cognitive impairment) and human error in neglecting or forgetting to enter data. In some fields we have recorded 100% data completeness. This is usually because the EMR forces the user to make an entry for this field. Forced choice data entry leads to high levels of data completeness but not necessarily data accuracy. One of the forced choice data fields in Medisoft Ophthalmology is the presence or absence of ocular co-pathology. An answer was recorded in 100% of cases but, in our cohort, co-pathology was recorded as present in just 29.7% of cases compared with 46.7% of cases in the RCOphth NOD audit report 2017. Our cataract patient cohort is comprehensive containing both new referrals and patients who already attend the clinic with other eye conditions so we were surprised to see the relatively low level of recorded ocular co-pathology. One explanation for this is that our cohort does in fact contain a lower proportion of patients with ocular co-pathology compared to the RCOphth NOD audit. Another explanation is that we have not recorded the presence of co-pathology accurately in our patients. This raises an important issue in paperless systems: In order to enter data in mandatory fields faithfully, those data must be easily accessible whilst the field is being filled. In our software it is difficult to access the past ophthalmic history and findings whilst completing the operation note. This barrier may explain the tendency for surgeons to tick the “no ocular co-pathology” mandatory field when filling the operation note in order to maintain efficiency in the operating theatre.

The easy availability of high-quality fully-representative outcome data is just one benefit of the move to paperless record-keeping. It provides real time feedback and the ability to audit results rapidly and comprehensively and then instigate improvements. However data will always be limited to accurate record keeping by the clinician regardless of how it is recorded.

Our study represents one of the most comprehensive and complete datasets on cataract surgery to be reported and appears to validate the outcome benchmarks reported by the RCOphth NOD audit reports.

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Table 1. Intra-operative complications compared to RCOphth NOD 2017

Intra-operative complications	n (%)	RCOphth NOD 2017 %
No intra-operative complications	4889 (97.6)	96.7
One or more intra-operative complications	119 (2.4)	3.3
PCR*	57* (1.14)	1.5*
Corneal epithelial abrasion	13 (0.3)	0.3
Zonule dialysis	10 (0.2)	0.4
Endothelial damage/Descemet's tear	7 (0.1)	0.1
Phaco burn/wound problems	6 (0.1)	<0.1
Torn iris / damage from phaco	3 (0.1)	0.2
Hyphaema	2 (<0.1)	<0.1
IOL exchange	1 (<0.1)	0.1
Iris prolapsed	1 (<0.1)	<0.1
Operation cancelled	1 (<0.1)	-
Other IOL problem	1 (<0.1)	0.1
Other	25 (0.5)	0.4

*Posterior capsular rupture (PCR) figure includes zonule rupture with vitreous loss and lens fragment into vitreous

Table 2. Post-operative complications compared to RCOphth NOD 2017

Presence or absence of post-operative complications	Recorded in 4938 of eyes (98.6%) n (%)	RCOphth NOD 2017 for operations with recorded data (35.6%) %
No post-operative complications	4454 (90.2)	88.6
One or more post-operative complications	484 (9.8)	11.4
Post-operative uveitis	129 (2.6)	3.2
Cystoid macular oedema	99 (2.0)	2.7
Corneal oedema/striae/Descemet's folds	78 (1.6)	2.7
Raised IOP (>21mmHg)	60 (1.2)	1.6
Reduction in vision*	50 (1.0)	
Macular oedema	33 (0.7)	0.0
Corneal decompensation	17 (0.3)	0.2
Unexpected refractive outcome	14 (0.3)	0.2
Vitreous in AC	9 (0.2)	0.3
Leaking wound (Seidel +ve)	7 (0.1)	<0.1
Hypotony<5	6 (0.1)	<0.1
Retained soft lens matter	6 (0.1)	0.4
IOL decentred	5 (0.1)	0.2

Iris to wound	5 (0.1)	<0.1
Vitreous to the section	4 (0.1)	0.1
Choroidal effusion/haemorrhage	3 (0.1)	<0.1
Retinal tear	3 (0.1)	<0.1
Posterior capsule opacification – YAG indicated	3 (0.1)	0.1
Corneal epithelial defect	2 (<0.1)	<0.1
Endophthalmitis	2 (<0.1)	<0.1
Hyphaema	2 (<0.1)	<0.1
Post-operative eyelid oedema	2 (<0.1)	<0.1
Anterior capsulophimosis	1 (<0.1)	<0.1
Diplopia	1 (<0.1)	<0.1
Iris prolapse	1 (<0.1)	<0.1
Post-operative ptosis	1 (<0.1)	<0.1
Posterior capsule opacification	1 (<0.1)	0.3
Progression of diabetic retinopathy	1 (<0.1)	<0.1
Retinal detachment	1 (<0.1)	<0.1
Vitreous haemorrhage	1 (<0.1)	<0.1
Other	69 (1.4)	1.3

*Note reduction of vision was reported by the clinician using EMR and is not the same as the RCOphth NOD definition of doubling of the visual angle or worse. We report a 1.26% rate of reduction in vision according to the RCOphth NOD criteria.

Table 3. Post-operative visual acuity (VA) by pre-operative VA, intra-operative complications and posterior capsular rupture (PCR) for cases where pre-operative and post-operative VA are recorded

		Post-operative Snellen visual acuity		
	Percentages (N)	≤ 6/6	≤6/12	≤6/24
	All eyes (4906)	40.8 (2004)	90.7 (4449)	96.8 (4750)
Presenting Snellen VA				
≤ 6/6	2.8% (137)	70.8 (97)	99.3 (136)	100 (137)
≤6/12	36.2% (1778)	49.7 (883)	98.0 (1743)	99.8 (1774)
≤6/24	67.6% (3316)	43.0 (1425)	94.5 (3134)	99.1 (3287)
Intra-operative complications				
No	97.6% (4789)	41.2 (1972)	90.9 (4354)	96.9 (4642)
Yes	2.38% (117)	27.4 (32)	81.2 (95)	92.3 (108)
PCR (RCOphth NOD definition)				
No	98.9% (4850)	41.0 (1989)	90.8 (4405)	96.9 (4702)
Yes	1.14% (56)	26.8 (15)	78.6 (44)	85.7 (48)

Table 4. Post-operative visual acuity in different post-operative time brackets and compared with RCOphth NOD benchmarks from 2017.

	Cases with visual acuity measurement within 14 days to 4 months post-operative	Cases with visual acuity measurement within 1 day to 6 months post-operative	RCOphth NOD Benchmarks (using 14 days to 4 months)
Percentage of eyes with pre- and post-operative data in our cohort	83%	98%	
≤6/6	39.1%	40.8%	39%
≤6/12	89.9%	90.7%	88.6%
≤6/24	96.5%	96.8%	95.9%