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Changing practice patterns in European cataract surgery as reflected in the European Registry of Quality Outcomes for Cataract and Refractive Surgery 2008–2017

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Running head: Changing practice patterns in cataract surgery.

Abstract

Purpose: To study practice patterns in European cataract surgery over a 10-year period.

Setting: European clinics affiliated to the European Registry of Quality Outcomes for Cataract and Refractive Surgery (EUREQUO).

Design: Registry cohort study.

Methods: The EUREQUO contains preoperative, intraoperative, and postoperative parameters reported by surgeons in many European clinics. All data reported to the registry are anonymized. Preoperative parameters included age, sex, visual acuity, target refraction, ocular comorbidity, and surgical difficulties. Surgical data included anaesthesia, surgical technique, intraocular lens optic biomaterial, and complications. Postoperative parameters included visual acuity, refraction, and short-term complications.

Results: During the study period (January 1. 2008–December 31, 2017) a total of 2,714,108 cataract extractions were reported to the EUREQUO. Preoperative data changed over time, with decreases in mean age (74.5 to 73.0), proportion of women from 60.6% (100,373/165,628) to 57.2% (174,908/305,845), and proportion of co-existing eye diseases from 30.0% (49,638/165,650) to 27.0% (82,704/305,846); and improvements in preoperative visual acuity (mean logMAR 0.46 to 0.37). The use of topical anaesthesia increased over time from 28.1% (26,238/93,320) to 71.7% (130,525/182,083). Surgical complications showed a significant decrease from 2.5% (4,107/165,650) to 1.2% (3,573/305,846). The visual outcome improved over time (mean logMAR 0.08 to 0.05), as did the absolute median prediction error (0.38 diopter [D] to 0.28 D).

Conclusions: Trends in European cataract surgery practice patterns from 2008 to 2017 have moved toward younger patients with better preoperative visual acuity, fewer surgical complications, and better predicted refractions and visual outcomes.

Introduction

Surgical techniques for cataract extraction have been refined over time because of better instruments, better machines and improved implants.[1] There is also a trend of surgeons doing more procedures per year.[2] Indications for cataract surgery have moved towards better preoperative visual acuity and younger and healthier eyes.[3] All these changes over time have contributed to improved outcomes. In this study we investigated changes in terms of indications, technique and outcomes as reflected in the European Registry of Quality Outcomes for Cataract and Refractive Surgery (EUREQUO).[4, 5]

Methods

EUREQUO was instituted in 2008 as a co-project between the European Union (EU) and the ESCRS and has been described extensively in the literature. [6, 7] Mandatory parameters included in the EUREQUO and to be reported are Patient: patient number, year of birth, gender, eye; Preoperative: corrected distance visual acuity (CDVA), biometry target refraction, co-existing eye disease (none, glaucoma, macular degeneration, diabetic retinopathy, amblyopia, other), complicating comorbidity (none, previous corneal refractive surgery, white cataract, pseudoexfoliation, previous vitrectomy, corneal opacities, small pupil/IFIS, other). Intraoperative: date of surgery, surgeon experience, type of operation, laser-assisted cataract surgery details, type of IOL optic biomaterial, complications during surgery. Postoperative: date of examination, CDVA operated eye, postoperative complications. The current study analysed preoperative, intraoperative, and postoperative parameters over time. Preoperative parameters were age, sex, visual acuity, target refraction, and risk factors including ocular comorbidity and surgical difficulties; intraoperative parameters were anaesthesia, surgical technique, intraocular lens (IOL) optic biomaterial, and surgical complications; postoperative parameters were visual acuity, refraction, and short-term complications. Some parameters had different denominators because they were not available in all reporting national registries affiliated to EUREQUO. All data reported to the

EUREQUO are anonymized. This study was approved by the Swedish Ethical Board (ref. number2020-01872) and was performed according to the tenets of the Declaration of Helsinki.

Statistical methods

Trends over time were analysed with a chi-squared test for categorical data and analysis of variance (ANOVA) for numerical data. All analyses were performed using SPSS (v. 25. SPSS Inc., IBM) at a 5% significance level.

Results

During the study period, (January 1. 2008–December 31, 2017), a total of 2,714,108 cataract extractions were reported to the EUREQUO from 14-16 countries per year.

Preoperative data

The mean age of the patients in our study decreased significantly over time from 74.5 years in 2008 to 73.0 years in 2017 (<0.001). Trends in patient age, sex, preoperative visual acuity and anticipated surgical difficulties over the study period are shown in Table 1.

Reported ocular comorbidities in the registry include age-related macular degeneration (AMD), glaucoma, diabetic retinopathy, amblyopia, and "other" sight-threatening ocular comorbidities. Over the study period the reported occurrence of AMD decreased from 12.6% (20,893/165,650) to 10.6% (32,329/305,846) (p<0.001), glaucoma decreased from 7.8% (12,939/165,650) to 6.6% (20,288/305,846) (p<0.001), diabetic retinopathy decreased from 3.9% (6,501/165,650) to 2.7% (8,219/305,846) (p<0.001) and amblyopia remained stable around 1.1% (p=0.389) [2017: 3,252/305,856]. Anticipated surgical difficulties were divided into eight categories: none, white cataract, small pupil, corneal opacities, pseudoexfoliation, previous corneal refractive surgery, previous vitrectomy, and "other" difficulties. The total proportion of anticipated surgical difficulties decreased slightly over the study period; from 12.6% (20,790/165,560) to 10.6% (32,403/305,846) (p<0.001), but within the group, previous corneal refractive surgery increased, and white cataract decreased over time. Previous vitrectomy, small pupil and corneal opacities were quite stable over the study period.

Surgical data

Anaesthesia

The trends regarding type of anaesthesia over time are shown in Table 2. This parameter is an optional one, and so is not reported for all cases in the database. The number of valid cases is also shown in Table 2. Combinations of anaesthesia methods are not included in the list of parameters in the registry. A chi squared test showed significant changes ($p<0.001$) over time for all types of anaesthesia except general anaesthesia. Topical anaesthesia increased over time while retrobulbar, sub tenon, peribulbar and intracameral anaesthesia decreased and general anaesthesia remained stable.

Type of surgery

The preferred type of surgery over the study period was phacoemulsification with implantation of an intraocular lens (IOL); this was used in 98.9% (2,622,443/2,653,551) of all surgeries, with a range of 98.1% to 99.4% per year. Phacoemulsification combined with a filtering procedure was reported in 0.2% (4735/2,653,551) of all cases with a decreasing trend from 0.4% (1137/292,336) in 2014 to 0% from 2015 onwards. This combination of procedures is not reported in all affiliated registries. Femtosecond laser-assisted cataract surgery was reported for the first time in 2012, being used in 0.1% (257/260,805) of cases; this increased to 0.8% (2333/292,336) in 2014 and then stabilized at 0.2%. Other types of surgery not listed among the pre-set registry variables were reported in 0.6% (16,726/2,653,551) of the cases on average.

Intraocular lens

EUREQUO contains data on type of IOL optic biomaterial. This is shown per year in Table 3. All changes in type of IOL optic biomaterial were statistically significant ($p<0.001$). Hydrophobic acrylic IOL showed a significant increase while all other types of biomaterial showed a significant decrease. There was also a significant decrease in leaving the eye aphakic after surgery (No IOL). IOL type other than monofocal has been reported to the database only sparsely (Table 4).

Surgical complications

Surgical complications are reported to the EUREQUO with the following options: posterior capsule rupture, vitreous loss, dropped nucleus, iris damage, complications related to laser-assisted surgery, "other" surgical complication and no complication (Table 5). Capsule complications include a break of the posterior capsule with or without loss of vitreous and surgically induced zonular dehiscence of one quadrant or more. Dropped nucleus does not include cortex material. A chi-squared test showed significant decrease over time for all surgical complications ($p<0.001$).

Outcomes data

Visual outcome

Table 6 gives the visual outcome as mean values for all patients and for patients without any co-existing eye disease, along with the proportions achieving a certain visual acuity. Over the study period the mean postoperative best corrected visual acuity improved over the years from logMAR 0.08 to logMAR 0.05, and the percentage achieving a postoperative CDVA of logMAR 0.0 (decimal 1.0) increased from 58.3% (44,221/75,915) to 75.0% (124,865/166,433).

Absolute prediction error

The absolute prediction error is calculated as the absolute difference between the target refraction and the actual refraction achieved after surgery. Target refraction is the predicted refraction for each surgeon using his/her preferred/available formula and biometry device. The postoperative refraction means refraction of the operated eye when testing subjective best distance visual acuity. Average follow-up time was 31 days. Median values are shown in Table 7 along with the proportions that achieved a difference of 0.5D or less and 1.0D or less, respectively.

The impact of monofocal or non-monofocal IOLs on the refractive outcome was not calculated per year due to the low annual numbers of non-monofocal IOLs. When the absolute median prediction error is calculated for the whole study period for monofocal IOLs the result

is 0.30D. An absolute prediction error of 0.5D or less for the same group was 72.0% (1,041,441/1,446,281).

Postoperative complications

Postoperative complications can be reported as no complication, persistent central corneal oedema, reduced vision because of posterior capsule opacification (PCO), uveitis with need for medication, endophthalmitis, uncontrolled elevated intraocular pressure, or "other" postoperative complication. Numbers per year are shown in Table 8.

Discussion

Our study showed a significant decrease in the mean age of cataract surgery patients, from a 74.5 in 2008 to 73.0 in 2017. This is close to the mean age of 73.2 years reported from Poland in 2010 – 2015 based on more than 1 million cataract extractions, although that study demonstrated no clear trend over the period.[9] In a previous publication from the European Cataract Outcome Study (ECOS) the mean age of patients was 73.7 years at time of surgery.[10] In our study the proportion of women undergoing cataract extraction decreased significantly during the study period from 60.6% to 57.2% while the proportion in the Polish study was fairly stable around 65.1%[9] and the ECOS study[10] showed a proportion of 65.7% for one study year. The relationship between age and sex distribution may be influenced by the difference in life expectancy between the sexes.[11] Another factor may be different patterns in requesting second eye surgery. [12]

Risk factors in terms of ocular co-morbidity showed a decreasing trend in our study. The average occurrence of glaucoma in the surgery eye (from 7.8% to 6.6%) was in line reports from the Malaysian national cataract registry (6.4%),[13] but lower than reports from Israel (14%). [14] Our finding of diabetic retinopathy in around 3% of eyes operated for cataract is much lower than that reported from the Malaysian cataract register (around 10%) which may be due to the well-known high incidence of diabetes in Malaysia. [15] These differences reflect the fact that different countries in different parts of the world may have great differences in baseline factors for cataract surgery patients. Our results offer a snapshot of cataract surgery practice from many surgeons and clinics in European countries.

Our data shows a clear transition from anaesthetic injections to topical anaesthesia. The same trend has been documented in surveys of preferred cataract surgery practices. [16] The drop in intracameral anaesthesia from 2015 and onward reflects a change in contributing country data.

Most of the surgeries in our study were phacoemulsification with implanted IOL, and this was stable over time. According to the coding guidelines combined surgeries (cataract extraction plus vitrectomy or corneal transplantation) should not be reported to the registry. The only exception is a cataract extraction combined with a filtering procedure; this kind of surgery declined in frequency over time in our study. A low percentage of laser-assisted femtosecond cataract extraction has been reported since 2012. For three years between 2013 and 2015, the EUREQUO received data from a femtosecond laser-assisted cataract surgery study [8] which explains the increase of this surgical type in the registry. The study protocol included meticulous reporting of complications which also affected the reporting of surgical and postoperative complications in these years.

Regarding choice of IOL the registry includes type of optic biomaterial and different kinds of non-monofocal IOLs (multifocal and toric IOLs). Hydrophobic acrylic IOLs dominate the material and have increased over time, while of silicon and PMMA has declined to nearly zero. Biomaterial in IOLs has usually been studied with a focus on complications such as posterior capsule opacification (PCO), anterior capsule opacification and glistening formation. The increase in hydrophobic acrylic IOLs in our study is not surprising, as the literature shows that this biomaterial is less related to anterior or posterior capsule opacification.[17] On the other hand, the material also seems related to glistening, even if this complication seldom affects visual acuity.[17] The number of non-monofocal IOLs implanted was surprisingly low in our study, given the huge focus on these IOLs in the literature. The EUREQUO database is dominated by Dutch and Swedish data, and our interpretation is that non-monofocal IOLs are mostly used in refractive lens exchange surgeries in these countries and not within ordinary cataract surgery. However, the frequency of these IOLs did increase over time in our study.

Capsule complications during surgery showed a decreasing trend in our study. A similar trend has also been reported from other registries collecting data over time. [18] Although findings regarding surgical complications may be flawed by underreporting,[18] we think that this decreasing trend is a solid finding. Reasons for this positive development may include better surgical quality and surgery on younger and healthier eyes. Our finding of decreasing complications in terms of dropped nucleus has been extensively discussed in a previous article.[7]

The visual outcome in terms of mean corrected distance visual acuity improved over time in our study. In a previous article, we discussed the visual outcome and the baseline parameters that influenced it.[19] The refractive outcome also showed an improving trend during the study period. Reasons for a poor refractive outcome based on data from the EUREQUO have been reported previously.[6]

The postoperative complications in our study must be seen in the light of a 30-day follow up, which prevents late complications like PCO from being represented in a fair way. The reported frequency of postoperative endophthalmitis showed a decreasing trend from around 0.05% to 0.02% which again must also be seen in the light of the average follow-up time. A weakness in our registration is the lack of information about preventive measures such as asepsis and intracameral antibiotic injection. However, we know from other sources that most surgeons in the Netherlands[20] and Sweden[21] use intracameral antibiotics as a prophylactic regime.

Another weakness of our study is the fact that the data were self-reported by surgeons and clinics. We believe, however, that the data are reliable because the reason for surgeons to participate is benchmarking and comparison, and each surgeon's or clinic's data is only visible to themselves. Finally, the registry protocol includes a limited number of parameters as well as a limited follow-up time, to reduce the clinical burden of reporting data.

A strength of our study is the large number of reported cases from many countries for more than a decade.

Conclusions: Trends in European cataract surgery practice patterns from 2008 to 2017 as reflected in the EUREQUO have moved toward slightly younger patients with better preoperative visual acuity, fewer surgical complications, and better visual outcomes and less absolute prediction error.

WHAT WAS KNOWN

- Mean age and gender distribution, surgical complications, and outcomes in cataract surgery have previously been reported in cohort studies and from some national registry data.

WHAT THIS PAPER ADDS

- This article uses data extracted from a large database to describe trends in patient demographics, anaesthetic and surgical techniques and visual and refractive outcomes and complications over a decade.

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Table 1. Number of reported surgeries, mean age, sex distribution, mean preoperative corrected distance visual acuity (CDVA), ocular comorbidity, and anticipated surgical difficulties per year.

Year	N = 2,714,108	Mean age (SD)	% Female	Preoperative CDVA logMAR (SD) [decimal]	% Ocular co-morbidity	% Anticipated surgical difficulties
2008	165,648	74.5 (10.0)	60.6	0.46 (0.29) [0.33]	30.0	12.6
2009	201,377	74.5 (10.0)	60.3	0.44 (0.28) [0.33]	29.7	11.7
2010	227,179	74.2 (10.0)	60.0	0.44 (0.28) [0.33]	30.1	12.4
2011	249,449	74.2 (9.8)	59.7	0.43 (0.28) [0.40]	29.7	12.0
2012	260,789	74.1 (9.7)	59.3	0.41 (0.27) [0.40]	28.7	11.1
2013	280,869	74.2 (9.6)	59.2	0.40 (0.27) [0.40]	29.5	12.0
2014	300,078	74.0 (9.6)	58.5	0.39 (0.27) [0.40]	29.4	12.3
2015	261,651	73.7 (9.3)	57.9	0.36 (0.25) [0.45]	28.2	10.4
2016	282,143	73.7 (9.3)	57.7	0.36 (0.25) [0.45]	27.3	10.9
2017	305,708	73.0 (9.7)	57.2	0.37 (0.27) [0.45]	27.0	10.6
P (trend)		<0.001**	<0.001*	<0.001**	<0.001*	<0.001*

* Chi-squared test
** One-way ANOVA
SD = standard deviation
CDVA = corrected distance visual acuity
logMAR = logarithm of minimum angle of resolution.

Table 2. Type of anaesthesia (%) reported to the database, 2008–2017.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Available data on anaesthesia (cases)	93,320	120,036	140,057	150,747	163,089	172,645	188,652	148,781	163,166	182,083
Retrobulbar	24.7	21.2	17.5	13.4	11,3	9.1	7.5	6.8	5.4	8.6
Subtenon	29.6	27.7	26.6	24.7	25.5	25.4	25.3	17.7	16.7	15.4
Peribulbar	8.1	5.7	5.0	4.3	4.5	3.4	2.3	1.0	1.1	1.3
Topical	28.1	35.8	38.5	43.9	46.7	49.5	51.5	70.7	73.1	71.7
Intracameral	6.0	6.2	8.7	10.2	8.9	9.4	10.2	0.9	0.8	0.5
General	2.6	2.4	2.7	2.9	2.6	2.6	2.7	2.8	2.8	2.5
“Other”	0.9	1.0	1.0	0.6	0.5	0.6	0.5	0.1	0.1	0

Table 3. Type of IOL optic biomaterial (%).

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Valid number of cases*	165,642	201,376	227,179	249,458	260,804	280,906	300,142	261,739	280,439	291,748
Hydrophobic acrylic	78.7	81.0	80.7	81.6	82.8	85.2	85.5	89.4	91.1	90.6
Hydrophilic acrylic	13.8	13.2	14.1	13.3	12.7	11.1	11.7	9.3	8.3	8.8
Silicon	5.8	4.1	3.5	2.4	1.9	1.6	0.8	0	0	0
PMMA	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0	0	0
No IOL	0.22	0.19	0.18	0.22	0.18	0.14	0.12	0.09	0.09	0.09

* Cases with reported optic biomaterial parameter
PMMA = polymethylmethacrylate
IOL = intraocular lens

Table 4. Reported use of non-monofocal IOL.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Valid number of cases*	72,436	82,093	85,765	95,048	96,118	109,124	112,776	113,560	119,943	124,631
Multifocal IOL (%)	0.21	0.37	0.66	0.83	1.03	1.14	1.98	1.28	1.36	1.67
Toric IOL (%)	0.06	0.12	0.27	0.46	0.46	0.51	0.59	0.28	0.27	0.30
Multifocal-toric IOL (%)					0.11	0.09	0.09	0.04	0.08	0.16

* Cases with reported non-monofocal parameter

Table 5. Reported surgical complications during the study period.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Any surgical complication (%)	2.5	2.3	2.2	2.5	1.9	1.7	1.6	1.3	1.2	1.2
Capsule complication (n)	2387	2725	2708	3976	2896	4181	4958	1969	2025	2007
Capsule complication (%)	1.44	1.34	1,19	1,59	1,11	1,49	1,65	0.75	0.72	0.66
Valid cases for dropped nucleus and iris damage (not available in Swedish registry)	93,344	120,186	142,594	155,717	166,189	173,118	189,682	149,143	163,482	182,560
Dropped nucleus (n)	87	124	126	145	130	129	162	96	72	85
Dropped nucleus (%)	0.09	0.10	0.09	0.09	0.08	0.08	0.08	0.06	0.04	0.05
Iris damage (n)	380	437	550	474	547	559	495	393	423	357
Iris damage (%)	0.41	0.36	0.39	0.30	0.33	0.32	0.26	0.25	0.26	0.20

Table 6. Visual outcome in terms of mean corrected distance visual acuity (CDVA) LogMAR [decimal] and % of cases with CDVA LogMAR 0.0 [1.0] or better and CDVA LogMAR 0.3 [0.5] or better.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	p
Number of all cases	75,915	100,257	110,061	115,338	124,101	132,189	148,199	146,022	159,281	166,433	
Postoperative CDVA LogMAR mean (SD), all cases	0.08 (0.18) [0.8]	0.08 (0.18) [0.8]	0.07 (0.18) [0.8]	0.07 (0.18) [0.8]	0.06 (0.17) [0.8]	0.06 (0.17) [0.8]	0.06 (0.17) [0.8]	0.05 (0.17) [0.8]	0.05 (0.17) [0.8]	0.05 (0.18) [0.8]	<0.001*
Postoperative CDVA LogMAR 0.0 [1.0] or better (%), all cases	58.3	60.8	62.2	62.9	64.7	66.0	66.9	70.8	73.0	75.0	<0.001**
Postoperative CDVA LogMAR 0.3 [0.5] or better (%), all cases	94.4	94.5	94.5	94.9	95.3	95.4	95.6	95.8	95.9	95.3	<0.001**
Number of cases without ocular comorbidity	56,384	74,741	81,364	87,658	95,243	99,633	109,611	110,605	121,626	127,662	
Postoperative CDVA LogMAR mean (SD), cases without ocular comorbidity	0.04 (0.12) [1.0]	0.04 (0.12) [1.0]	0.03 (0.11) [1.0]	0.04 (0.12) [1.0]	0.03 (0.11) [1.0]	0.03 (0.11) [1.0]	0.02 (0.11) [1.0]	0.01 (0.10) [1.0]	0.01 (0.11) [1.0]	0.02 (0.13) [1.0]	<0.001*
Postoperative CDVA LogMAR 0.0 [1.0] or	66.7	69.3	71.0	70.9	72.4	74.7	76.5	79.6	80.6	82.1	

better (%), cases without ocular comorbidity											<0.001**
Postoperative CDVA LogMAR 0.3 [0.5] or better (%), cases without ocular comorbidity	98.2	98.2	98.3	98.2	98.4	98.4	98.7	98.9	98.8	97.8	<0.001**

* One-way ANOVA
** Chi square
CDVA = corrected distance visual acuity
LogMAR = logarithm of minimum angle of resolution
SD = standard deviation

Table 7. Absolute prediction error in terms of deviation from the intended refraction with the absolute value.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	P
Number of cases	75,915	100,257	110,061	115,338	124,101	132,189	148,199	146,022	159,281	166,433	
Absolute median prediction error	0.38	0.35	0.33	0.30	0.30	0.30	0.30	0.30	0.30	0.28	<0.001*
Absolute prediction error ≤0.5D, %	66.9	69.0	70.1	71.1	72.3	71.7	72.4	73.1	73.1	73.4	<0.001**
Absolute prediction error ≤1.0D, %	89.6	91.4	91.8	92.6	93.1	92.6	92.7	93.4	93.4	93.6	<0.001**

* One-way ANOVA
** Chi-squared test
D = dioptre

Table 8. Postoperative complications reported to the EUREQUO (absolute numbers). The average follow-up period is 30 days. One or more complications can be registered. PCO is not displayed in the table because of the short follow-up time.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Valid number of cases	76,234	100,718	111,291	115,942	124,594	132,669	148,888	146,668	159,955	167,366
Central corneal oedema/striae	108	136	168	162	162	174	198	148	164	648
Uveitis	36	50	52	55	59	90	112	3	1	3
Endophthalmitis	43	51	42	52	36	40	24	43	16	24
Uncontrolled IOP	52	52	83	55	43	50	59	47	56	64
“Other”	1220	1383	1526	1506	1567	3364	4528	2050	2077	2023
Total number	1436	1646	1867	1822	1844	3714	4935	2283	2340	3153
Total %	1.88	1.63	1.68	1.57	1.48	2.80*	3.31*	1.56	1.46	1.88

* Cases from the ESCRS FLACS study[8] are included
IOP = intraocular pressure