Comparison of cataract surgery refractive outcomes in a tertiary hospital and an outreach cataract service centre

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ABSTRACT

Objective: The aim of this study was to compare the postoperative refractive outcome after cataract surgery between a hospital-based and an outreach-based cataract service centre.

Methods: This study was conducted at the Hospital Selayang (HS), Selangor, Malaysia, a tertiary referral centre and an outreach-based cataract service centre (Pusat Pembedahan Katarak MAIWP, PPKM). Data was sourced from the Cataract Surgery Registry (CSR) in the National Eye Database (NED).

Results: A total of 2318 surgeries were analysed. PPKM achieved postoperative refraction outcome within ±1.0D in 94.3% of cases compared with 88.4% in Selayang Hospital. Mean absolute prediction error was also better in PPKM (0.39±0.27D vs. 0.33±0.24D, p<0.001). Multivariate analysis showed that the tertiary hospital, persons of Chinese ethnicity, history of uveitis, previous history of ocular surgery and intraoperative complications as significant independent predictive factors for poor refractive outcomes.

Conclusion: The outreach-based cataract service centre, which incorporates streamlined process designs and workflows, achieved superior refractive outcomes within ±1 dioptre after cataract surgery compared to a tertiary hospital.

KEYWORDS:
Refractive outcomes; cataract surgery; outreach; process design; workflow

INTRODUCTION

Malaysia is a developing country in the Southeast Asia region and adopts a universal healthcare system run by the Ministry of Health (MOH). MOH provides cataract surgery services via 42 healthcare facilities, including hospitals and cataract centres. Cataracts represent a significant burden of visual impairment and is the leading cause of bilateral reversible blindness in Malaysia (39.1%) with an estimate of 216000 people afflicted.[1] Based on the data from the 11th Report of the National Eye Database (Year 2017), a total number of 54242 cataract surgeries were performed in the MOH hospitals.[3] Phacoemulsification has become the preferred surgical technique for cataract surgeries in Malaysia, accounting for more than three quarters of cataract surgeries performed.[4]

In view of the increased demand for cataract surgery especially in the urban communities, the MOH with the collaboration from the Federal Terrritories Islamic Religious Council founded the Cataract Surgical Centre (PPKM) in 2012. The PPKM is based on the Aravind Eye Care System model, which adheres to the principle of providing high volume and high-quality cataract surgery by adopting a set of process designs based on an efficient framework model into the cataract surgery pathway.[5,6] This streamlined process designs and workflows as interventions have shown improvement in error reduction and information flow in intensive medical units,[7] improved patient flow in the emergency department,[8] as well as improved Pap smear test quality and diagnostic accuracy.[9] Such process designs have also shown to improve quality in high-volume cataract pathways in terms of lead times, hospital visits and costs.[10] High volume and high-quality cataract surgery can be viewed from a system's approach, whereby demand and resources are considered as the input, systems and procedures as the process, and high volume, high quality cataract surgeries as the output.[6] PPKM aims to achieve this by optimising each of these components.

The rationale of this study is to determine and compare the outcomes of achieving postoperative spherical equivalent within ±1 dioptre of target spherical equivalent after cataract surgery and intraocular lens implantation between a hospital-based and an outreach-based cataract centre. This study was also done to ascertain the main determinant factors for such outcomes. Analysis of such data providing evidence of potential improvement in postoperative refraction outcomes, and thus cataract surgery success would be an important supportive data in establishing more cataract centres structured on a similar model. Such intervention would be especially pertinent in reducing the significant cataract burden in the country.

METHODS

A total of 2318 surgeries were included for this study by consecutive non-random sampling based on data sourced from the CSR. All patients who had undergone cataract

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surgery in the HS and PPKM from January 2017 to December 2017 who have fulfilled inclusion and exclusion criteria were considered. Patients who had undergone cataract surgeries on one or both eyes, as well as postoperative refractions done at or within 90 days were included. Patients with no documented preoperative vision or refraction, or no documented follow-up appointment within 90 days were excluded. The demographic variables (age, gender and ethnicity) and clinical variables were obtained through sourced data from CSR. Following our institutional protocol, all data reported were deidentified.

The data for refractive outcomes is derived from the values of absolute prediction error. Prediction error (PE) is the difference in dioptres between the actual and target refractive outcome in a patient and it is calculated in that the PE is negative for an outcome more myopic than intended and positive for a hyperopic outcome. The absolute value of this data is then used to calculate the mean absolute prediction error (MAPE), in which the mean of the absolute value of the PE is taken in a cohort.[12]

The descriptive statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) Version 24. Refractive error levels as dichotomous variables were used for simple logistic and multivariate logistic regression analysis. Multivariate logistic regression analysis was done to identify factors which may affect the probability of poor cataract outcomes, which in this case is measured as achieving mean absolute prediction error >1 dioptre. The variables which were analysed were age, gender, ethnicity, biometry, preoperative ocular comorbidities, intraoperative complications, surgeon experience and the type of cataract centre, which in this case constitutes a hospital-based cataract centre (Selayang Hospital) and an outreach-based cataract centre (PPKMS). For all analyses, a p value of less than 0.05 was considered statistically significant.

RESULTS

A total of 571 cataract surgeries were performed on 549 patients in HS and 1747 cataract surgeries were performed on 1560 patients in PPKM. These represent 57.31% of the total surgeries in the HS and 56.28% of surgeries in PPKM respectively after taking into account inclusion and exclusion criteria. Of the 571 surgeries, 505 (88.4%) eyes achieved postoperative refraction within ±1.0 dioptre of target refraction in HS compared to 1647 of the 1747 (94.3%) surgeries in PPKM.

Demographic data of the participants is presented in Table I. Patients in HS were significantly older, were more likely to be of Chinese ethnicity and had more systemic and ocular comorbidities. Table II compares the demographic and ocular characteristics of the subjects in the two centres. Significant differences were seen in patients with good refractive outcome (who fall within the <1D group) in terms of gender (more females in PPKM), ethnicity (more Malays in PPKM), some pre-operative co-morbidities (more glaucoma, diabetic retinopathy, age related macula degeneration and other ocular conditions in the HS) and postoperative complications (more in the HS). However, in patients with poor refractive outcomes, there were no significant difference between the two centres apart from a higher number of extracapsular cataract extraction in the HS.

The PE, which is the difference between target and postoperative refraction, ranged from -3.55 to +4.60 D, with an average of -0.09±0.69 D in the tertiary hospital; and from -3.48 to +4.25 D, with an average of -0.03±0.53 D in the outreach-based cataract centre. The MAPE value in those who achieved ±1 dioptre was significantly higher in the HS (0.39±0.27D) compared to PPKM (0.33±0.24D (p<0.001). This difference may, however, not be clinically significant. It was interesting to note however that MAPE values were significantly higher in the HS group when stratified according to age groups, gender, biometry and surgeon expertise level.

Multivariable logistic regression was then done and showed there were five variables that were significantly associated with poor postoperative refractive outcomes (>1 dioptre) when other covariates were adjusted (Table III). Cataract surgeries performed at HS had 58.0% higher chance for poorer refractive outcome compared to those performed at PPKM when other factors were adjusted for (p=0.016). In other words, PPKM had a 36.7% lesser likelihood for poorer refractive outcomes compared with the HS. Patients of Chinese ethnicity were at 49% higher risk to experience poorer refractive outcome compared with Malay patients when other factors were adjusted (p=0.039). Surgery conducted on those patients who had history of uveitis had 4.42 times higher risk of poor refractive outcome compared to those without (p=0.028). Patients with history of previous ocular surgery tend to have 2.47 times higher risk to experience poorer refractive outcomes compared to those without (p<0.001). Cataract surgeries with intraoperative complications were at 6.35 times greater risk of poorer refractive outcome compared to without (p<0.001).

DISCUSSION

In this study, the 88.4% of operations performed in the HS and 94.3% of operations performed in PPKM achieved postoperative refractive outcomes within ±1.0 dioptres. Based on these results, the postoperative refractive outcomes of both these institutions have surpassed the benchmark adopted by the Royal College of Ophthalmologists, which is that at least 85% of cataract operations should have postoperative refraction outcomes within ±1.0 dioptre of their planned refraction.[13] These outcomes were also better in comparison to other postoperative refractive outcomes studies without exclusion of pre-existing ocular diseases in other ophthalmology centres in Europe, the United States of America and Australia which range from 72-82%.[14-17] These results appear to surpass the results of studies measuring postoperative outcomes which excluded patients with pre-existing ocular disease and ocular surgeries like a study conducted in Parma University Hospital, Italy (77%),[18] and, in the case of PPKM, when compared to a study done in Queen Elizabeth Hospital, Australia (93%).[19]

The superior postoperative refractive outcomes could be accounted by the use of optical biometry as first-line biometry whenever possible. Optical biometry was performed on

Table I: Demographics (n=2109)

Characteristic	All population N = 2109		P-value
	Selayang Hospital N=549 (%)	PPKM-HS N=1560 (%)	
Age (y),			
Mean (standard deviation)	66.86(9.91)	65.21(8.86)	0.001[1]
Range	20 – 89	20 – 89	
Gender (%)			
Male	269 (49.0)	682 (43.7)	0.032
Female	280 (51.0)	878 (56.3)	0.032
Ethnicity (%)			
Malay	180 (32.8)	674 (43.2)	<0.001
Chinese	273 (49.7)	595 (38.1)	<0.001
Indian	94 (17.1)	283 (18.1)	0.592
Others	2 (0.4)	8 (0.5)	>0.999[2]
Preoperative comorbidity (%)			
Previous ocular surgery	59 (10.7)	114 (7.3)	0.012
Glaucoma	71 (12.9)	44 (2.8)	<0.001
Chronic uveitis	7 (1.3)	6 (0.4)	0.049[2]
Diabetic retinopathy	87 (15.8)	90 (5.8)	<0.001
Age-related macular degeneration	19 (3.5)	21 (1.3)	0.002
Retinal detachment	9 (1.6)	5 (0.3)	0.003[2]
Previous ocular trauma	2 (0.4)	1 (0.1)	0.168[2]
Other ocular pathology	85 (15.5)	63 (4.0)	<0.001

PPKM=HS = Pusat Pembedahan Katarak MAIWP-Hospital Selayang or MAIWP Cataract Surgical Center
Pearson Chi-squared tests were applied
[1]Independent t-test with equal variance was not assumed; 2 Fisher's Exact tests were applied

Table II: Surgeries Population Characteristics (Number of Eyes; n=2318)

Characteristic	All population N=2318 eyes			Within 1 D N=2152 eyes			Outside 1D N=166 eyes		
	Hospital Selayang N=571 eyes	PPKM-HS N=1747 eyes	P-value	Hospital Selayang N=505 eyes	PPKM-HS N=1647 eyes	P-value	Hospital Selayang N=66 eyes	PPKM-HS N=100 eyes	P-value
Age (y),									
Mean (standard deviation)	66.88(9.79)	65.30(8.77)	0.001[1]	66.98 (9.78)	65.29 (8.76)	<0.001[3]	66.15(9.91)	65.53(9.00)	0.676[3]
Range	20 – 89	20 – 89		20 – 89	20 – 89				
Gender (%)									
Male	280 (49.0)	753 (43.1)	0.013	251 (49.7)	703 (42.7)	0.005	29(43.9)	50 (50)	0.444
Female	291 (51.0)	994 (56.9)		254 (50.3)	944 (57.3)		37 (56.0)	50(50)	
Ethnicity (%)									
Malay	190 (33.3)	764 (43.7)	<0.01	173 (34.3)	727 (44.1)	<0.001	17 (25.8)	37(37)	0.130
Chinese	282 (49.4)	667(38.2)	<0.01	241 (47.7)	622 (37.8)	<0.001	41 (62.1)	45(45)	0.031
Indian	97 (17.0)	308 (17.6)	0.726	89 (17.6)	290 (17.6)	0.993	8 (12.1)	18 (18)	0.308
Preoperative comorbidity (%)									
Previous ocular surgery	59 (10.3)	129 (7.4)	0.025	45 (8.9)	114 (6.9)	0.135	14 (21.2)	15 (15)	0.302
Glaucoma	73 (12.8)	45 (2.6)	<0.001	66 (13.1)	41 (2.5)	<0.001	7 (10.6)	4 (4)	0.116[2]
Chronic uveitis	7 (1.2)	6 (0.3)	0.014	4 (0.8)	5 (0.3)	0.137	3 (4.5)	1 (1)	0.302[2]
Diabetic retinopathy	88 (15.4)	94 (5.4)	<0.001	78 (15.4)	86 (5.2)	<0.001	10 (15.2)	8 (8)	0.147
Age-related macular degeneration	19 (3.3)	21 (1.2)	0.001	18 (3.6)	20 (1.2)	<0.001	1(1.5)	1(1)	>0.999
Retinal detachment	9 (1.6)	6 (0.3)	0.004[2]	5 (1.0)	5 (0.3)	0.061[2]	4 (6.1)	1(1)	0.082
Previous ocular trauma	2 (0.4)	1 (0.1)	0.152[2]	2 (0.4)	1 (0.1)	0.139[2]	0	0	NA
Other ocular pathology	87 (15.2)	67 (3.8)	<0.001	75 (14.9)	58 (3.5)	<0.001	12 (18.2)	9 (9)	0.082
Biometry									
Optical	392 (68.7)	1319 (75.5)	0.001	353 (70.0)	1245 (75.6)	0.010	39 (59.1)	74 (74)	0.044
Ultrasound	179 (31.3)	428 (24.5)		152 (30.1)	402 (24.4)		27 (40.9)	26 (26)	
Intraoperative complication (%)									
Posterior Capsular Rupture	11 (1.9)	12 (0.7)	0.01	6 (1.2)	6 (0.4)	0.041[2]	5 (7.6)	6 (6)	0.755[2]
Vitreous Loss	6 (1.1)	7 (0.4)	0.1[2]	2 (0.4)	4 (0.2)	0.63[2]	4 (6.1)	3 (3)	0.438[2]
Zonular Dialysis	9 (1.6)	10 (0.6)	0.03[2]	4 (0.8)	8 (0.5)	0.492[2]	5 (7.6)	2 (2)	0.116[2]
Dropped Nucleus	1 (0.2)	1 (0.1)	0.432[2]	0 (0)	0 (0)	1.0[2]	1 (1.5)	1 (1)	1.0[2]
Others	3 (0.5)	5 (0.3)	0.416[2]	3 (0.6)	5 (0.3)	0.4[2]	0 (0)	0(0)	1.0[2]
Surgery (%)									
Phacoemulsification	552 (96.7)	1725 (98.7)	0.001	492 (97.4)	1628 (98.8)	0.021	60 (90.9)	97 (97)	0.158[2]
ECCE	10 (1.8)	4 (0.2)	<0.001[2]	6 (1.2)	4 (0.2)	0.014[2]	4 (6.1)	0 (0)	0.024[2]
Phaco convert ECCE	5 (0.9)	5 (0.3)	0.074[2]	3 (0.6)	2 (0.1)	0.088[2]	2 (3.0)	3 (3)	1.0[2]
Lens aspiration	3 (0.5)	13 (0.7)	0.774[2]	3 (0.6)	13 (0.8)	1.0[2]	0 (0)	0 (0)	1.0[2]
ICCE	1 (0.2)	0 (0)	0.246[2]	1 (0.2)	0 (0)	0.235[2]	0 (0)	0 (0)	1.0[2]

PPKM=HS = Pusat Pembedahan Katarak MAIWP-Hospital Selayang or MAIWP Cataract Surgical Center
Pearson Chi-squared tests were applied
[1]Independent t-test with equal variance was not assumed; [2] Fisher's Exact tests were applied;
[3]Independent t-test with equal variance was assumed
* Odd ratio <0.001; [1]Hosmer and Lemeshow test: X^2(df) = 7.50(8); p=0.483, indicated the model was fit well. [2]Classification table showed 93.1% of outcome was correctly classified

Table III: Multivariate Logistic Regression Results for Main determinants of Postoperative Refractive Outcomes (n=2318)

Characteristic	Refractive Outcome		Simple Logistic Regression			Multivariate Logistic Regression		
	Within 1D n (%)	Outside 1D n (%)	Crude OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Cataract centre								
Hospital Selayang	505(88.4)	66(11.6)	2.15	1.55-2.98	<0.001	1.58	1.09-2.28	**0.016**
PPKM-HS	1647(94.3)	100(0.06)	1			1		
Age								
20-29	10(0.5)	0(0)	0	NA	0.999	0	NA	0.999
30-39	21(1.0)	2(1.2)	0.90	0.18-4.40	0.892	0.64		0.616
40-49	48(2.2)	6(3.6)	1.18	0.40-3.43	0.768	1.12		0.841
50-59	367(17.1)	28(16.9)	0.71	0.34-1.53	0.389	0.80		0.577
60-69	998(46.4)	71(42.8)	0.67	0.33-1.34	0.256	0.76		0.460
70-79	614(28.5)	49(29.5)	0.75	0.37-1.53	0.430	0.78		0.518
80-89	94(4.4)	10(6.0)	1			1		
Male Gender	954(44.3)	79(47.6)	1.14	0.83-1.56	0.416	1.08	0.77-1.50	0.665
Ethnicity								
Malay	900(41.8)	54(32.5)	1			1		
Chinese	863(40.1)	86(51.8)	1.66		0.005	1.49	1.02-2.16	0.039
Indian	379(17.6)	26(15.7)	1.14	1.17-2.36	0.108	1.23	0.75-2.02	0.412
Others	10(0.5)	0(0)	*	0.71-1.85 NA	0.999	*	NA	0.999
Preoperative ocular comorbidity								
Glaucoma diagnosis	107(5.0)	11(6.6)	1.36	0.71-2.58	0.352	0.86	0.42-1.74	0.669
History of uveitis	9(0.4)	4(2.4)	5.88	1.79-19.30	0.003	4.42	1.17-16.68	**0.028**
Diabetic retinopathy	164(7.6)	18(10.8)	1.47	0.88-2.47	0.139	1.26	0.72-2.19	0.415
Age-related macular degeneration	38(1.8)	2(1.2)	0.68	0.16-2.84	0.595	0.48	0.11-2.10	0.325
Retinal detachment	10(0.5)	5(3.0)	6.65	2.28-19.70	0.001	2.45	0.71-8.47	0.157
Previous ocular surgery	159(7.4)	29(17.5)	2.65	1.72-4.09	<0.001	2.47	1.53-3.97	<0.001
Other ocular comorbidities	133(6.2)	21(12.7)	2.20	1.35-3.59	0.002	1.64	0.96-2.78	0.071
Biometry								
Optical	554(25.7)	53(31.9)	1			1		
Ultrasound	1598(74.3)	113(68.1)	1.35	0.96-1.90	0.082	1.26	0.88-1.80	0.217
Surgeon Experience								
Medical Officer	138(6.4)	22(13.3)	2.23	1.40-3.61	0.001	1.65	0.97-2.79	0.065
Specialist	2014 (93.6)	144(86.7)	1			1		
Intraoperative complications	32(1.5)	18(10.8)	8.06	4.42-14.70	<0.001	6.35	3.35-12.03	<0.001

PPKM=HS = Pusat Pembedahan Katarak MAIWP-Hospital Selayang or MAIWP Cataract Surgical Center
* Odd ratio <0.001; 1Hosmer and Lemeshow test: X^2(df) = 7.50(8); p=0.483, indicated the model was fit well. 2Classification table showed 93.1% of outcome was correctly classified

68.7% and 75.5% respectively of patients in the HS and PPKM MAIWP in this study. The optical biometer known as IOLMaster (Carl Zeiss, Meditec AG, Jena, Germany) is currently used in both Selayang Hospital and PPKM. This optical biometer uses double-beam partial coherence interferometry (PCI) technology. Its use results in highly reproducible and operator-independent biometry measurements which are unaffected by the eye movement of the patients or any direct eye contact.[21,21] Studies achieving postoperative refractive outcomes within ±1.0 dioptre using PCI technology has ranged from 92-96% (19, 22-24). Nevertheless, a meaningful comparison between these studies and ours would be difficult as many exclusion criteria including pre-existing ocular diseases or previous ocular surgeries have been used in these studies. However, it is interesting to note that, even when these exclusion criteria are employed, PPKM has achieved a higher postoperative refractive outcome as compared to a study in Aarhus University Hospital, Denmark (94.4% vs. 92.4%).[22]

Other factors leading to improved postoperative refractive outcomes for both these centres would include the standardisation of lens selection and implantation process. All selections of lenses are based in accordance to a standardised protocol such as the accurate lens formula for a specific axial length or A-constant for a specific intraocular lens when a different biometry technique is used. These lens selections are then validated by another senior resident or surgeon to ensure minimisation of error. The practice of ensuring the availability of a sulcus lens and anterior chamber lens for all surgeries will promote the most optimal postoperative refraction in inadvertent complications or defective lenses during surgery.

Comparison between the mean absolute prediction error achieving ±1 dioptre in the HS (0.39±0.27D) and in PPKM (0.33±0.24D) showed there was a statistically significant mean difference (p<0.001). Comparison of gender between the two centres also showed statistically significant difference between them with males achieving 0.39±0.28D in the HS and 0.32±0.24D in PPKM (p<0.001). Likewise, this was also seen in biometry comparison with statistical significant difference seen between them with optical biometry achieving 0.38±0.27D in the HS and 0.33±0.24D in PPKM (p<0.001); as well as in ultrasound biometry with 0.40±0.27D in the HS and 0.34±0.24D in PPKM (p=0.013).

Similar results were also seen concerning certain age groups showing statistical significant difference between these two centres, specifically, in the age groups of 40-49 with

0.53±0.25D and 0.35±0.20D (p=0.018), 50-59 with 0.40±0.27D and 0.33±0.24D (p=0.027), and 70-79 with 0.38±0.25D and 0.34±0.25D (p=0.044) for the HS and the PPKM respectively. Apart from that, comparison of specialists performing cataract surgeries between the two centres showed statistically significant difference between them with 0.39±0.26D in the HS and 0.33±0.24D in the PPKM (p<0.001).

These results highlight the fact that the PPKM, being a cataract centre with streamlined process designs and workflows, has produced significantly better postoperative refractive outcomes within those achieving ≤1 dioptre, in comparison to the HS. As a function of significant difference in regards to biometry of both ultrasound and optical techniques between these centres, they also demonstrate better quality of biometry service in the setting of streamlined process designs, as seen in the PPKM.

A multivariate logistic regression analysis was done to identify factors which may affect the postoperative refractive outcomes within these two centres; which in this case, poor cataract outcome is measured as achieving mean absolute prediction error >1 dioptre. Based on the analysis, the type of cataract centre as a variable is identified as an independent predictor of postoperative refractive outcomes. In other words, a cataract centre with streamlined process designs and workflows such as the PPKM, is independently correlated with less poor cataract outcomes, in comparison to the HS. This analysis also revealed other independent variables as significant independent predictors of postoperative refractive outcomes. This includes Chinese ethnicity, history of uveitis, previous history of ocular surgery and patients with intraoperative complications. Age, gender and biometry technique were interestingly not identified as independent variables in predicting postoperative refractive outcomes.

Limitations in this study include the retrospective nature of the analysis; as well as the exclusion of patients who had missing data within the National Eye Registry. Some recommendations to intercept this problem may include methods of double validation of data entry by separate individuals, or automated software upgrades where missing patient data is highlighted and is not presented in the registry unless all essential or required data is entered. Also, a large number of patients were excluded from this study; with only 57.31% (571 of 937 surgeries) and 56.28% (1747 of 3104 surgeries) of surgeries analysed from The HS and MAIWP respectively. Patients who didn't have postoperative refractive assessment within 90 days, as well as those with missing data in the National Eye Registry were excluded. This included patients who may not have undergone post-op refraction in view of poor vision. Failure to capture these patients from the database and the possibility of poorer outcomes among these patients which may have skewed a more favorable result in our analysis. Nevertheless, this limitation is mitigated by the large population sample size. Other limitations include the lack of other cataract centres with streamlined process designs in Malaysia, and no comparable studies can be done and evaluated with the current study and its results.

CONCLUSION

This study has shown that superior cataract surgery refractive outcomes are achieved in an outreach cataract service centre compared to a tertiary hospital. Patients of Chinese ethnicity, history of uveitis, history of ocular surgery and intraoperative complications were independent predictors of poorer refractive outcomes. This study also highlights the impact of cataract centres incorporating streamlined process designs and workflows in reducing the cataract waiting times in an urban setting.

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