Clinical Audit and Quality Assurance in Ophthalmology:

The SNEC Experience

Singapore National Eye Centre
SingHealth

The Pursuit of Quality Assurance

How it all began...

"Professor Arthur Lim introduced Quality Assurance Programmes in SNEC. Every single major operation is videotaped and monitored. The clinical outcomes of SNEC are comparable to the world's best centres. We know, because we measure our results all the time. Professor Lim has succeeded in inculcating the quality culture in us. As a result, SNEC's reputation for high standards and quality has spread both locally and internationally."

Associate Professor Vivian Balakrishnan
Medical Director, SNEC, 1999–2000

Foreword

The achievements and dedication of the Singapore National Eye Centre (SNEC) to providing high-quality, evidence-based eye care to its patients are highly commendable. With its humble beginnings in 1990 under the leadership of the late Professor Arthur Lim, SNEC's founding Medical Director, the centre has gone from strength to strength, establishing itself as an eye centre of repute both in Singapore and on the international scene.

Professor Lim's vision was to develop a culture of excellence at SNEC. As such, he led the introduction of several quality assurance initiatives, which, despite initial reservations, evolved as part of SNEC's continuous effort towards clinical excellence. Among Professor Lim's initiatives was to collect and analyse data relating to all major surgeries performed at the centre. These data are processed and reported by the Clinical Audit Department and also serve as excellent teaching materials for trainee ophthalmologists. Over the last 25 years SNEC has accumulated a wealth of data on surgical outcomes, enabling the centre to benchmark itself against international standards.

I congratulate SNEC for its admirable achievements and continuous efforts in maintaining high standards of clinical care and for striving to make quality assurance a core component of its service. The rigorous Quality Assurance Programme itself is a testament to SNEC's success and has created confidence in clinicians and patients alike.

This clinical audit report, "*Clinical Audit and Quality Assurance in Ophthalmology: The SNEC Experience,*" showcases the centre's rigorous clinical audit process and details the respective audits performed for the various subspecialties. Patient loads, types of cases, surgical outcomes, measures of success and breakthroughs in technology are included in this report. It also demonstrates the excellent standard of ophthalmic care given to patients at SNEC, benchmarking it against other reputable centres from around the world.

Looking to the future, I am confident that SNEC will not only continue maintaining its high standards through impeccable quality assurance practices but will also continue to push the boundaries of our understanding in each of the key subspecialties. Furthermore, the centre's continuing commitment to comprehensive ophthalmic education, training and cutting-edge eye research will enhance its status as an ophthalmic centre of excellence. These key contributors will ensure that SNEC continues its remarkable efforts in providing accessible, affordable and quality eye care for patients.

Dr Lam Pin Min

Minister of State
Ministry of Health

Message From the Medical Director

The Singapore National Eye Centre (SNEC) commenced operations in 1990 with a team of 9 ophthalmologists, some nurses and a few administrative staff. From the outset, the late Professor Arthur Lim, the founding Medical Director, initiated and promoted quality assurance policies and practices aimed at achieving a high standard of care for our patients. Despite initial resistance from a few doctors who felt concern at being continually assessed based on their clinical outcomes, the maintenance of high-quality standards and good clinical practices are now very much ingrained in SNEC's work culture. SNEC's rigorous clinical audit process has resulted in improvements in clinical care and played a pivotal role in making it one of the leading eye centres in the world.

At SNEC, we record outcome data from surgical procedures and closely monitor results. Quality Assurance Seminars are carried out annually to share best practices and peer review. Senior surgeons collectively review the outcome data and provide guidance to junior ophthalmologists. The Clinical Audit Department processes and compiles the outcomes of surgical procedures and prepares periodic reports to monitor and gauge the level of medical care that we provide to our patients. I am pleased to report that our surgical outcomes are comparable with and, in some instances, better than world standards – an achievement we are very proud of.

One of the most notable outcomes of the stringent clinical audit process is the low rate of post-operative infections. For the past 10 years, we have achieved an infection rate close to 0% among the surgeries performed, which include laser refractive and cataract surgery procedures. Success rates of most eye surgeries have also been consistently high at 90% or more, reaffirming our success at delivering excellent patient care.

In addition, the Tissue Audit Committee has been set up to ensure the highest level of clinical and surgical care, ranging from surgery to histological diagnosis and post-operative care. The audit is performed by an independent, non-biased team to ensure that surgical care meets the highest possible standards.

With the accumulation of years of clinical outcome data, we have compiled a summary of our successes and benchmarks, which we are very proud of and are excited to showcase and share.

This clinical audit report, "*Clinical Audit and Quality Assurance in Ophthalmology: The SNEC Experience*," collates surgical outcomes for all the audited subspecialties and describes statistics on the number of patients seen, diagnoses made and comparisons with international standards. I trust that this publication will serve as a good reference for the local and overseas ophthalmic fraternity to better our skills and improve outcomes for our patients.

Professor Wong Tien Yin

Medical Director, SNEC

The Clinical Audit Department: Standing (left to right): Jenny Na, Jane Koh, Woon Puay San, Yang Younian, Christian Rimalos and Yeo Yi Lin. Seated (left to right): Nur Fatihah, Stephanie Lang, Glenda Leong and Ang Yu Sieu.

Clinical Audit at SNEC

Background and purpose

Clinical audit was introduced by the founding Medical Director of the Singapore National Eye Centre (SNEC), the late Professor Arthur Lim. It was his belief that, "a patient's eye is not for experimentation." He placed high importance on a patient's well-being and therefore implemented several quality assurance initiatives in an effort to develop a culture of excellence at SNEC.

The Clinical Audit Department was set up as part of SNEC's focus on quality assurance, commitment to the highest standards of clinical governance and ensuring the delivery of safe and high-quality ophthalmic care.

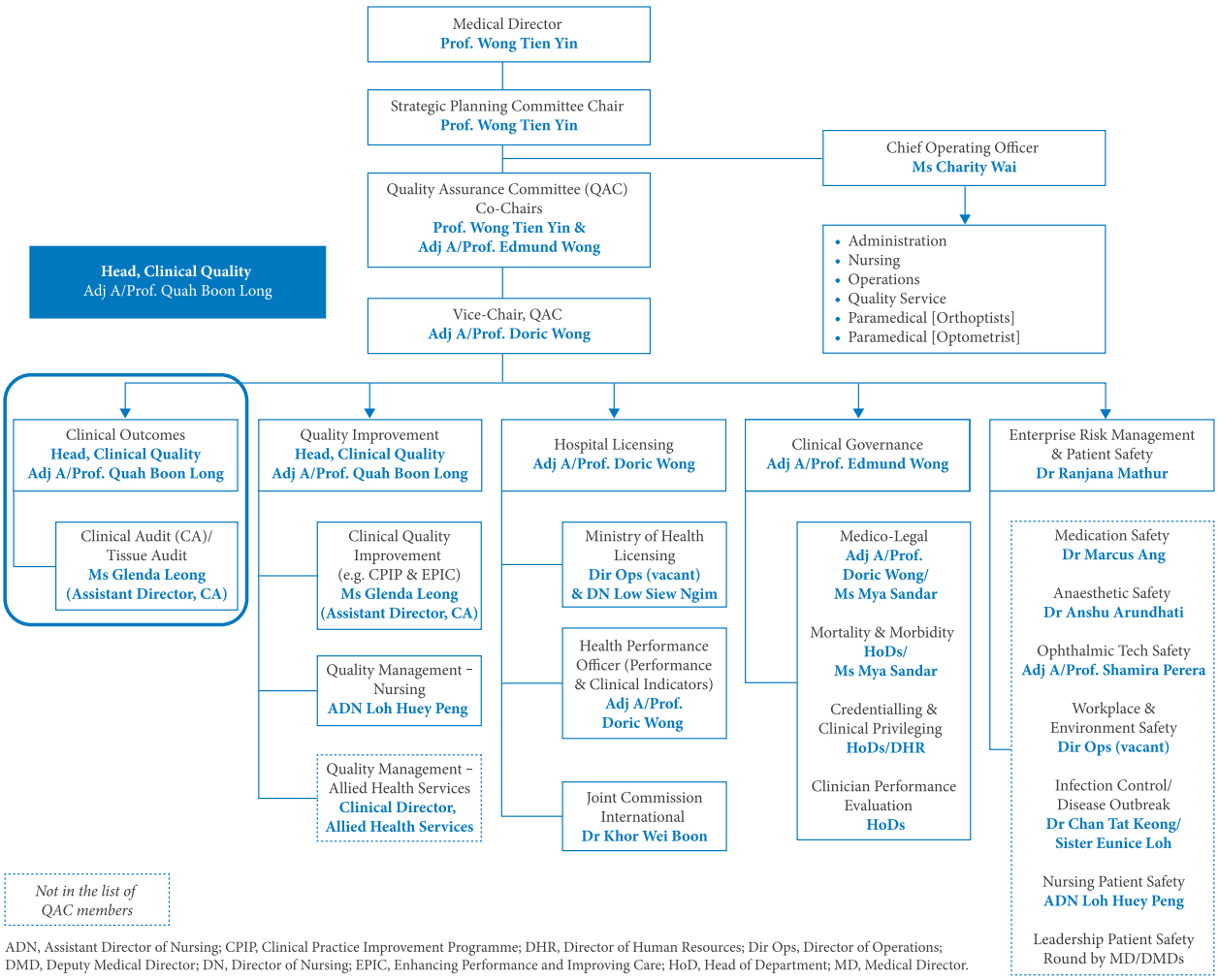
The goals of the clinical audit process are to:

- review and evaluate the process and outcomes of patient care and clinical performance against prescribed targets and standards
- ensure that the highest standard of eye care is provided to all patients
- provide data to SNEC's doctors for training, education, research, presentations and publications
- ensure regular compilation and reporting of statistics for the Quality Assurance Committee.

All major surgeries performed at SNEC are video-recorded for training and education, and the outcomes are audited.

The Clinical Audit Department

The Clinical Audit Department comprises 10 staff who support the Head of Clinical Quality, Adjunct Associate Professor Quah Boon Long, who is responsible for coordinating the clinical governance activities at SNEC (Figure 1). Adjunct Associate Professor Quah was also Head of the Paediatric Ophthalmology and Adult Strabismus Department for 11 years. He has now passed on leadership of the department to aid in the development of a new generation of leaders at SNEC.



ADN, Assistant Director of Nursing; CPIP, Clinical Practice Improvement Programme; DHR, Director of Human Resources; Dir Ops, Director of Operations; DMD, Deputy Medical Director; DN, Director of Nursing; EPIC, Enhancing Performance and Improving Care; HoD, Head of Department; MD, Medical Director.

Figure 1. Organisation chart of SNEC's Quality Assurance Department

Standard operating procedures for clinical audit and sources of information

The Clinical Audit Department audits more than 10,000 case notes annually. It currently tracks more than 30 indicators in the following subspecialties: cataract surgery, surgical retina, medical retina, laser refractive surgery (LASIK [laser in-situ keratomileusis]), corneal surgery, glaucoma surgery, paediatric ophthalmology and strabismus surgery, oculoplastic surgery, neuro-ophthalmology and ophthalmic pathology.

The surgical outcomes at SNEC's branches and affiliates, i.e. SNEC Eye Clinic@Changi General Hospital, the Alexandra and Balestier branches and KK Women's and Children's Hospital Eye Clinic, are also audited in the same way to ensure maintenance of a high standard of ophthalmic care for all patients across SNEC's affiliated institutions and branches in Singapore.

The information is primarily collected from various sources, such as theatre lists, log books, case notes and data forms (from operating theatres and clinics). The data are then evaluated and processed, with the output of the clinical audit being in the form of presentations, reports, statistics and data for research. Recommendations for improvement in the standard of delivery of care can be derived from the outcome data and statistics. This wealth of collected data serves as a valuable resource for audit, benchmarking and research when further analysed. These audit reports are presented to all clinical, nursing, allied health and key administrative staff at the annual Quality Assurance Seminars. This is part of a clinician's training and education for improved patient care and also serves to reinforce clinical quality and patient safety.

SNEC's published clinical audit data

SNEC's clinical audit data have been used and reported in several publications – a few of which are elaborated on below.

1. LASIK: the efficacy, predictability and safety of LASIK surgery as a treatment for myopia was evaluated in a 10-year prospective clinical audit. The study demonstrated that myopic LASIK performed on Asian eyes with appropriate clinical audit governance can be safe and effective, with high refractive predictability (Yuen, Chan, Koh, Mehta, & Tan, 2010).
2. Cataract surgery outcomes after posterior capsule rupture (Ti, Yang, Lang, & Chee, 2014): a retrospective audit study was done to describe the capsule rupture rates and visual outcomes after phacoemulsification, analyse risk factors for poor vision and compare results of the faculty and residents. The study revealed that the overall capsule rupture rate was 1.8%. Although residents had higher capsule rupture rates, visual success rates were still comparable with those of the faculty. Risk factors included age above 65 years and intraocular complications.
3. Post-cataract surgery complications (Ti, Chee, Tan, Yang, & Shuang, 2013): the efficacy of air bubble tamponade for Descemet's membrane detachment (DMD) after clear corneal incision phacoemulsification surgery and its risk factors were evaluated over a 4-year period. The study found that air bubble tamponade for DMD effectively restored corneal clarity in the majority of patients. Significant risk factors included endothelial disease and corneal oedema on the 1st post-operative days.

4. Oculoplastics (ptosis) (Young et al., 2013): a prospective audit was conducted over a 2-year period to evaluate the demographics, presentation and surgical outcomes of patients undergoing ptosis surgery. This was the first prospective ptosis surgery audit to be conducted in an Asian population and exemplifies SNEC's commitment and continued effort toward surgical excellence. The audit was a leading step in assessing both subjective and objective surgical outcomes as well as benchmarking SNEC with other major centres worldwide.
5. Femtosecond laser-assisted cataract surgery (FLACS) outcomes (Chee, Yang, & Ti, 2015): This study compared the clinical outcomes of surgeons with more than 50 laser cases in the first 2 years of initiation of FLACS (cases) surgery to manual phacoemulsification (controls). The study found that FLACS had a low complication rate. In addition, FLACS achieved significantly better unaided visual acuity at the 20/25 level or better and manifest refraction spherical equivalent than that of the controls.

References

Chee, S. P., Yang, Y., & Ti, S. E. (2015). Clinical outcomes in the first two years of femtosecond laser-assisted cataract surgery. *American Journal of Ophthalmology*, *159*, 714–719.

Ti, S. E., Chee, S. P., Tan, D. T., Yang, Y. N., & Shuang, S. L. (2013). Descemet membrane detachment after phacoemulsification surgery: risk factors and success of air bubble tamponade. *Cornea*, *32*, 454–459.

Ti, S. E., Yang, Y. N., Lang, S. S., & Chee, S. P. (2014). A 5-year audit of cataract surgery outcomes after posterior capsule rupture and risk factors affecting visual acuity. *American Journal of Ophthalmology*, *157*, 180–185.

Young, S. M., Lim, L. H., Seah, L. L., Choo, C. T., Chee, E. W., Shen, S. Y., . . . Looi, A. L. (2013). Prospective audit of ptosis surgery at the Singapore National Eye Centre: two-year results. *Ophthalmic Plastic and Reconstructive Surgery*, *29*, 446–453.

Yuen, L. H., Chan, W. K., Koh, J., Mehta, J. S., & Tan, D. T. (2010). A 10-year prospective audit of LASIK outcomes for myopia in 37,932 eyes at a single institution in Asia. *Ophthalmology*, *117*, 1236–1244.

"A regular, rigorous institutional review of outcomes of surgical and medical treatments is essential to benchmark the institution against the best in the world in the pursuit of excellence. The aim is to try to do better for our patients, and to be amongst the best. I am pleased that more than two decades of clinical audit at SNEC has finally been distilled in this first publication of clinical audit data that we can share with colleagues, peers and patients alike."

Adjunct Associate Professor Quah Boon Long
Head of Clinical Quality, SNEC

The Clinical Audit Process

At the start of every audit period, staff of the Clinical Audit Department will liaise with the Head of Department (HoD) of each subspecialty to discuss topics to be audited for the year. These can be a repetition of the previous year's topics (to ensure the availability of a prospective yearly trend, i.e. 10-year trend) or a new topic (to allow exploration of a variety of topics). Audit topics can vary from success rates and complications of a certain surgical procedure or a new intraocular lens to diagnoses in new patients or survival rates of corneal transplants.

Once the audit topic has been determined, the objective of the topic and the inclusion year(s) of surgeries will be decided upon to generate the list of patients/cases. Concurrently, HoDs will list the required fields to be collected and define the measurable indicators that determine the success or failure of each case. In addition, they will provide the exclusion criteria for cases as well as instructions on how to treat defaulted cases.

After the planning stage, staff of the Clinical Audit Department will create the database and audit forms in accordance with the list of fields and indicators to be used for data collection. Data will be collected from case notes, operating theatre lists or electronic medical records.

Following the data collection stage, the database will be prepared and "cleaned" to ensure consistency and no missing values. The data will then be analysed and the results reflected in quality assurance reports, which will be compared against predetermined targets and international standards. If the standards are not met, the cases will undergo further review to explore reasons for the results, serving as a focus for future improvement measures.

The audit results are presented to all medical and key administrative staff at the annual Quality Assurance Seminars, the aims of which are to highlight key outcomes and complications and to address queries regarding performance and results. The end of this presentation marks the start of a new audit period during which the above cycle will repeat.

Clinical Subspecialties and Audited Data

1 General Cataract and Comprehensive Ophthalmology

Department overview

The department provides cataract surgery and forms the backbone of primary eye care for most Singapore National Eye Centre (SNEC) patients. It is led by Dr Allan Fong (Head and Consultant), who is supported by more than 70 consultant surgeons trained in the management of cataract and general eye diseases. Regular continuing medical education, internal audit, proper accreditation and privileging ensures a high standard of practice and quality care for patients.

General eye care services include evaluation and treatment for cataracts, provision of eye evaluation and management of important sight-threatening eye diseases such as glaucoma, diabetic retinopathy and age-related macular degeneration. Other diseases screened and managed include floaters, flashes and other retinal conditions; corneal and ocular surface disorders; dry eyes; eye infections; eyelid diseases such as ptosis; and injuries to the eyes.

A wide range of diagnostic and screening services are available, including refraction and optometric services, slit-lamp evaluation, ophthalmoscopy, tonometry, gonioscopy, retina and optic nerve scanning and visual field testing. The department also provides referrals for and coordinates advanced care in subspecialty departments within SNEC.

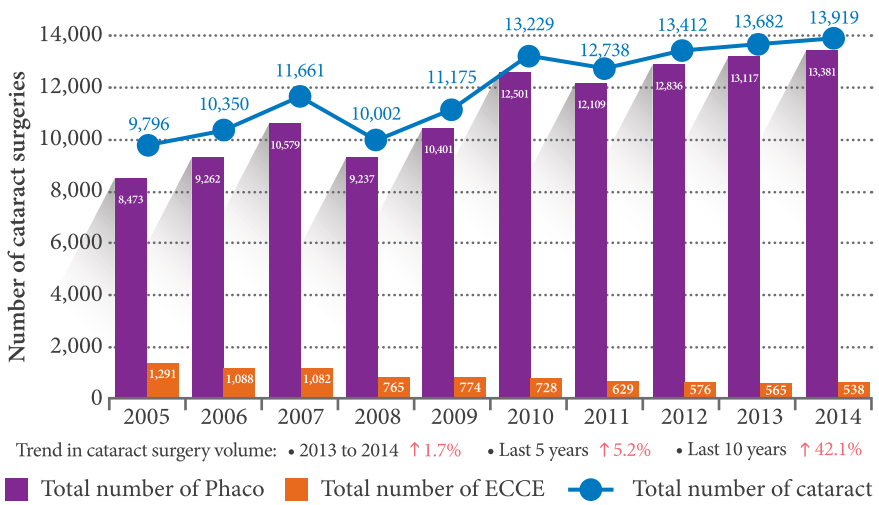
Key facts and figures

- Annually, close to 17,000 cataract surgeries are performed at SNEC. These take place both at the main centre and at satellite branches. The overall visual success rate is very high at 98 to 99% (patients achieve best-corrected visual acuity [BCVA] of 6/12 or better).
- 13,919 of the 17,682 cataract surgeries performed in 2014 at SNEC were performed at SNEC's main centre, and the remainder were carried out at its branches.
- The average endophthalmitis (sight-threatening microbial infection) incidence rate was very low for the 127,046 cataract operations performed from 2005 to 2014: 0.0143% for culture-positive cases and 0.0208% for cases diagnosed using clinical criteria. *Please refer to Section 11 for more information on endophthalmitis.*

Statistics

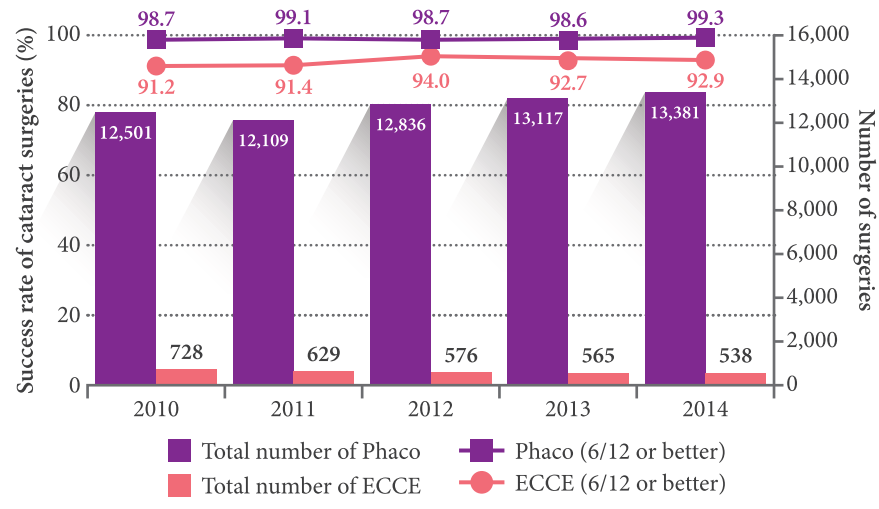
The numbers of cataract surgeries performed, visual outcomes and posterior capsule rupture (PCR) rates are shown in Figures 1.1 to 1.3.

Figure 1.1. 10-year trend of cataract surgeries at SNEC's main centre from 2005 to 2014



ECCE, extracapsular extraction; Phaco, phacoemulsification.

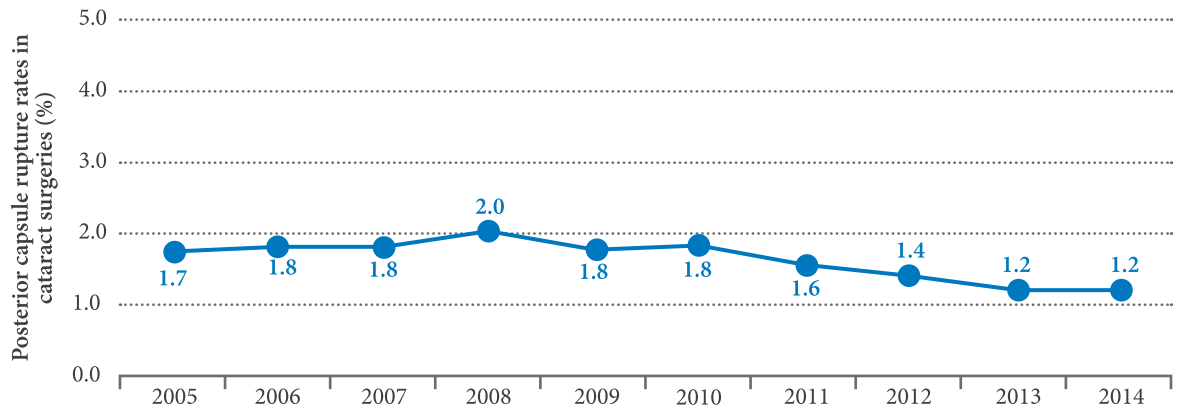
Figure 1.2. 5-year success rate post-cataract surgery with BCVA 6/12 or better from 2010 to 2014



BCVA, best-corrected visual acuity; ECCE, extracapsular extraction; Phaco, phacoemulsification.

Annually, close to 17,000 cataract surgeries are performed at SNEC. These take place both at the main centre and at satellite branches. The overall visual success rate is very high at 98 to 99% (patients achieve best-corrected visual acuity of 6/12 or better).

Figure 1.3. Posterior capsule rupture rates in cataract surgeries performed from 2005 to 2014*



*Data for main SNEC centre only.

Benchmarks of success

Table 1.1. Outcomes of cataract surgery from international studies and at SNEC

Title of study	Country	Number of cases	BCVA 6/12 or better with ocular comorbidity	
			No (%)	Yes (%)
The Cataract National Dataset electronic multi-centre audit of 55,567 operations: updating benchmark standards of care in the United Kingdom and internationally (Jaycock et al., 2009)	UK	55,567	94.7	79.9
Determination of valid benchmarks for outcome indicators in cataract surgery: a multicenter, prospective cohort trial (Hahn et al., 2011)	Germany	1,685	98.5	–
Visual outcome of cataract surgery; study from the European Registry of Quality Outcomes for Cataract and Refractive Surgery (Lundstrom, Barry, Henry, Rosen, & Stenevi, 2013)	15 European countries	368,256	98.2	94.3
SNEC (main centre) 2014 audit data – phacoemulsification outcomes	Singapore	13,682	99.3	–

BCVA, best-corrected visual acuity.

Latest audit results

Due to the large number of cataract surgeries performed at SNEC, only 10% of the surgeries in 2015 were audited (1,334 surgeries). All 167 PCR cases were included in the audit. BCVA and refraction were assessed 3 to 14 weeks post-surgery.

References

Hahn, U., Krummenauer, F., Kolbl, B., Neuhann, T., Schayan-Araghi, K., Schmickler, S., & Neuhann, I. (2011). Determination of valid benchmarks for outcome indicators in cataract surgery: a multicenter, prospective cohort trial. *Ophthalmology*, *118*, 2105–2112.

Jaycock, P., Johnston, R. L., Taylor, H., Adams, M., Tole, D. M., Galloway, P., & Sparrow, J. M. (2009). The Cataract National Dataset electronic multicentre audit of 55,567 operations: updating benchmark standards of care in the United Kingdom and internationally. *Eye*, *23*, 38–49.

Lundstrom, M., Barry, P., Henry, Y., Rosen, P., & Stenevi, U. (2013). Visual outcome of cataract surgery; study from the European Registry of Quality Outcomes for Cataract and Refractive Surgery. *Journal of Cataract & Refractive Surgery*, *39*, 673–679.

2 Complicated Cataract

Department overview

The department provides cataract surgery for complicated cases such as subluxated (displaced) cataracts and intraocular lenses (IOLs). Complicated cases often present with other pathologies, including brunescent cataract with low cornea endothelial cell count and posterior polar cataract.

The cataract subspecialty team is led by Professor Chee Soon Phaik (Head and Senior Consultant) and comprises 4 faculty members. The team/department conducts lens-related research and evaluates new cataract technologies, including new and premium IOL implants, devices and cataract removal technologies (e.g. phacoemulsification and femtosecond laser-assisted cataract surgery [FLACS]).

Key facts and figures

- Complicated Cataract was separated from General Cataract and Comprehensive Ophthalmology in 2014. Before the split, a focus group was convened monthly to discuss complicated cases. The audit process began in May 2012.
- Various in-house and external courses are conducted, including FLACS training as well as courses on the latest cataract surgical technologies and techniques, IOL implants and devices relating to cataract surgery.
- Local, regional and international instructional courses are taught on a regular basis to facilitate the structured training of cataract surgery, which aims to maintain quality visual outcomes without compromising patient safety.
- Referrals are received for the management of complicated cataracts nationwide and from the region, with more than 300 subluxated cataract surgeries being performed since 2002.
- The department is an early pioneer of FLACS in Singapore, having performed it since 2012.

Breakthroughs in technology

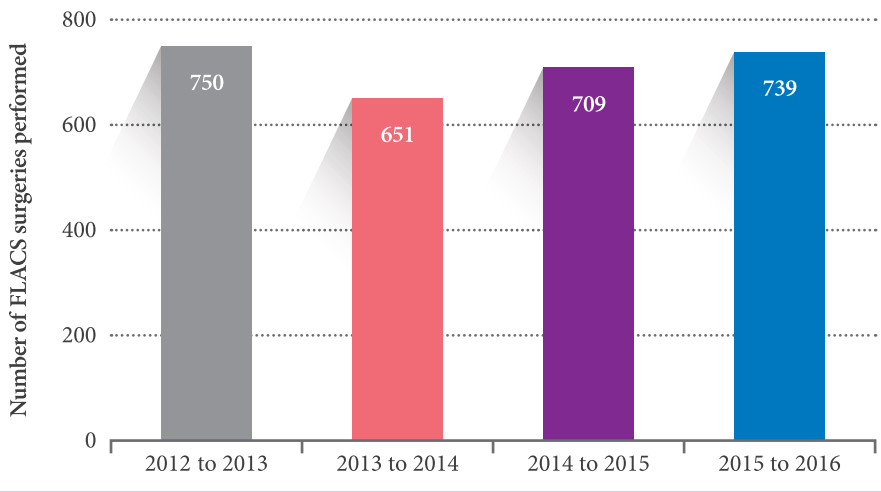
1. FLACS: this is the latest adjunct to enhance surgery predictability. It has a special safety role in complicated cases, such as brunescent cataract and posterior polar cataract. FLACS reduces the amount of ultrasound energy needed for nuclear fragmentation, and is equipped with a live optical coherence tomography imaging function to track eye movements. Analysing the clinical outcomes in the first 2 years of FLACS at the Singapore National Eye Centre (SNEC), the percentage of 6-week post-operative unaided visual acuity (UAVA) of 20/25 or better was higher in FLACS patients (68.6%) than in the controls (56.3%; $P < 0.0001$). This study also demonstrated a low complication rate with FLACS surgery (Chee, Yang, & Ti, 2015).

2. Professor Chee has also designed surgical instruments, such as lens-holding forceps and suture hooks for iris-fixated IOL cases, to handle complex cataract surgery.

Statistics

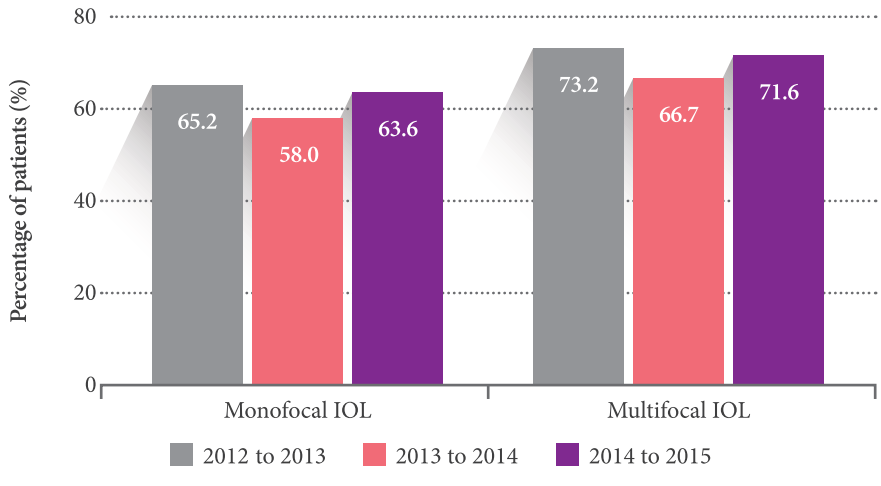
The FLACS surgery trends, types of lenses used and surgery outcomes are shown in Figures 2.1 to 2.4.

Figure 2.1. FLACS volume – 4-year trend from 2012 to 2016



FLACS, femtosecond laser-assisted cataract surgery.

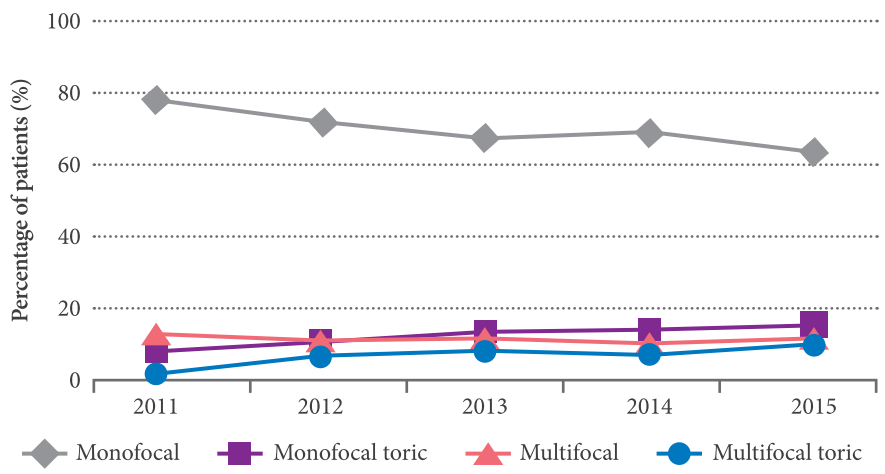
Figure 2.2. Comparison of post-operative UAVA of 6/7.5 or better at the 1-month follow-up, for different IOL types, from 2012 to 2015



IOL, intraocular lens; UAVA, unaided visual acuity.

A larger percentage of patients achieve UAVA of 6/7.5 or better with multifocal IOL compared with monofocal IOL.

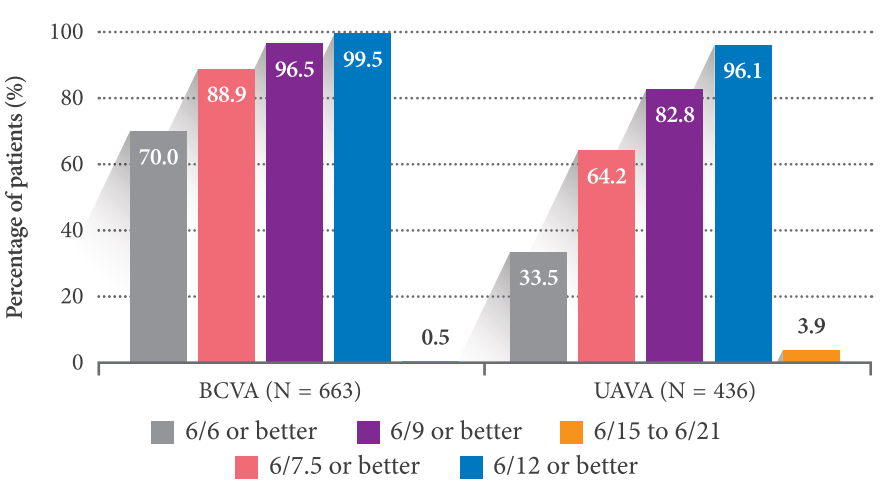
Figure 2.3. Types of IOL implants used for private patients at SNEC from 2011 to 2015



IOL, intraocular lens.

SNEC uses a high standard of implants and is in the process of replacing current implants with better quality ones, such as monofocal toric implants.

Figure 2.4. FLACS visual outcomes at the 1-month follow-up



BCVA, best-corrected visual acuity; FLACS, femtosecond laser-assisted cataract surgery; UAVA, unaided visual acuity.

Almost all the patients achieved a BCVA and UAVA of 6/12 or better: 99.5% and 96.1%, respectively.

In the first 2 years of femtosecond laser surgery (FLACS) at SNEC, the percentage of the 6-week post-operative unaided visual acuity of 20/25 or better was higher in FLACS patients (68.6%) than in the controls (56.3%; $P < 0.0001$) (Chee, Yang, & Ti, 2015).

Latest audit results

From June 2014 to June 2015, there were 709 cases (524 patients) of FLACS, all of which were audited. The number of cases with 1-month follow-up was 687, with a default rate of 3.1%.

Reference

Chee, S. P., Yang, Y., & Ti, S. E. (2015). Clinical outcomes in the first two years of femtosecond laser-assisted cataract surgery. *American Journal of Ophthalmology, 159*, 714–719.

3 Corneal and External Eye Disease

Department overview

The Corneal and External Eye Disease Department primarily provides medical and surgical care for patients with corneal disorders. It provides a wide range of services including those related to various types of corneal transplants, ocular surface stem cell reconstruction, artificial corneal transplant (including Boston keratoprosthesis and osteo-odonto keratoprosthesis [OOKP]), contact lens-related problems, infectious keratitis, specialised treatment of dry eyes as well as imaging services. Additionally, this department has one of the few medical contact lens services available regionally.

A number of different transplant procedures, including penetrating keratoplasty (PK), anterior lamellar keratoplasty (ALK), deep ALK and endothelial keratoplasty (EK), have been introduced at the Singapore National Eye Centre (SNEC) over the years. The Singapore Eye Bank (SEB) provides high-quality donor corneas for these transplants. SNEC and SEB work hand-in-hand to maintain the high quality and standards needed when harvesting donor corneas.

The Corneal and External Eye Disease Department is led by Associate Professor Jod Mehta (Head and Senior Consultant) and comprises 10 consultants.

Key facts and figures

- The Corneal Transplant Programme began in 1991, and SEB was set up in 1993.
- 80% of corneal transplants in Singapore are performed at SNEC.
- The department prides itself at having a graft survival rate of more than 90%.
- Serves as a teaching centre for complex corneal transplants and other complex surgeries (e.g. OOKP).
- SNEC is the regional referral centre for complex corneal procedures. Descemet stripping automated endothelial keratoplasty (DSAEK) surgeries account for more than 50% of the corneal transplants performed here, and lamellar keratoplasty accounts for 75% to 80% of all cases.

SNEC is a leading centre regionally and has performed more than 4,000 corneal transplants since its inception; ~350 transplants are performed annually, with a graft survival rate of more than 90%.

Osteo-odonto keratoprosthesis was first performed in 2004, and more than 50 successful surgeries have been performed to date.

Breakthroughs in technology and future developments

1. OOKP procedure (Tan et al., 2008)

This landmark "tooth-in-eye" surgery, first performed in 2004, is a complex procedure for those who have lost their vision due to corneal or ocular surface disorders and who are not suitable for conventional corneal or stem cell transplant treatment regimens. SNEC has successfully restored the vision of more than 50 patients, nationally and internationally, using this procedure.

2. The EndoGlide for EK surgery

A surgical device, the EndoGlide, was invented in 2009 by Professor Donald Tan and Associate Professor Mehta to perform EK surgery (Khor, Han, Mehta, & Tan, 2013; Mehta, Por, Poh, Beuerman, & Tan, 2008). This device enables donor cornea insertion into a patient's eye with ease and minimal trauma. Approximately 20,000 corneal transplants using this device have been performed around the world to date. It was first used as part of the SNEC DSAEK EndoGlide Clinical Trial, and ~600 eyes have undergone DSAEK surgery using the EndoGlide. This device has resulted in good visual outcomes, has been shown in published literature to have the lowest rates of endothelial cell loss and has a reduced risk of complications.

SNEC and Singapore Eye Research Institute have patented a new surgical technique that includes a new Descemet membrane endothelial keratoplasty (DMEK) surgical insertion device, similar to the EndoGlide.

3. ALK techniques for corneal transplant

The advanced lamellar keratoplasty/DSAEK training course was initiated in 2006 and is directed by Professor Tan and Associate Professor Mehta. Annually, 14 to 16 surgeons from the Asia-Pacific region and from other countries outside of the region are trained in an intensive 3-day course involving hands-on wet laboratory teaching and a live demonstration of the latest lamellar surgical techniques. Shorter versions of the advanced lamellar courses are also being conducted internationally in the United States, Europe, Korea, India and China.

4. Ocular Stem Cell Transplant Service

An Ocular Stem Cell Transplant Service was introduced in 2003.

5. Future aspirations of the Corneal and External Eye Disease Department

The future aspirations of this department are to:

a. carry out trials with endothelial cell culture/ tissue engineered transplants

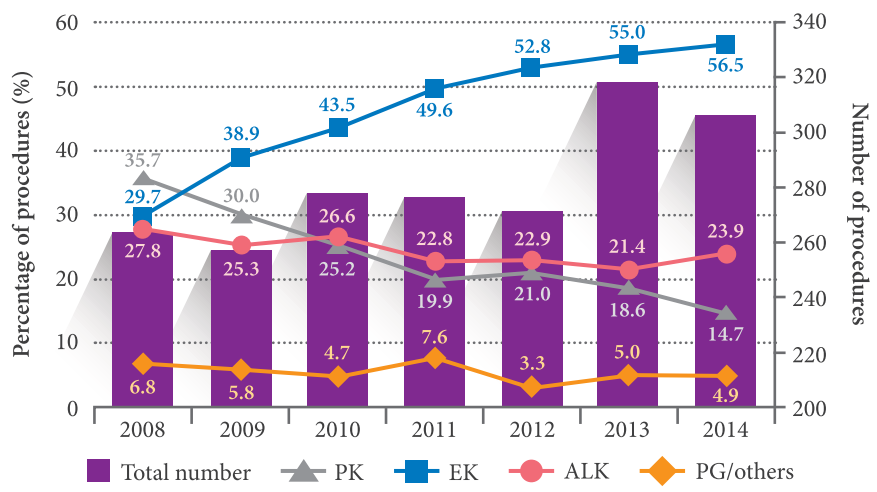
b. introduce the use of femtosecond lasers for ocular surface reconstruction

c. use a new artificial cornea to replace OOKP.

Statistics

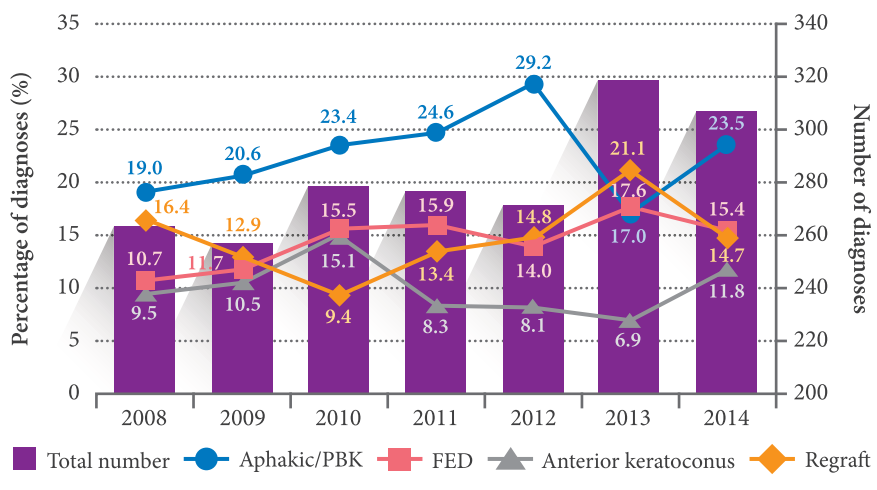
The number of corneal transplant surgeries performed, success rates, diagnoses made and a comparison of success rates and survival rates, between procedures (PK versus ALK versus EK), are shown in Figures 3.1 to 3.4.

Figure 3.1. Types of procedures performed from 2008 to 2014



ALK, anterior lamellar keratoplasty; EK, endothelial keratoplasty; PG, patch graft; PK, penetrating keratoplasty.

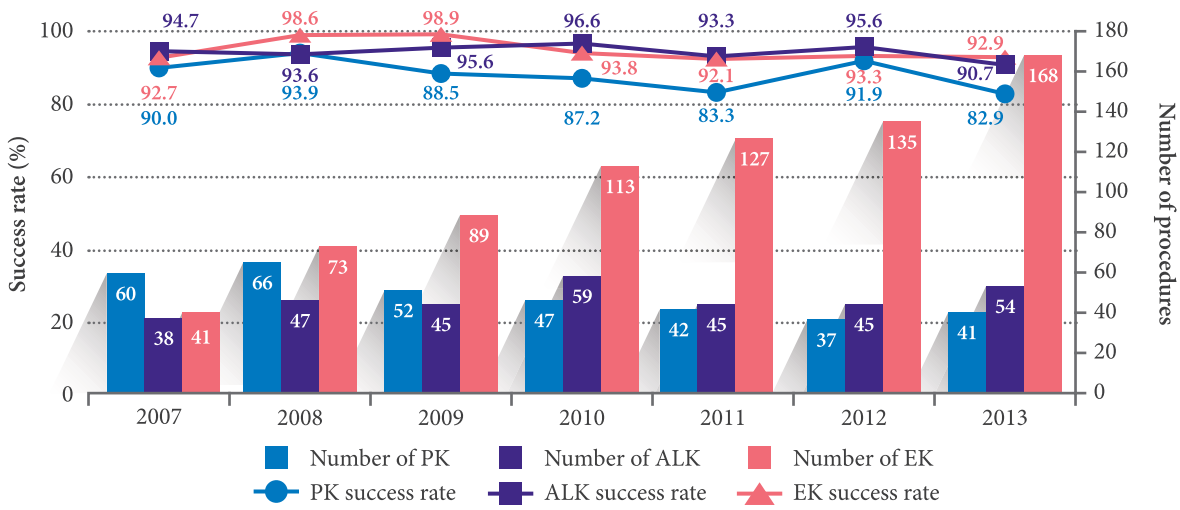
Figure 3.2. Major diagnoses requiring corneal transplant from 2008 to 2014



FED, Fuchs' endothelial dystrophy; PBK, pseudophakic bullous keratopathy.

PK is a form of microsurgery in which the central portion of the damaged or cloudy cornea is removed, and a clear and healthy donor cornea is sutured in its place with very fine microsurgical nylon sutures. In EK, the diseased posterior of the back layers of the cornea are replaced (includes DSAEK and DMEK). In ALK, diseased portions of the anterior layers of the cornea are removed and replaced, preserving the healthy corneal tissues.

Figure 3.3. 1-year success rates of PK, ALK and EK from 2007 to 2013*

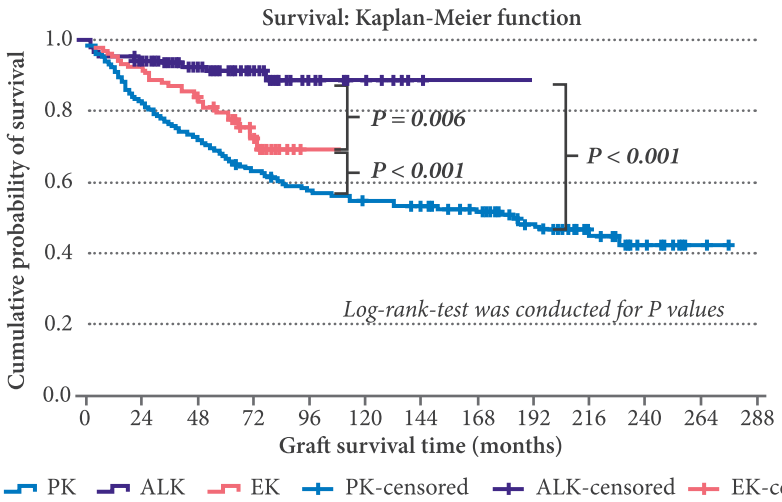


*Optical cases only.

ALK, anterior lamellar keratoplasty; EK, endothelial keratoplasty; PK, penetrating keratoplasty.

The advantages of EK/DSAEK include lack of suture-related problems, a lower risk of graft rejection, very good graft survival and faster visual recovery.

Figure 3.4. Comparison of survival rates between procedures (PK versus ALK versus EK) from 1991 to 2013



	PK		ALK		EK	
Year	No.	%	No.	%	No.	%
1	1,131	91.5	392	95.6	559	95.5
2	888	82.4	273	94.2	430	92.0
3	644	76.4	163	93.5	230	87.0
4	530	72.0	121	92.5	154	83.8
5	439	66.6	85	91.3	95	79.5
10	184	54.6	16	88.8	–	–

ALK, anterior lamellar keratoplasty; EK, endothelial keratoplasty; PK, penetrating keratoplasty.

ALK was associated with the highest cumulative probability of survival followed by EK and PK.

Benchmarks of success

Table 3.1. Comparison of SNEC audit data with other corneal graft registries/studies

Procedure	Name of corneal graft registry/study	Graft survival (%)
PK	SNEC audit data	92/67 (1-year/5-year)
	Australian Corneal Graft Registry (Williams et al., 2015)	94/68 (1-year/6-year)
	Cornea Donor Study (USA) (Cornea Donor Study Investigator Group, 2008)	97/86 (1-year/5-year)
	United Kingdom Transplant Database (Kasbekar, Jones, Ahmad, Larkin, & Kaye, 2014)	92 (5-year)
ALK	SNEC audit data	96/94/91 (1-year/3-year/5-year)
	Australian Corneal Graft Registry (Williams et al., 2015)	93/87 (1-year/3-year)
	United Kingdom Transplant Database (Kasbekar et al., 2014)	90 (5-year)
DSAEK (All diagnoses)	Singapore Corneal Transplant Study (Ang, Soh, Htoon, Mehta, & Tan, 2016)	79.4 (5-year)
EK (Fuchs' dystrophy)	Singapore Corneal Transplant Study (Ang et al., 2012)	93 (3-year)
	Australian Corneal Graft Registry (Williams et al., 2015)	96 (3-year)

ALK, anterior lamellar keratoplasty; DSAEK, Descemet stripping automated endothelial keratoplasty; EK, endothelial keratoplasty; PK, penetrating keratoplasty.

References

Ang, M., Mehta, J. S., Lim, F., Bose, S., Htoon, H. M., & Tan, D. (2012). Endothelial cell loss and graft survival after Descemet's stripping automated endothelial keratoplasty and penetrating keratoplasty. *Ophthalmology*, *119*, 2239–2244.

Ang, M., Soh, Y., Htoon, H. M., Mehta, J. S., & Tan, D. (2016). Five-year graft survival comparing Descemet stripping automated endothelial keratoplasty and penetrating keratoplasty. *Ophthalmology*, *123*, 1646–1652.

Cornea Donor Study Investigator Group. (2008). The effect of donor age on corneal transplantation outcome results of the cornea donor study. *Ophthalmology*, *115*, 620–626.

Kasbekar, S. A., Jones, M. N., Ahmad, S., Larkin, D. F., & Kaye, S. B. (2014). Corneal transplant surgery for keratoconus and the effect of surgeon experience on deep anterior lamellar keratoplasty outcomes. *American Journal of Ophthalmology*, *158*, 1239–1246.

Khor, W. B., Han, S. B., Mehta, J. S., & Tan, D. T. (2013). Descemet stripping automated endothelial keratoplasty with a donor insertion device: clinical results and complications in 100 eyes. *American Journal of Ophthalmology*, *156*, 773–779.

Mehta, J. S., Por, Y. M., Poh, R., Beuerman, R. W., & Tan, D. (2008). Comparison of donor insertion techniques for descemet stripping automated endothelial keratoplasty. *Archives of Ophthalmology*, *126*, 1383–1388.

Tan, D. T., Tay, A. B., Theng, J. T., Lye, K. W., Parthasarathy, A., Por, Y. M., . . . Liu, C. (2008). Keratoprosthesis surgery for end-stage corneal blindness in Asian eyes. *Ophthalmology*, *115*, 503–510.

Williams, K. A., Keane, M. C., Galettis, R. A., Jones, V. J., Mills, R. A., & Coster, D. J. (2015). *The Australian Corneal Graft Registry 2015 Report*. Retrieved from https://www.flinders.edu.au/medicine/sites/ophthalmology/clinical/the-australian-corneal-graft-registry.cfm

4 Glaucoma

Department overview

Glaucoma is an eye disease caused when high fluid pressure within the eye damages the delicate fibres of the optic nerve. The Glaucoma Department at the Singapore National Eye Centre (SNEC) treats a range of glaucoma conditions, including primary open-angle glaucoma, primary angle-closure glaucoma (PACG) and secondary glaucoma. Various laser procedures for glaucoma are performed, which include transscleral cyclophotocoagulation, peripheral iridotomy, selective laser trabeculoplasty (SLT) and endoscopic cyclophotocoagulation. The department is equipped with the latest medical imaging technologies, including the Humphrey visual field analyser, stereoscopic optic disc photography, Heidelberg retinal tomography, optical coherence tomography, ultrasound bio-microscopy and anterior segment optical coherence tomography. New technologies enable the detection of early signs of glaucoma and provide management solutions for advanced glaucoma as well as the laser and surgical management of glaucoma. The main aim of treatment of glaucoma is to reduce intraocular pressure (IOP).

The department is led by Adjunct Associate Professor Ho Ching Lin (Head and Senior Consultant; Clinical Services) and Professor Aung Tin (Head and Senior Consultant; Research, Education and Development) and comprises 14 faculty members.

Key facts and figures

- More than 40,000 glaucoma cases are managed annually (2,000 from other countries in the region), comprising both paediatric and adult patients.
- More than 600 glaucoma surgeries are performed annually.
- More than 1,300 laser procedures are performed annually to manage glaucoma.
- Glaucoma is the largest department at SNEC in terms of research trials, research patients (i.e. patients recruited to clinical trials) and has received numerous research grants from the National Medical Research Council and National Research Foundation, Singapore.
- Serves as a referral centre for the secondary and tertiary management of glaucoma locally and regionally.
- Serves as a teaching/training centre, training 3 Clinical Fellows and 3 to 4 Research Fellows annually.
- Provides education, counselling and support group services to patients with glaucoma.
- Launched a mobile application called "MyEyeDrops" which reminds patients to apply their eye drops and medications according to the prescribed plan. The application is used by patients with glaucoma and corneal conditions.

Breakthroughs in technology and future developments in the pipeline

1. New slow release glaucoma medications

a. A procedure that allows sustained delivery of latanoprost-loaded liposomes via subconjunctival injection, resulting in vitreous reservoir, was jointly developed by Dr Tina Wong and her team from the Singapore Eye Research Institute (SERI) and Professor Subbu Venkatraman and his team from Nanyang Technological University (NTU). The injection to the eyeball is delivered under local anaesthetic and takes only a minute. It contains millions of tiny capsules of glaucoma medication, which release their contents slowly over time. This procedure promises to overcome the biggest challenges of eye drop treatment in terms of non-compliance and side effects, while providing sustained action.

b. Scientists at SERI and NTU have also developed an innovative approach to rescuing failing filtering blebs in glaucoma surgery. A clinical trial showed that the use of a fluorouracil sustained-release formulation resulted in a 40% decrease in the number of injections needed to prevent scarring after surgery. This novel treatment lowers the risk of ocular infection and side effects, because patients require fewer injections.

2. Imaging, genetics and phenotyping for angle-closure glaucoma

a. Professor Aung and his team have employed advanced imaging techniques to identify novel risk factors for angle closure. Using just a single scan of the eye, the team have developed a mathematical formula that can detect the presence of angle closure and its likely cause(s). In addition, and in collaboration with the Institute for Infocomm Research, Singapore, the only fully automated software tool for detecting angle closure from eye scans has been developed. These advancements have the potential to help clinicians provide increasingly individualised management of angle-closure disease.

b. The SNEC glaucoma/SERI team conducts leading research for angle-closure glaucoma, with many studies related to treatments, imaging, risk factors and genetics for the disease.

c. The glaucoma genetics research group at SNEC/SERI has identified more than 10 genetic loci associated, findings of which have been published in *Nature Genetics*.

3. Lasers for glaucoma (SLT in PACG)

The SNEC Glaucoma Service, led by Adjunct Associate Professor Ho, was part of a multicentre trial which first discovered the efficacy of SLT in angle-closure glaucoma. The results of this trial, published in 2009, found SLT to be safe and effective in lowering IOP in eyes with primary angle closure (PAC) with at least 90 degrees of visible pigmented trabecular meshwork after a patent peripheral iridotomy (Ho et al., 2009). A randomised controlled trial by Professor Aung's team explored SLT as a therapeutic option in eyes with angle closure and showed that, at 6 months, the IOP-lowering efficacy of SLT for PAC and

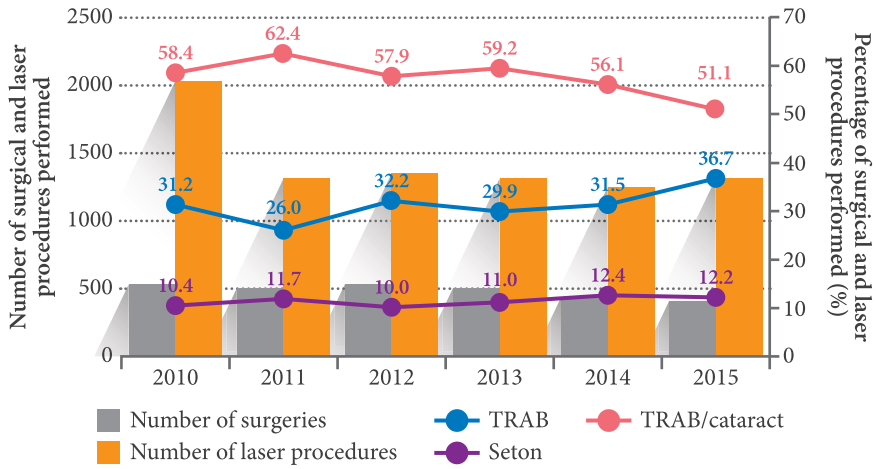
In the 2010 surgical audit, the overall success rate of trabeculectomy (TRAB) in primary glaucoma was 98.8%, whereas that of aqueous shunt surgery was 94.6%. The overall success rate of combined TRAB and cataract surgery was 98.5%.

PACG was similar to that of prostaglandins in eyes with at least 180 degrees of visible trabecular meshwork (Narayanaswamy et al., 2015). SLT is considered to be a viable, safe and effective alternative to medications for lowering IOP in patients with PAC and PACG after iridotomy. In addition to its effectiveness, lack of permanent side effects and ease of application, SLT eliminates the challenge of drug availability and patient non-compliance.

Statistics

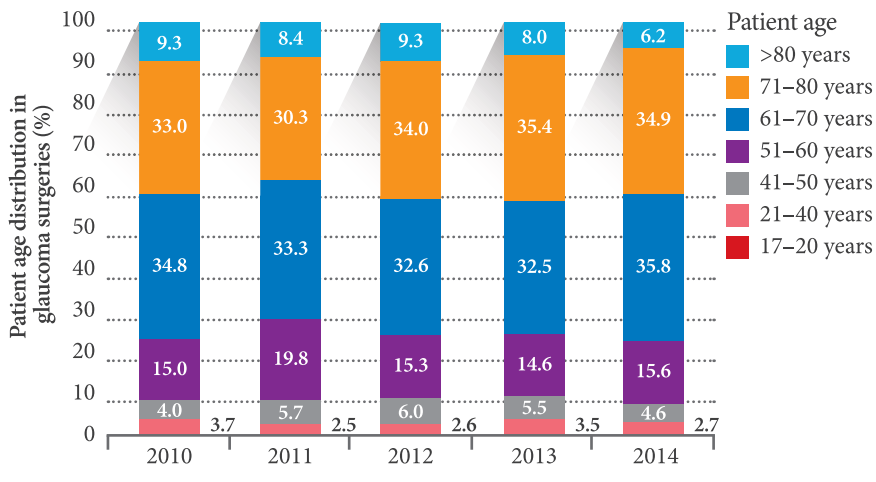
The number of glaucoma procedures, patients' ages, diagnoses made and success rates for the various glaucoma procedures performed are shown in Figures 4.1 to 4.6.

Figure 4.1. Number of surgical (TRAB, seton and TRAB/cataract) and laser procedures performed from 2010 to 2015



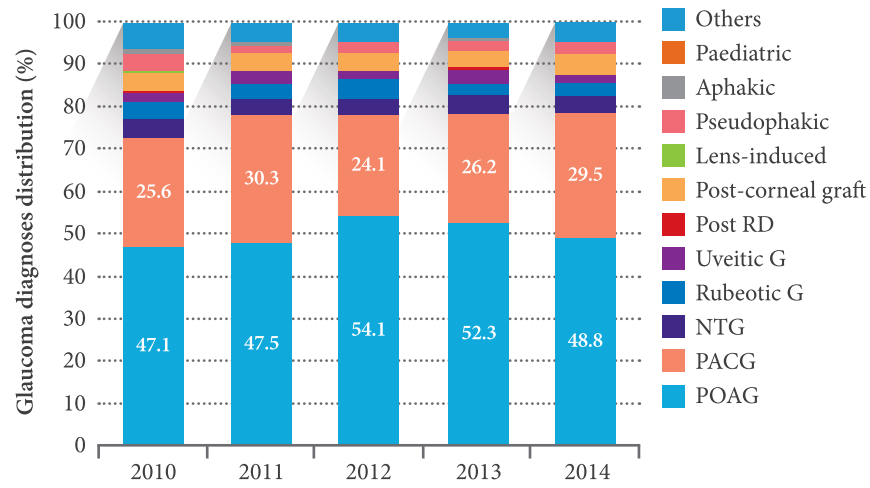
TRAB, trabeculectomy.

Figure 4.2. Patient age distribution from 2010 to 2014*



*The age distribution chart consists of patients who had all types of glaucoma surgery, including trabeculectomy. However, the number excludes all transscleral cyclophotocoagulation and paediatric cases.

Figure 4.3. Glaucoma diagnoses from 2010 to 2014*

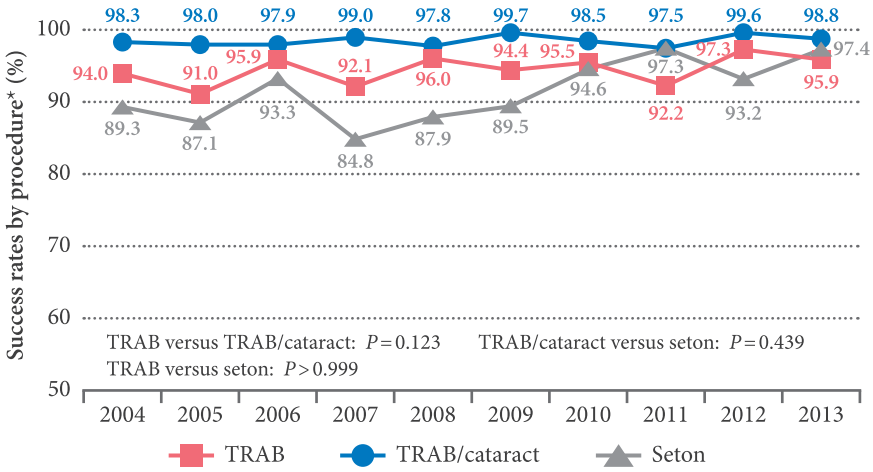


*Transscleral cyclophotocoagulation and paediatric glaucoma cases are excluded.

Note: others included PXF glaucoma (9), traumatic glaucoma (7), ICE syndrome (3), steroid-induced glaucoma (3), phacolytic glaucoma (1), pigment dispersion syndrome (1), subluxated IOL (1) and post-surgical glaucoma with unspecified ocular diagnosis (1).

G, glaucoma; ICE, iridocorneal endothelial; IOL, intraocular lens; NTG, normal-tension glaucoma; PACG, primary angle-closure glaucoma; POAG, primary open-angle glaucoma; PXF, pseudoexfoliation; RD, retinal detachment.

Figure 4.4. Glaucoma surgeries: success rates by procedure (TRAB, TRAB/cataract, seton)

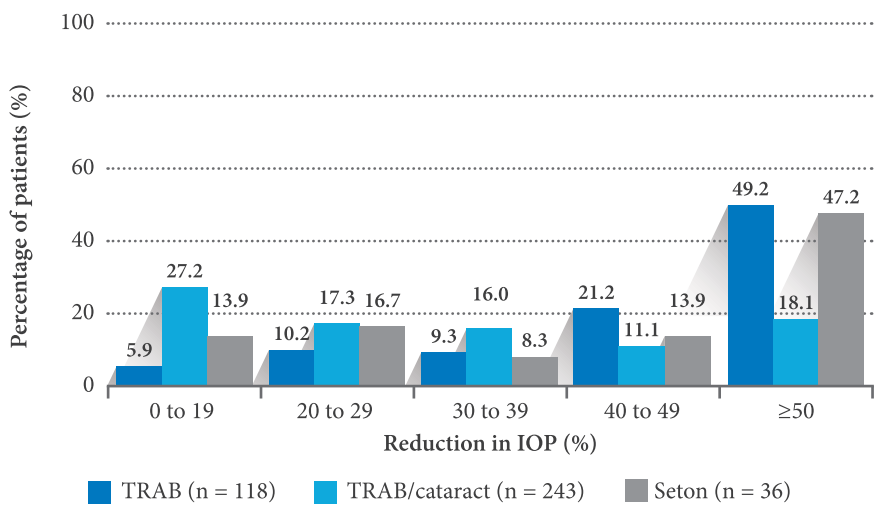


*Total success is defined as IOP ≤21 mm Hg, regardless of further medical intervention.

TRAB, trabeculectomy.

In the 2010 surgical audit, the overall success rate of trabeculectomy (TRAB) in primary glaucoma was 98.8%, whereas that of aqueous shunt surgery was 94.6%. The overall success rate of combined TRAB and cataract surgery was 98.5%.

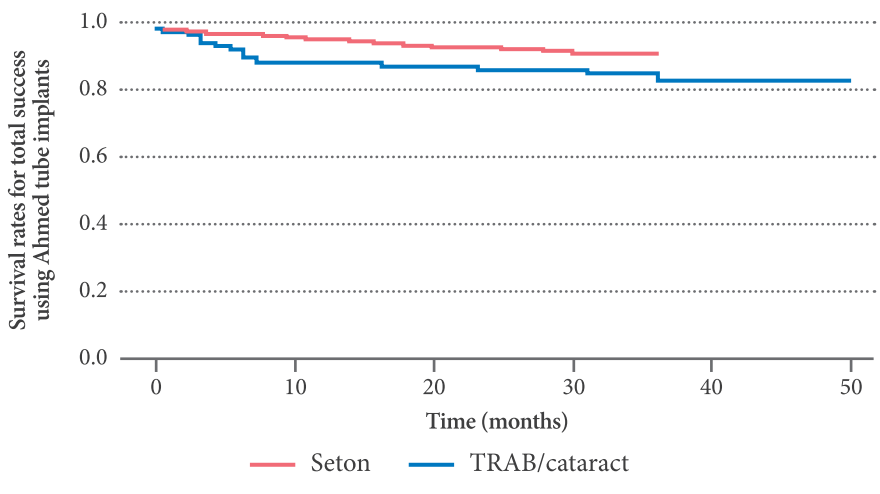
Figure 4.5. Reduction in IOP for total success cases, comparing TRAB, TRAB/cataract and seton



IOP, intraocular pressure; TRAB, trabeculectomy.

Of the total success cases, 7.6% experienced an increase in IOP 12 months post-operation (TRAB: 5 [4.2%]; TRAB/cataract: 25 [10.3%]).

Figure 4.6. 36-month survival rates for total success using Ahmed tube implants (2010 cases followed until 2013)



TRAB, trabeculectomy.

Benchmarks of success

Table 4.1. 1-year success rates compared with other international studies

	SNEC 2011	SNEC 2012	SNEC 2013	TVT RCT (Gedde et al., 2007b)	ABC RCT (Budenz et al., 2011)	Bascom Palmer Eye Institute (Scott et al., 1998)	Hong Kong (Lai, Tham, Chan, & Lam, 2004)	UK National Study (Edmunds, Thompson, Salmon, & Wormald, 2001)
TRAB	Overall 92.2% (N = 103); Primary 91.2% (N = 68)	Overall 97.3% (N = 147); Primary 98.9% (N = 95)	Overall 95.9% (N = 123); Primary 98.8% (N = 84)	87% (N = 100) Mainly primary glaucoma	–	92.7% (N = 89) Mainly primary glaucoma	–	92% (N = 1,240) Mainly primary glaucoma
TRAB/ cataract	Overall 97.5% (N = 276)	Overall 99.6% (N = 273)	Overall 98.8% (N = 246)	–	–	–	87.1% to 70.6% (N = 65) POAG-PACG	–
Seton implant	Overall 97.3% (N = 37)	Overall 93.2% (N = 44)	Overall 97.4% (N = 38)	Primary 96% (N = 104)	83.6% (N = 143)	–	–	–

ABC, Ahmed Baerveldt comparison; PACG, primary angle-closure glaucoma; POAG, primary open-angle glaucoma; RCT, randomised clinical trial; TRAB, trabeculectomy; TVT, tube versus trabeculectomy.

Table 4.2. Comparison of TRAB and TRAB/cataract complication rates with international studies

	SNEC 2011 (N = 380) (%)	SNEC 2012 (N = 420) (%)	SNEC 2013 (N = 369) (%)	AGIS (AGIS Investigators, 2002) (N = 509) (%)	CIGTS (Jampel et al., 2005) (N = 465) (%)	UK National Study (Edmunds, Thompson, Salmon, & Wormald, 2002) (N = 1,240) (%)	TVT study (Gedde et al., 2007a) (N = 105) (%)
Overfiltration	8.7	7.6	5.7	15.5	13.9	24.3	10
Wound leak	7.6	6.2	6.0	6.5	6	17.6	11
Endophthalmitis	0	0	0	–	–	0.2	3
Cataract	–	–	0	4.1	17.3	20.2	48
Hyphema	3.4	3.3	6.8	11.4	10	24.6	8
Suprachoroidal haemorrhage	0	0	0	–	0.7	–	3
Malignant glaucoma	0	0.2	0	–	0.4	–	1

AGIS, Advanced Glaucoma Intervention Study; CIGTS, Collaborative Initial Glaucoma Treatment Study; TRAB, trabeculectomy; TVT, tube versus trabeculectomy.

Table 4.3. Comparisons of seton complication rates with international studies

	SNEC 2011 (N = 37) (%)	SNEC 2012 (N = 44) (%)	SNEC 2013 (N = 38) (%)	AVB study (Christakis et al., 2011) (N = 124) (%)	ABC study (Budenz et al., 2011) (N = 132) (%)	TVT study (Gedde et al., 2007a) (N = 107) (%)
Overfiltration	16.2	6.8	13.2	15	19	11
Endophthalmitis	2.7	2.3	0	2	0	1
Hyphema	10.8	22.7	13.2	3	9	2
Tube related	13.5	11.4	5.3	9	2	2
Malignant glaucoma	0	2.3	0	2	–	3

ABC, Ahmed Baerveldt comparison; AVB, Ahmed versus Baerveldt; TVT, tube versus trabeculectomy.

Latest audit results

Of the glaucoma procedures performed in 2013, 488 of the 502 glaucoma surgery cases were audited (N = 452). In the independent annual surgical audit, success is defined as an achievement of an IOP ≤ 21 mm Hg at the end of the first post-operative year.

References

AGIS Investigators. (2002). The Advanced Glaucoma Intervention Study (AGIS): 11. Risk factors for failure of trabeculectomy and argon laser trabeculoplasty. *American Journal of Ophthalmology*, *134*, 481–498.

Budenz, D. L., Barton, K., Feuer, W. J., Schiffman, J., Costa, V. P., Godfrey, D. G., & Buys, Y. M. (2011). Treatment outcomes in the Ahmed Baerveldt Comparison Study after 1 year of follow-up. *Ophthalmology*, *118*, 443–452.

Christakis, P. G., Kalenak, J. W., Zurakowski, D., Tsai, J. C., Kammer, J. A., Harasymowycz, P. J., & Ahmed, I. I. (2011). The Ahmed Versus Baerveldt study: one-year treatment outcomes. *Ophthalmology*, *118*, 2180–2189.

Edmunds, B., Thompson, J. R., Salmon, J. F., & Wormald, R. P. (2001). The National Survey of Trabeculectomy. II. Variations in operative technique and outcome. *Eye*, *15*, 441–448.

Edmunds, B., Thompson, J. R., Salmon, J. F., & Wormald, R. P. (2002). The National Survey of Trabeculectomy. III. Early and late complications. *Eye, 16*, 297–303.

Gedde, S. J., Herndon, L. W., Brandt, J. D., Budenz, D. L., Feuer, W. J., & Schiffman, J. C. (2007a). Surgical complications in the Tube Versus Trabeculectomy Study during the first year of follow-up. *American Journal of Ophthalmology*, *143*, 23–31.

Gedde, S. J., Schiffman, J. C., Feuer, W. J., Herndon, L. W., Brandt, J. D., & Budenz, D. L. (2007b). *American Journal of Ophthalmology*, *143*, 9–22.

Ho, C. L., Lai, J. S., Aquino, M. V., Rojanapongpun, P., Wong, H. T., Aquino, M.C.,. . . Barkana, Y. (2009). Selective laser trabeculoplasty for primary angle closure with persistently elevated intraocular pressure after iridotomy. *Journal of Glaucoma, 18*, 563–566.

Jampel, H. D., Musch, D. C., Gillespie, B. W., Lichter, P. R., Wright, M. M., & Guire, K. E. (2005). Perioperative complications of trabeculectomy in the collaborative initial glaucoma treatment study (CIGTS). *American Journal of Ophthalmology*, *140*, 16–22.

Lai, J. S., Tham, C. C., Chan, J. C., & Lam, D. S. (2004). Phacotrabeculectomy in treatment of primary angle-closure glaucoma and primary open-angle glaucoma. *Japanese Journal of Ophthalmology*, *48*, 408–411.

Narayanaswamy, A., Leung, C. K., Istiantoro, D. V., Perera, S. A., Ho, C. L., Nongpiur, M. E.,. . .Aung, T. (2015). Efficacy of selective laser trabeculoplasty in primary angle-closure glaucoma: a randomized clinical trial. *JAMA Ophthalmology, 133*, 206–212.

Scott, I. U., Greenfield, D. S., Schiffman, J., Nicolela, M. T., Rueda, J. C., Tsai, J. C., & Palmberg, P. F. (1998). Outcomes of primary trabeculectomy with the use of adjunctive mitomycin. *Archives of Ophthalmology*, *116*, 286–291.

5 Neuro-ophthalmology

Department overview

The department provides a service for the evaluation and diagnosis of neurological conditions involving the visual system. The majority of patients are seen as referrals from other subspecialties within the Singapore National Eye Centre (SNEC) or other specialties within the campus. The most common conditions for which patients are referred include visual loss, double vision, droopy eyelids and facial or eyelid spasms. Visual loss may be due to acquired or inherited optic nerve disorders or disorders affecting intracranial visual pathways, such as stroke or tumour, or may be unexplained and require an extensive, in-depth work-up. Double vision is most commonly due to eye movement abnormalities. Referrals received from around the region are often tertiary referrals and of a complex nature.

Some neuro-ophthalmologic patients may receive a diagnosis of complicated or potentially life-threatening systemic conditions that require co-management with other disciplines, such as neurosurgery, neuroradiology and neurology. To address the need for streamlining the provision of medical care to patients with pituitary disorders, the Pituitary Clinic commenced operations in November 2008 as a joint effort between endocrinologists and neurosurgeons from Singapore General Hospital (SGH) and neuro-ophthalmologists from SNEC.

The Neuro-ophthalmology Department also works closely with the Otolaryngology Department at SGH to provide neuro-ophthalmologic evaluation of patients with complaints of dizziness.

The neuro-ophthalmology team comprises 4 consultants (including 1 visiting consultant) led by Adjunct Associate Professor Sharon Tow (Head and Senior Consultant). As well as running 14 neuro-ophthalmology clinic sessions per week, the department has also increased its focus on active research in recent years, leading to interdisciplinary collaborations with various institutions.

Key facts and figures

- The department was set up in 1999.
- Sees approximately 4,500 patients annually.
- Organises an annual neuro-ophthalmology 1-day teaching course for ophthalmology residents, both locally and regionally.
- Co-organised the 19th International Neuro-Ophthalmology Society meeting in 2012.
- To date has trained 5 Fellows, including candidates from the region as well as from Singapore.
- Receives regular observers from around the region.

Selected recent publications and current research projects

Recent publications

1. *Cerebral neural correlates of differential melanopic photic stimulation in humans* (Hung et al., 2016): Non-visual light responses in humans are not well understood. This joint study used functional magnetic resonance imaging (fMRI) to localise cerebral regions differentially activated by metameric light. It found that melanopsin-based photoreception activated a cerebral network, including frontal regions, typically involved in ocular motor responses.

2. *Multiethnic involvement in autosomal-dominant optic atrophy in Singapore* (Loo et al., 2016): Autosomal-dominant optic atrophy (ADOA), often associated with mutations in the OPA1 gene (chromosome 3q28-q29), is rarely reported in Asia. The team at SNEC reported the first cases of genetically confirmed OPA1-related ADOA from Singapore, including a novel mutation causing "ADOA plus" syndrome. Further epidemiological studies are needed to determine the prevalence of ADOA in South-East Asia.

Selected current research projects

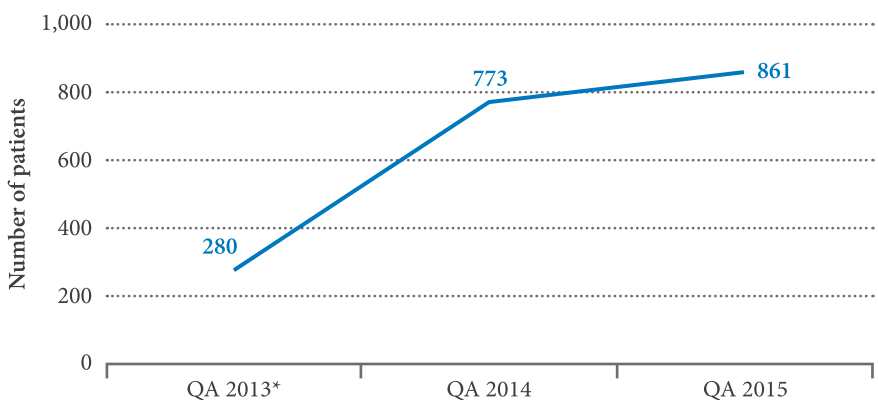
1. Eye-brain eye tracker project with ongoing collaborations with neurology departments at the National University Hospital of Singapore and the National Neuroscience Institutes at Tan Tock Seng Hospital and SGH.

2. Active collaborations with the neuroscience group at Duke-National University of Singapore Medical School, specifically in new pupillometry and fMRI projects.

Statistics

The number of procedures, patient numbers, source of referrals and common diagnoses of patients are shown in Figures 5.1 to 5.3.

Figure 5.1. Number of new patients from 2013 to 2015



QA 2013: January 2013 to August 2013; QA 2014: September 2013 to August 2014; QA 2015: September 2014 to August 2015

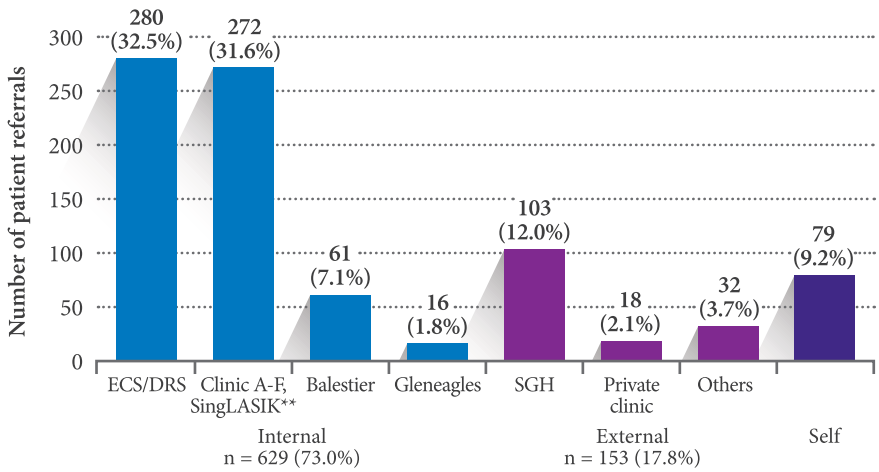
*QA 2013 was not a whole year; hence, it was smaller in number.

QA, quality assurance.

Number of procedures

Botox: the number of botox injections for eyelid and facial spasms ranged between 128 to 176 annually (2013 to 2015).

Figure 5.2. Source of patient referrals (N = 861)*



*More than 60% of referrals are from other ophthalmologists within SNEC.

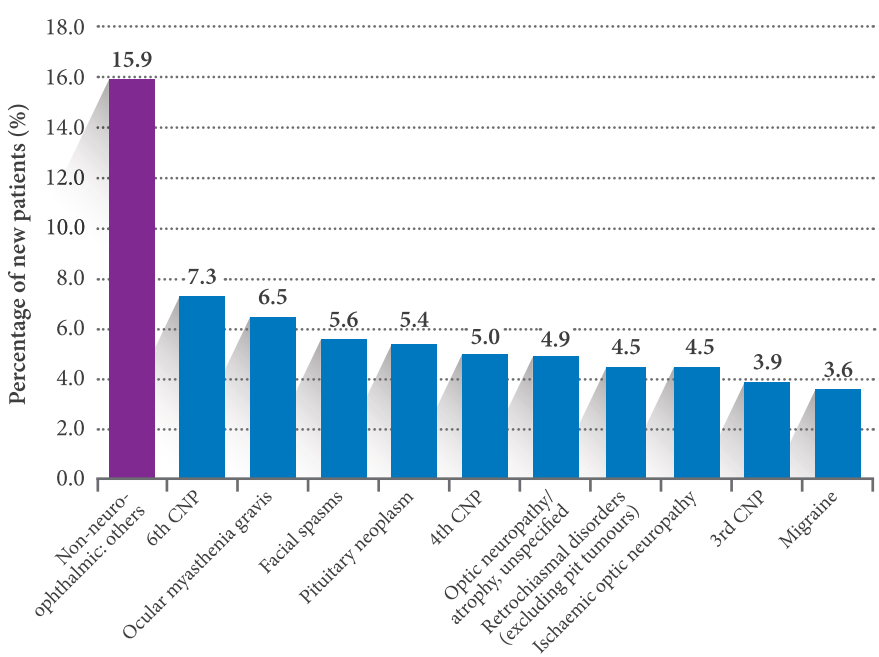
**Clinic A-F serves private patients.

DRS, diabetic retinopathy service; ECS, eye clinic subsidised; SGH, Singapore General Hospital.

The most common conditions for which patients are referred to the Neuro-ophthalmology Department include visual loss, double vision, droopy eyelids and facial or eyelid spasms.

The department works closely with the Otolaryngology Department at Singapore General Hospital to provide neuro-ophthalmologic evaluation of patients with complaints of dizziness.

Figure 5.3. The 10 most common neuro-ophthalmic diagnoses of new patients from 2013 to September 2015



CNP, cranial nerve palsy.

The most common neuro-ophthalmic diagnoses were 6th cranial nerve palsy (7.3%), ocular myasthenia gravis (6.5%) and facial spasms (5.6%).

Latest audit results

In 2015, a total of 861 new cases were audited.

References

Hung, S. M., Milea, D., Rukmini, A. V., Najjar, R. P., Tan, J. H., Vienot, F., . . . Hsieh, P. J. (2016). Cerebral neural correlates of differential melanopic photic stimulation in humans. *Neuroimage*. doi: 10.1016/j.neuroimage.2016.09.06

Loo, J. L., Singhal, S., Rukmini, A. V., Tow, S., Amati-Bonneau, P., Procaccio, V., . . . Milea., D. (2016). Multiethnic involvement in autosomal-dominant optic atrophy in Singapore. *Eye*. doi: 10.1038/eye.2016.255

6 6.6 Oculoplastics

Department overview

Oculoplastics, also known as oculoplastic surgery and ophthalmic plastic and reconstructive surgery, is a subspecialty within ophthalmology. The Oculoplastic Department manages conditions arising from the ocular adnexa (including eyebrows, upper and lower eyelids, midface, ocular surface, lacrimal apparatus and orbital structures) of both congenital and acquired nature.

The department comprises 8 trained specialists led by Dr Sunny Shen (Head and Senior Consultant). As a subspecialty/tertiary department, its services are categorised into general oculoplastic services and specialised subspecialty services.

General oculoplastic services

These services encompass eyebrow ptosis, eyelid ptosis and dermatochalasis (droopy eyelids), eyelid ectropion and entropion, eyelid oncology and periocular reconstruction, facial nerve palsy and facial spasm, nasolacrimal duct obstruction (blocked tear ducts), periorbital trauma and oculoplastic emergencies.

Subsubspecialty services

- The Aesthetic Eyeplastic Service, led by Clinical Director Dr Choo Chai Teck, caters to the aesthetic demands for surgery to the periocular region (endoscopic eyebrow lift, small-incision Asian blepharoplasty, cosmetic blepharoplasty, lower eyelid blepharoplasty [eye bags surgery], midface lift and cosmetic Botox and filler injections).
- The Thyroid Eye Disease Service, led by Clinical Director Adjunct Associate Professor Seah Lay Leng, provides one-stop comprehensive care for patients with thyroid eye disease (combined specialist clinic for orbital decompression, strabismus surgery, rehabilitative surgery and medical management).
- The Orbit Service manages orbital inflammation and tumours, vascular malformations, post-ablative surgery and trauma reconstruction.
- The Paediatric Oculoplastic Service caters to congenital ptosis, epiblepharon, congenital nasolacrimal duct obstruction, periocular congenital tumours and congenital anophthalmia.
- The Ocular Prosthetics Service, led by Dr Teoh Khim Hean, a collaboration with the National Dental Centre Singapore, provides care for patients with anophthalmia (e.g. socket reconstruction).

Key facts and figures

- The Oculoplastic Department was set up in 1990.
- The team attends to more than 11,000 specialist outpatient visits and performs more than 1,200 oculoplastic procedures annually at the Singapore National Eye Centre (SNEC), Singapore General Hospital and SNEC satellite clinics (SNEC Eye Clinic@Changi General Hospital, KK Women's and Children's Hospital [KKH] Eye Clinic and SNEC Balestier branch).
- The department regularly teaches courses on advanced microsurgical skills, essential oculoplastic procedures and cadaveric dissections and performs live surgery demonstrations both locally and internationally.
- Has successfully trained more than a dozen international eye specialists in the region through the Oculoplastic Fellowship Program.
- Actively participates in international collaborative research on oculoplastic diseases with the International Thyroid Eye Disease Society, European Group on Graves' Orbitopathy, Orbit Society and Asia Pacific Society of Ophthalmic Plastic and Reconstructive Surgery.

Recent breakthroughs and future developments

The Oculoplastic Department is actively collaborating with the National University of Singapore Bioengineering Department to develop bioresorbable osteoconductive implant materials for the repair of orbital fractures.

In the future, the department will continue to expand and provide more dedicated subsubspecialty services. The Paediatric Oculoplastic Service will be expanded as part of the KKH Eye Clinic redevelopment programme in 2017. Fully functional general oculoplastic services will be set up at the latest SNEC satellite at Sengkang General Hospital, in 2018. New multispecialty services, including the Cranio-Orbital Service, SingHealth Skin Cancer Service and Integrated Facial Reconstruction Service, are in the pipeline and will provide more comprehensive and holistic patient care for our population.

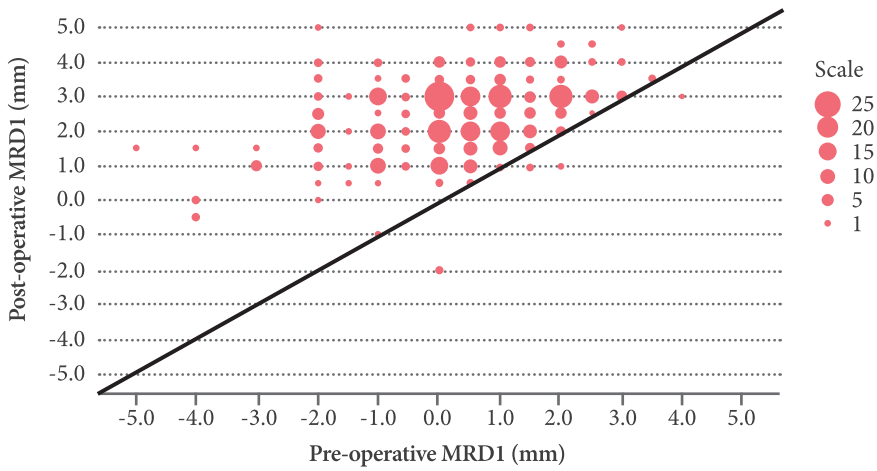
Statistics and benchmarks of success

The department's work is benchmarked against the international “best-in-class.” The types of surgeries performed and the success rates are shown in Figures 6.1 to 6.6.

The Oculoplastic Department attends to more than 11,000 specialist outpatient visits and performs more than 1,200 oculoplastic procedures annually.

Of the patients undergoing ptosis surgery, 97% expressed satisfaction with the surgical results in 2014 (91% achieved good symmetry or no more than 1 mm asymmetry).

Figure 6.1. Comparison of pre- and post-operative MRD1 (N = 432) in 2014*



*Total number is counted by operated eyes, excluding defaults and missing data.

MRD1, margin reflex distance 1.

Ptosis

Of the patients undergoing ptosis surgery, 97% expressed satisfaction with the surgical results in 2014 (91% achieved good symmetry or no more than 1 mm asymmetry).

A study by McCulley et al. (2003) demonstrated that 23% of patients had imperfect eyelid position by subjective patient grading in a comparison of several institutions in the United States (McCulley, Kersten, Kulwin, & Feuer, 2003). The British Oculoplastic Surgery Society National Ptosis Survey demonstrated, in a 1-year prospective study of ptosis surgery results, a 57% success rate and a 39% partial success rate after assessing an interlid margin reflex distance difference < 1 mm, an interlid crease difference < 2 mm and the symmetry of lid contour (Scoppettuolo, Chadha, Bunce, Olver, & Wright, 2008).

Figure 6.2. Symmetry of lid height in ptosis surgeries performed from 2010 to 2014

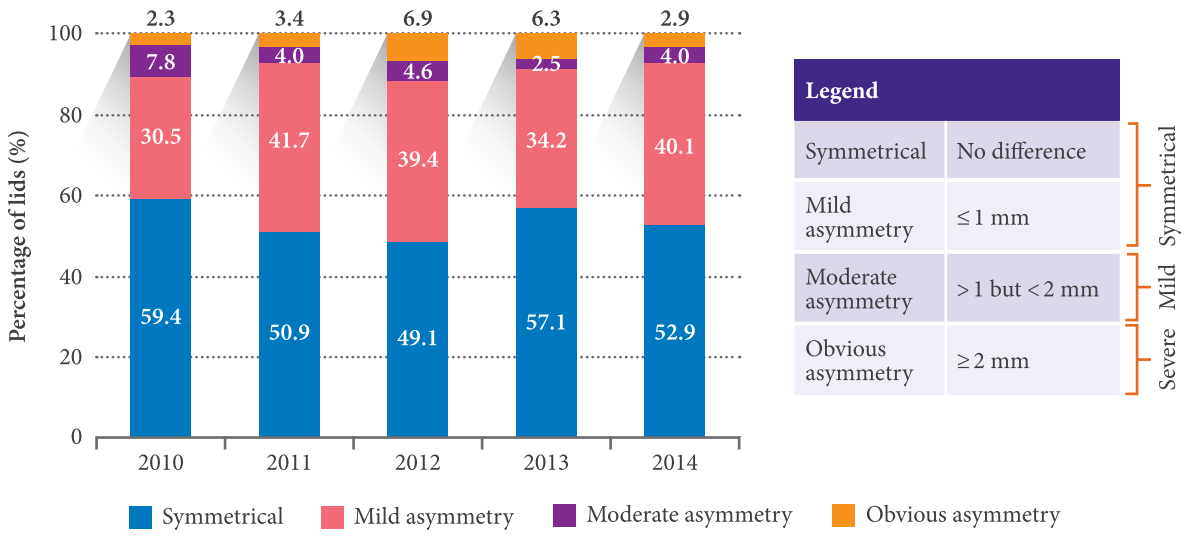
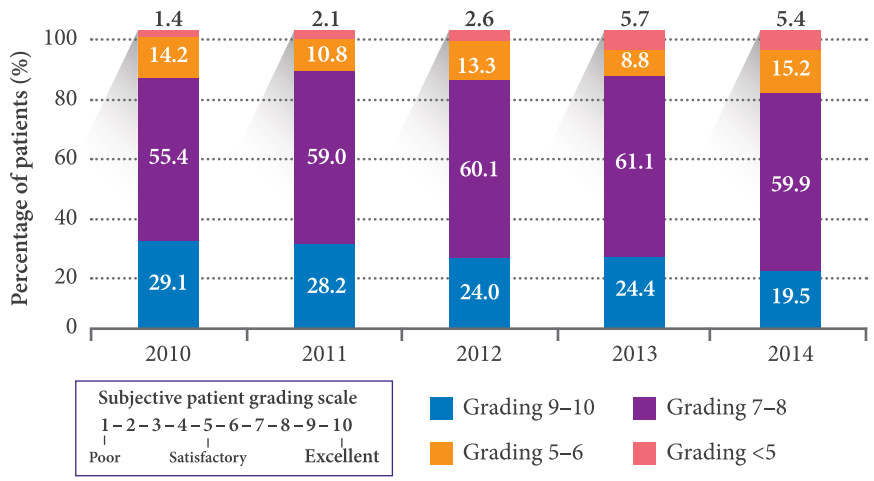
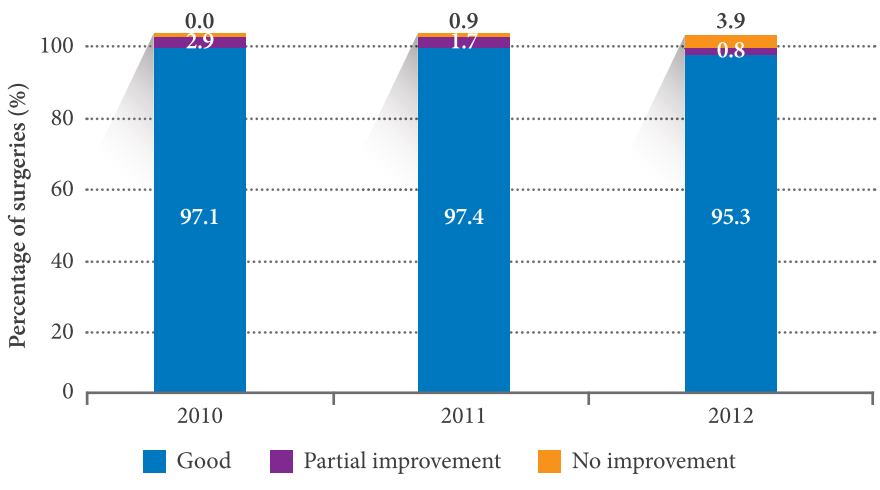


Figure 6.3. Ptosis surgery: patient satisfaction grading from 2010 to 2014



Entropion

Figure 6.4. Post-operative outcome (lid-globe apposition) for surgeries from 2010 to 2012

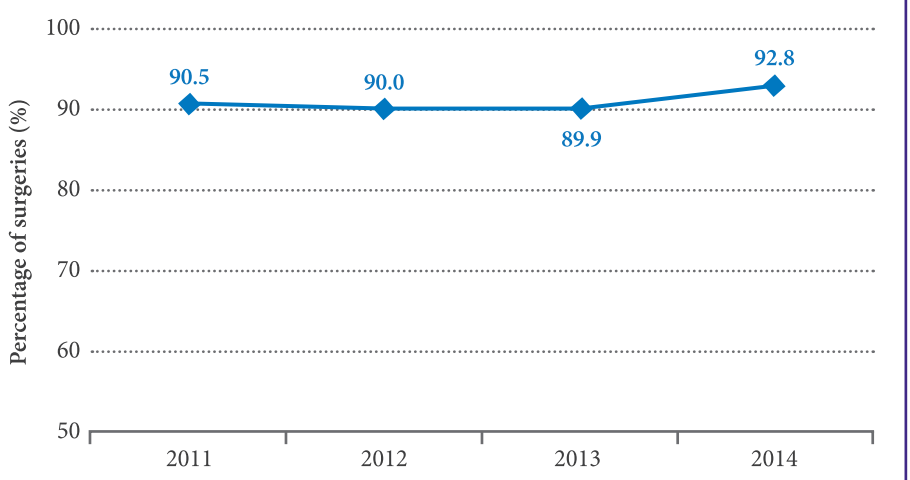


Surgical audits from 2010 demonstrated that 98% of all cases achieved good lid-globe apposition for entropion correction.

98% of all cases achieved good lid-globe apposition for entropion correction.

Dacryocystorhinostomy

Figure 6.5. Overall success based on symptoms from 2011 to 2014



Blepharoplasty

Figure 6.6. Blepharoplasty surgeries: patient satisfaction grading

Grading	Number	%
Grading 9–10	18	21.2
Grading 7–8	36	42.4
Grading 5–6	16	18.8

Subjective patient grading scale
1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10
Poor Satisfactory Excellent

Of the patients undergoing blepharoplasty surgery, 82.4% rated their experience as satisfactory or excellent. The average and median ratings were 7 out of 10.

References

McCulley, T. J., Kersten, R. C., Kulwin, D. R., & Feuer, W. J. (2003). Outcome and influencing factors of external levator palpebrae superioris aponeurosis advancement for blepharoptosis. *Ophthalmic Plastic and Reconstructive Surgery*, *19*, 388–393.

Scoppettuolo, E., Chadha, V., Bunce, C., Olver, J. M., & Wright, M. (2008). British Oculoplastic Surgery Society (BOPSS) National Ptosis Survey. *British Journal of Ophthalmology*, *92*, 1134–1138.

7 Tissue Audit

Department overview

The Tissue Audit Department is a collaboration between the Singapore National Eye Centre (SNEC) and the Department of Anatomical Pathology at Singapore General Hospital (SGH). The department aims to standardise the quality of tissue specimens removed by all surgeons at SNEC to the SingHealth and SGH pathology standards and to ensure that all pathological samples are well documented to enable reference if the surgical results are not as expected. The auditing is performed by the independent, non-biased Ophthalmic Pathology Service, composed of an ophthalmologist and pathologists who have no conflict of interest with the surgeons or patients.

Led by Dr Anita Chan (Senior Consultant), the department comprises a dual-qualified ophthalmology and pathology specialist and general pathologists with special interests in ophthalmology. Together, this team works to diagnose specialised surgical specimens from the eye.

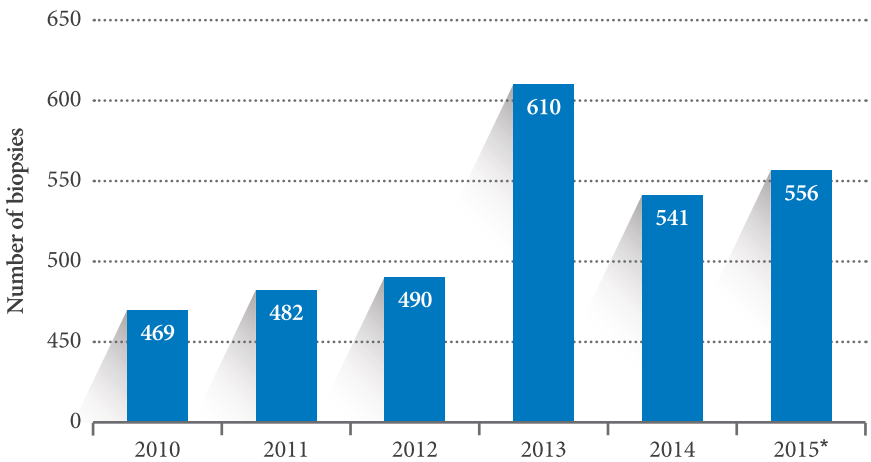
Key facts and figures

- Tissue audit was instituted in 1999.
- It serves to achieve the following:
  - » establish a mechanism to ensure follow-up of patients after diagnosis or for future appointments if patients default or miss appointments
  - » ensure that follow-up and holistic support, beyond surgical support, are provided to cancer patients
  - » ensure high surgical quality by categorising specimen quality and relevance.
- The Ophthalmic Pathology Service was set up in SNEC in 2013. This service handles complicated cases, such as whole-globe and exenteration specimens and small intraocular biopsies such as vitreous cytology and retina and iris biopsies.

Statistics

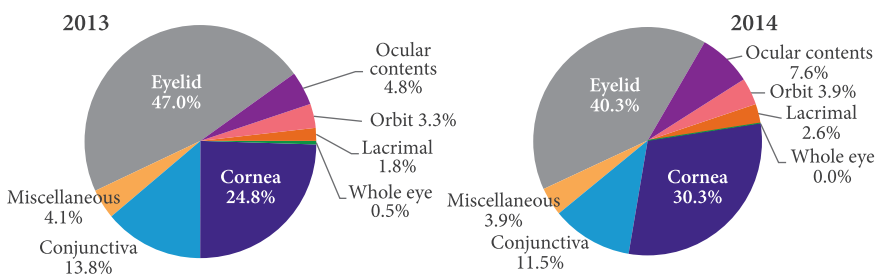
The number of biopsies and cases audited by tissue category or category coding are shown in Figures 7.1 to 7.3.

Figure 7.1. Number of biopsies at SNEC from 2010 to 2015



*The audit for 2015 has not been completed yet.

Figure 7.2. Cases audited by tissue category (external and internal parts of the eye)

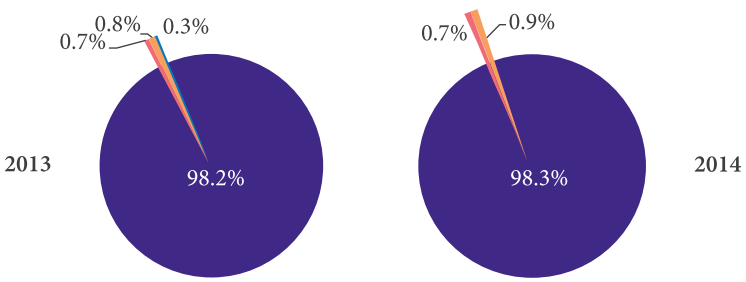


Tissue categories	2013		2014	
	Number	%	Number	%
Eyelid	287	47.0	218	40.3
Ocular contents	29	4.8	41	7.6
Orbit	20	3.3	21	3.9
Lacrimal	11	1.8	14	2.6
Globe/whole eye	3	0.5	0	0.0
Cornea	151	24.8	164	30.3
Conjuctiva	84	13.8	62	11.5
Miscellaneous	25	4.1	21	3.9
Total	610	100	541	100

Eyelid Ocular contents Orbit Lacrimal
Whole eye Cornea Conjunctiva Miscellaneous

The most common tissue categories audited in 2013 and 2014 were the eyelid and cornea, followed by the conjunctiva.

Figure 7.3. Cases audited by category coding



Legend	
1A	Pathological findings were expected for the clinical diagnosis/surgery
1B	Pathological findings were present but not expected for the diagnosis/surgery
2A	No pathological findings but were expected
2B	No pathological findings. Not expected for the procedure
3A	Inadequate/unsuitable material
3B	Insufficient clinical information

Catergory coding	2013		2014	
	Number	%	Number	%
1A	599	98.2	532	98.3
1B	4	0.7	4	0.7
2A	5	0.8	5	0.9
2B	0	0.0	0	0.0
3A	2	0.3	0	0.0
3B	0	0.0	0	0.0
Total	610	100	541	100

For routine biopsies, grades 1A to 2A are acceptable. Grades 2B to 3B indicate potential mismatches in surgical technique and clinical diagnosis, which may lead to potential delays in patient care. The Tissue Audit Department will flag these issues and identify areas that need to be addressed to ensure the highest quality of clinical care for the patients at SNEC. From the 2013 and 2014 audits, ~98% of cases audited fell into the grade 1A category.

Auditing is performed by the independent, non-biased Ophthalmic Pathology Service, composed of an ophthalmologist and pathologists who have no conflict of interest with the surgeons or patients.

From the 2013 and 2014 audits, ~98% of audited biopsies fell into the grade 1A category.

8 Paediatric Ophthalmology and Adult Strabismus

Department overview

The Paediatric Opthalmology and Adult Strabismus Department has a key role in managing many childhood eye disorders including myopia, amblyopia, childhood cataracts, retinopathy of prematurity (ROP), retinoblastoma, childhood and adult strabismus (ocular misalignment). It also manages complex inherited and acquired paediatric eye conditions, supported by other subspecialties at the Singapore National Eye Centre (SNEC), such as glaucoma, oculoplastics, corneal and external eye disease, medical and surgical retina and neuro-ophthalmology. Visual electrophysiological tests are conducted to identify children with poor vision, diagnose genetic eye conditions and monitor children who are on medications potentially toxic to the eye.

The department is led by Adjunct Associate Professor Audrey Chia (Head and Senior Consultant) and has 7 faculty members. Daily clinics are run at SNEC and at the KK Women's and Children's Hospital (KKH). The department provides training for ophthalmologists in Singapore and provides an advanced fellowship programme for local and overseas ophthalmologists regionally and internationally.

Key facts and figures

- Handles close to 32,000 outpatient visits at SNEC and KKH annually.
- Was the first in the region to acquire the Retcam retinal imaging system in 2000, which was upgraded to include fundal fluorescein angiography in 2009.
- Conducts ROP screening in ~250 premature infants across hospitals in Singapore per year.
- Performs electroretinograms and visual evoked potential tests for ~60 children per year.
- Has treated over 1,300 patients with atropine 0.01% eye drops to reduce the progression of childhood myopia since November 2013.

Breakthroughs in technology

Treating myopia with atropine eye drops (Chia et al., 2012; Chia, Lu, & Tan, 2016)

SNEC has spent more than 15 years researching myopia treatment. A 5-year study conducted by SNEC and the Singapore Eye Research Institute, which began in 2006, demonstrated that 0.01% atropine was almost as effective as higher concentrations of atropine eye drops at slowing myopia progression.

The study found that atropine 0.01% eye drops caused minimal dilation of the pupil and had nearly no side effects on vision in children. Since 2014, SNEC has produced and made available Myopine™ eye drops with 0.01% atropine to reduce the progression of childhood myopia.

Statistics

Details on strabismus (eye misalignment) surgery, amblyopia, paediatric (childhood) cataract, ROP, paediatric electrophysiology and the use of atropine for the treatment of myopia in children are shown below.

1. Strabismus (eye misalignment) surgery

a. Aims of surgery: improvement in ocular alignment, cosmesis, elimination of diplopia (double vision) and improvement in head posture.

b. Successful ocular alignment: post-operative esotropia (inward deviation) or exotropia (outward deviation) of 0 to 10 prism dioptres (PD) or vertical deviation of ≤ 5PD. Cosmesis is achieved if patients and doctors are happy with the appearance and no further surgery is required.

c. Most common types of paediatric strabismus that needed surgery: intermittent exotropia (51%), infantile esotropia (15%), accommodative esotropia (10%) and superior oblique palsy (6%).

d. Success rates for paediatric strabismus measured at 6 to 12 months.

   i. Successful ocular alignment was achieved in 70% and cosmesis in 87% of children with intermittent exotropia.

   ii. Successful ocular alignment was achieved in 76% and cosmesis in 91% of children with accommodative esotropia.

   iii. Successful ocular alignment was achieved in 46% and cosmesis in 75% of children with infantile esotropia.

e. Most common types of adult strabismus that needed surgery: childhood or decompensated concomitant strabismus (58%), sensory strabismus due to poor vision in 1 eye (11%), paralytic strabismus (10%), thyroid eye disease (8%) and residual or consecutive strabismus (i.e. persistent strabismus after strabismus operation) (6%).

f. Success rates for adult strabismus.

   i. Successful ocular alignment was achieved in 75% and cosmesis in 83 to 90% of adults with childhood or decompensated strabismus.

   ii. For paralytic strabismus, outcomes depended on the type (3rd, 4th and 6th nerve palsy) and degree of paralysis. Overall successful alignment and cosmesis were achieved in 65% and 90% of patients, respectively. In patients with thyroid eye disease, successful alignment and cosmesis were achieved in 80% and 84% of patients respectively.

   iii. For residual or consecutive strabismus: alignment and cosmesis were achieved in 60% and 80% of patients, respectively.

   iv. Complete success was achieved in 76% and partial success in 17% of patients when the reason for surgery was to relieve diplopia.

SNEC has spent more than 15 years researching myopia treatment, demonstrating that 0.01% atropine was almost as effective as higher concentrations of atropine eye drops in slowing myopia progression.

2. Amblyopia

a. Most common causes: refractive error (79%), strabismus (6%), combination of refractive error and strabismus (14%) and visual deprivation (1%).

b. Breakdown of cases: unilateral amblyopia accounts for 59% and bilateral amblyopia for 41% of cases.

c. The most common refractive error was astigmatism (78%) and the most common strabismus was exotropia (60%).

d. Outcomes definition: good if visual acuity 6/7.5 or better, fair if 2 lines of improvement achieved on Snellen acuity test but visual acuity < 6/7.5 and poor if < 2 lines of improvement achieved on Snellen acuity test.

e. Outcomes at 9 to 12 months: good in 49%, fair in 21% and poor in 9% of patients (21% of children lost to follow-up).

   i. Refractive amblyopia: good/fair in 77% of patients.

   ii. Combined refractive/strabismic and strabismic amblyopia: good/fair in 53% and 35% of patients, respectively.

3. Paediatric (childhood) cataract

a. Distribution of patients and time of assessment of final visual acuity.

   i. Group 1 (n = 72): ≥ 8 years of age at time of surgery; assessed 2 months after surgery.

   ii. Group 2 (n = 36): ≤ 8 years of age at time of surgery; assessed at 8 years of age.

b. Mean age at time of surgery: 6.6 years.

c. Success rates of cataract surgery.

   i. Group 1: 71% and 50% of children in this group achieved Snellen visual acuity of 6/18 and ≥ 6/9 or better, respectively.

   ii. Group 2:

   – 75% and 53% achieved Snellen visual acuity of 6/18 and 6/9 or better, respectively

   – visual outcome at 8 years of age was better in patients with bilateral cataracts than in those with unilateral cataracts (85% versus 56% for visual acuity of 6/18 or better) and better in patients with developmental cataracts than in those with congenital cataracts (90% versus 69% for visual acuity of 6/18 or better).

d. Complications within 1 year: posterior capsule opacification (14.5%), glaucoma (4.6%) and retinal detachment (1.2%).

e. Overall measures of success: Snellen visual acuity of 6/18 or better achieved in ~75% of children.

4. ROP

a. Review of 454 premature infants screened for ROP.

b. ROP was present in 30.8% of infants; 5.3% required laser treatment for ROP.

c. Mean gestational age and birth weights of infants requiring treatment: 25.9 +/- 1.5 weeks and 785 +/- 12.2 g, respectively.

d. Mean post-conception age at time of ROP treatment: 36.2 +/- 2.1 weeks.

e. Progression to the more severe, stage 4 or 5, ROP: 1.3% of infants.

f. Children who required laser treatment were more likely to develop amblyopia (2–5x) and myopia and astigmatism (2x) than children who did not receive treatment.

5. Paediatric electrophysiology

a. Patients: 586 children with a mean age of 8.2 +/- 4.3 years (range, 3 months to 16 years).

b. Main reasons for referrals: poor vision of unknown cause (40%), poor vision with suspected retina/optic nerve pathology (17%), confirmation of retina/optic nerve dysfunction (12%), investigation of nystagmus (14%), investigation of visual symptoms (e.g. photosensitivity, night blindness or visual imagery) (5%) and screening for drug toxicity (e.g. vigabatrin or hydroxychloroquine), familial genetic disease or assessment of visual potential (12%).

c. Findings:

   i. 50% were found to have a retinal disorder (e.g. rod-cone, cone, cone-rod dysfunction/dystrophy or maculopathy), 14% had findings suggestive of an optic nerve or cortical pathology, 30% returned normal responses and 6% of results were inconclusive

   ii. visual electrophysiology was helpful in the diagnosis and management of poor vision in children.

6. Atropine 0.01% eye drops for the treatment of myopia in children

a. Mean age at start of treatment: 8.9 +/- 1.9 years; 88% of Chinese ethnicity.

b. Average degree of myopia: -4.94 +/- 1.91 dioptres (D). The estimated myopic progression in the year preceding treatment was 1.98 +/- 1.16D. The mean increases in myopia at 6 and 12 months were -0.53 +/- 0.73D and -0.59 +/- 0.80D, respectively. These findings were similar to those from the first year of the Atropine for Treatment of Myopia (ATOM2) study (Chia et al., 2012; Chia et al., 2016).

c. 20 to 25% progressed > 1D over 1 year, a value that was slightly higher than that in ATOM2 (18%) (Chia et al., 2012).

d. Adverse effects: experienced by 9.5% of patients (included glare [6.3%] or stinging from drops [1.9%]).

Benchmarks of success

The success rates of strabismus surgery at SNEC in comparison with international studies are shown in Table 8.1. It is difficult to compare success rates between studies due to differences in the definitions of success rates, variation in the types and degrees of strabismus and differences in the post-operative follow-up periods.

Table 8.1. Success rates of surgery at SNEC versus international studies in children and adults with strabismus (eye misalignment)

	SNEC (%)	Other studies (%) (Arnoldi, 2002; Birch & Stager, 2006; Ekdawi, Nusz, Diehl, & Mohney, 2009; Helveston et al., 1983; Keenan & Willshaw, 1992; Kushner, 2001; Mills, Coats, Donahue, & Wheeler, 2004; Pineles, Ela-Dalman, Zvansky, Yu, & Rosenbaum, 2010; Rowe, 2000; Wu, Sun, Xia, L. Xu, & X. Xu, 2006)
Strabismus (eye misalignment) surgery		
Children with intermittent exotropia achieving:		
Ocular alignment	70	46–79
Cosmesis	87	–
Children with accommodative esotropia achieving:		
Ocular alignment	76	37–68
Cosmesis	91	–
Children with infantile esotropia achieving:		
Ocular alignment	46	50–83
Cosmesis	75	60
Adult strabismus		
Ocular alignment*	60–80	68–85
Relief of diplopia		
Complete success	76	45–100
Partial success	17	–

*Success rates variable depending on the type of strabismus.

Table 8.2. Success rates of paediatric cataract surgery at SNEC versus international studies

	SNEC (%)	Other studies (%) (Casaer, Casteels, & Foets, 2005; Cassidy, Rahi, Nischal, Russell-Eggitt, & Taylor, 2001; Congdon, Ruiz, Suzuki, & Herrera, 2007; Foster, Gilbert, & Rahi, 1997; Khandekar, Sudhan, Jain, Shrivastav, & Sachan, 2007; Ledoux, Trivedi, Wilson, & Payne, 2007; Yang et al., 2006; Yorston, Wood, & Foster, 2001)
Paediatric cataract		
BCVA of 6/18 or better	75	19–64

BCVA, best-corrected visual acuity.

Latest audit details

The audit details for strabismus surgery, amblyopia, atropine, paediatric cataract, ROP and paediatric electrophysiology are shown in Table 8.3.

Table 8.3. Audit details for strabismus surgery, amblyopia, atropine, paediatric cataract, ROP and paediatric electrophysiology

	Audit period	Number of patients*
Strabismus surgery	2002 to 2014	1,608
Amblyopia	2008 to 2009	200 randomly selected children
Atropine	2013 to 2014	386
Paediatric cataract surgery	2004 to 2013	108 (134 eyes)
ROP	2002 to 2005	454
Paediatric electrophysiology	2003 to 2014	586

*Number of patients for surgical procedures refer to those patients who had follow-up long enough for audit purpose. Patients lost to follow-up or whose follow-up duration did not fulfill audit criteria were not included.

ROP, retinopathy of prematurity.

References

Arnoldi, K. (2002). Long-term surgical outcome of partially accommodative esotropia. *American Orthoptic Journal, 52*, 75–84.

Birch, E. E., Stager, D. R. Sr. (2006). Long-term motor and sensory outcomes after early surgery for infantile esotropia. *Journal of American Association for Pediatric Ophthalmology and Strabismus, 10*, 409–413.

Casaer, P., Casteels, I., & Foets, B. (2005). Surgical treatment outcomes of congenital and juvenile cataracts. *Bulletin of the Belgian Society of Ophthalmology, 297*, 47–57.

Cassidy, L., Rahi, J., Nischal, K., Russell-Eggitt, I., & Taylor, D. (2001). Outcome of lens aspiration and intraocular lens implantation in children aged 5 years and under. *British Journal of Ophthalmology, 85*, 540–542.

Chia, A., Chua, W. H., Cheung, Y. B., Wong, W. L., Lingham, A., Fong, A., & Tan, D. (2012). Atropine for the treatment of childhood myopia: safety and efficacy of 0.5%, 0.1%, and 0.01% doses (Atropine for the Treatment of Myopia 2). *Ophthalmology, 119*, 347–354.

Chia. A., Lu, Q. S., & Tan, D. (2016). Five-year clinical trial on atropine for the treatment of myopia 2: myopia control with atropine 0.01% eyedrops. *Ophthalmology, 123*, 391–399.

Congdon, N. G., Ruiz, S., Suzuki, M., & Herrera, V. (2007). Determinants of pediatric cataract program outcomes and follow-up in a larger series in Mexico. *Journal of Cataract & Refractive Surgery, 33*, 1775–1780.

Ekdawi, N. S., Nusz, K. J., Diehl, N. N., & Mohney, B. G. (2009). Postoperative outcomes in children with intermittent exotropia from a population-based cohort. *Journal of American Association for Pediatric Ophthalmology and Strabismus, 13*, 4–7.

Foster, A., Gilbert, C., & Rahi, J. (1997). Epidemiology of cataract in childhood: a global perspective. *Journal of Cataract & Refractive Surgery, 23*, 601–604.

Helveston, E. M., Ellis, F. D., Schott, J., Mitchelson, J., Weber, J. C., Taube, S., & Miller, K. (1983). Surgical treatment of congenital esotropia. *American Journal of Ophthalmology, 96*, 218–228.

Khandekar, R., Sudhan, A., Jain, B. K., Shrivastav, K., & Sachan, R. (2007). Pediatric surgery outcomes in Central *India: a hospital based study. Indian Journal of Medical Sciences, 61*, 15–22.

Keenan, J. M., & Willshaw, H. E. (1992). Outcome of strabismus surgery in congenital esotropia. *British Journal of Ophthalmology, 76*, 342–345.

Kushner, B. J. (2001). Fifteen-year outcome of surgery for the near angle in patients with accommodative esotropia and a high accommodative convergence to accommodation ratio. *Archives of Ophthalmology, 119*, 1150–1153.

Ledoux, D. M., Trivedi, R. H., Wilson, M. E. Jr., & Payne, J. F. (2007). Pediatric cataract extraction with intraocular lens implantation: visual acuity outcome when measured at age four years and older. *Journal of American Association for Pediatric Ophthalmology and Strabismus, 11*, 218–224.

Mills, M. D., Coats, D. K., Donahue, S. P., & Wheeler, D. T. (2004). Strabismus surgery for adults: a report by the American Academy of Ophthalmology. *Ophthalmology, 111*, 1255–1262.

Pineles, S. L., Ela-Dalman, N., Zvansky, A. G., Yu, F., & Rosenbaum, A. L. (2010). Long-term results of the surgical management of intermittent exotropia. *Journal of American Association for Pediatric Ophthalmology and Strabismus, 14*, 298–304.

Rowe, F. J. (2000). Long-term postoperative stability in infantile esotropia. *Strabismus, 8*, 3–13.

Wu, H., Sun, J., Xia, X., Xu, L., & Xu, X. (2006). Binocular status after surgery for constant and intermittent exotropia. *American Journal of Ophthalmology, 142*, 822–826.

Yang, M. L., Hou, C.H., Lee, J. S., Liang, Y. S., Kao, L. Y., & Lin, K. K. (2006). Clinical characteristics and surgical outcomes of pediatric cataract in Taiwan. *Graefe's Archive for Clinical and Experimental Ophthalmology, 244*, 1485–1490.

Yorston, D., Wood, M., & Foster, A. (2001). Results of cataract surgery in young children in east Africa. *British Journal of Ophthalmology, 85*, 267–271.

9 Refractive Surgery

Department overview

The department provides a range of laser correction services, including laser in-situ keratomileusis (LASIK), surface ablations, refractive lenticule extraction (ReLEx), small incision lenticule extraction (SMILE), phakic intraocular lens surgery and refractive cataract surgery. LASIK is a procedure that permanently changes the shape of the cornea, the clear covering of the front of the eye, using an excimer laser. The technology has advanced from using a blade to bladeless surgeries. Meanwhile, LASIK Xtra™ is an enhanced LASIK procedure with an add-on corneal strengthening procedure (cross-linking). Laser-assisted subepithelial keratomileusis (LASEK) is an example of an advanced surface ablation procedure. It is a method of laser vision correction that does not require a flap to be cut, and is suitable for individuals with thin corneas and those with active and vigorous lifestyles.

ReLEx® SMILE is a new technique of laser vision correction that does not create a flap and involves the use of a femtosecond laser only. This technique results in less severe immediate post-operative discomfort and tearing and no risk of flap dislodgement. Phakic intraocular lenses, including the implantable collamer lens, are artificial lenses that are implanted into the eye to correct refractive errors. The procedure is performed without removing the eye's natural lens and is usually suited to patients with very high refractive errors or thin corneas.

The Singapore National Eye Centre's (SNEC) Refractive Surgery Department is equipped with 4 laser platforms that are used in a variety of laser vision correction procedures: the WaveLight® EX500 Excimer Laser, Visumax® Femtosecond Laser, AMO IntraLase® iFS Laser System and Ziemer Z8 Femtosecond System.

The department is led by Dr Mohamad Rosman (Head and Senior Consultant) and comprises a team of 14 doctors. It serves as a referral centre for complicated and difficult cases from Singapore and around the region. Additionally, SNEC's team of refractive surgeons teach courses locally (basic LASIK accreditation course) and at regional and international meetings, such as those of the Asia-Pacific Association of Cataract and Refractive Surgeons, the American Society of Cataract and Refractive Surgery and the European Society of Cataract and Refractive Surgeons.

Key facts and figures

- The department sees 1,000 to 2,000 cases per year, and frequently receives referrals for complex cases regionally.
- Photo refractive keratectomy was launched in 1992, LASIK in 1998, phakic intraocular lens surgery in 1999, femtosecond LASIK in 2005, SingLASIK™ in 2006 and ReLEx® SMILE in 2013 (which was introduced at SNEC ahead of other centres globally).

- More than 64,000 laser refractive surgery procedures were performed at SNEC from 1992 to 2014.
- SNEC was the first in the Asia-Pacific region to perform excimer laser refractive surgery procedures in 1992.
- All surgeons undergo accreditation and re-accreditation to ensure currency and expertise with the rapid development of laser refractive surgery technologies.
- All surgeries are audited to ensure continued optimal outcomes for patients.

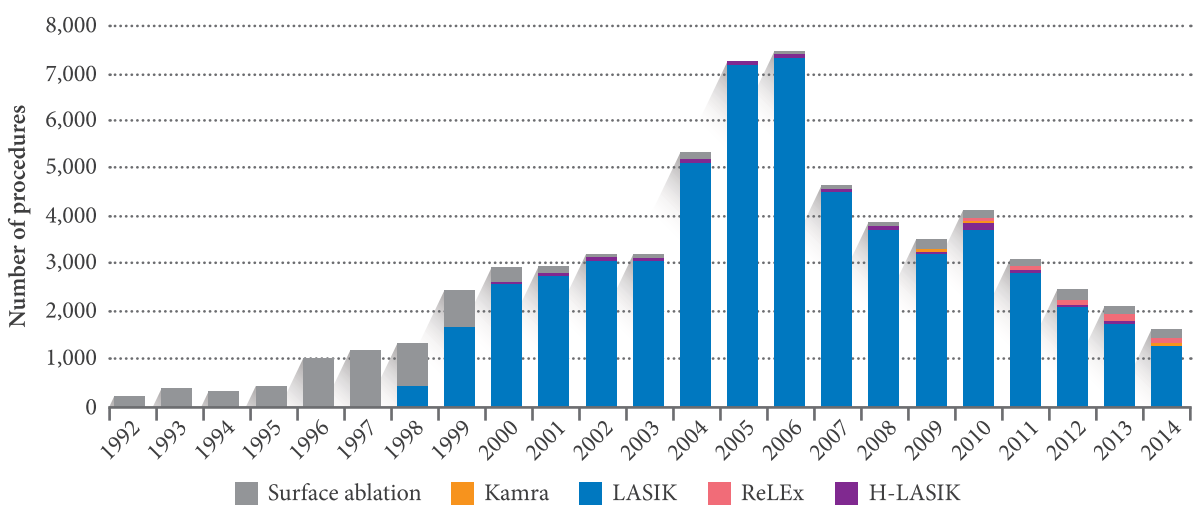
Breakthroughs in technology/publication highlights

1. SNEC has designed and developed 5 novel SMILE lenticule strippers to more easily locate and extract lenticules. These strippers were found to improve the safety and quality of SMILE surgery, particularly in cases of difficult lenticule extraction (Liu, Pujara, & Mehta, 2014).
2. Researchers at the Singapore Eye Research Institute found that SMILE results, relating to lower nerve damage and faster nerve recovery, compared well with LASIK results (Mohamed-Noriega et al., 2014).

Statistics

The numbers, efficacy, predictability and safety of laser refractive surgery procedures are shown in Figures 9.1 to 9.4.

Figure 9.1. Number of laser refractive surgery procedures performed at SNEC from 1992 to 2014

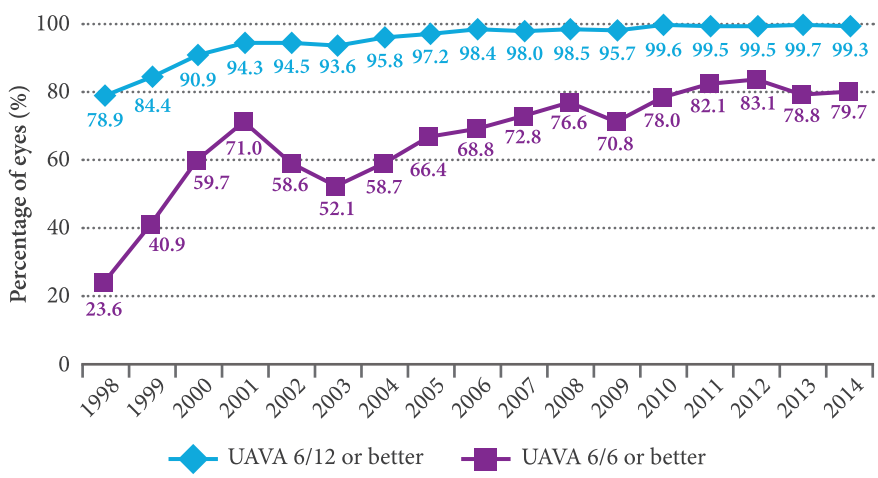


Year 2014: LASIK (1,276 cases); surface ablation: 196 cases; ReLEx: 133 cases; H-LASIK: 18 cases.

H-LASIK, hyperopic LASIK to treat far-sightedness; LASIK, laser in-situ keratomileusis; ReLEx, refractive lenticule extraction.

A total of 64,932 laser refractive surgery procedures were performed at SNEC from 1992 to 2014.

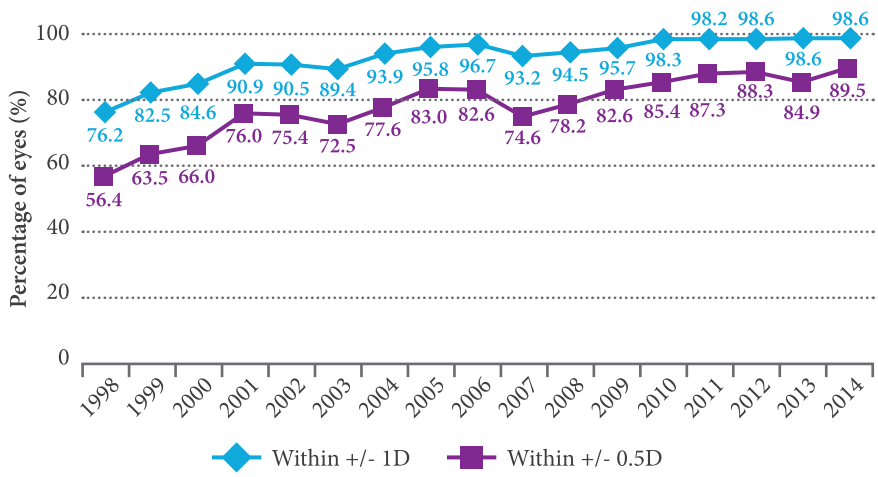
Figure 9.2. Efficacy comparison of laser refractive surgery procedures from 1998 to 2014*



*Efficacy is defined as the percentage of cases achieving a UAVA of 6/12 or better at 3 months post-operation.
UAVA, unaided visual acuity.

Over the past 10 years, nearly 100% of patients achieved an unaided visual acuity of 6/12 or better after laser refractive surgery procedures.

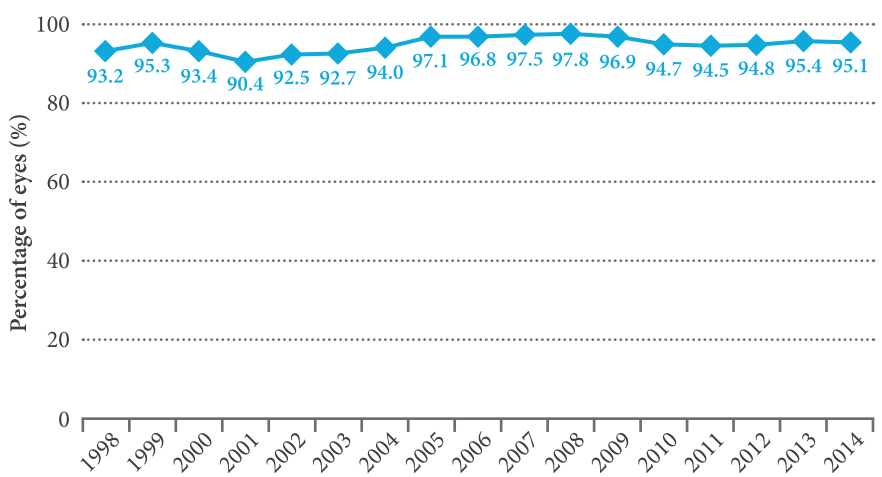
Figure 9.3. Predictability comparison of laser refractive surgery procedures from 1998 to 2014*



*Predictability is defined as the percentage of cases that were within +/- 1D of attempted correction.
D, dioptre.

Since 2010, predictability has been consistently greater than 95% at SNEC.

Figure 9.4. Safety trend of laser refractive surgery procedures from 1998 to 2014*



*The safety read-out is defined as the percentage of cases with improved or unchanged post-operative BCVA compared with pre-operative BCVA.

BCVA, best-corrected visual acuity.

Benchmarks of success

Table 9.1. Laser refractive surgery procedures: comparison of the FDA's 2003 study with SNEC's efficacy and safety rates in 2014

	Post-operative 3-month comparison	FDA (Allegretto laser) (U.S. Food and Drug Administration, 2003) N = 290 ≤ −7D	SNEC (EX500 laser) (2014) N = 357 ≤ −7D
Efficacy (%)	Eyes with UAVA 6/12 or better	96.4	99.7
	Eyes with UAVA 6/6 or better	68.9	83.8
Predictability (%)	Eyes with predictability +/- 1.00D	–	98.8
	Eyes with predictability +/- 0.50D	–	90.9
Safety (%)	Eyes with loss of ≥ 2 lines BCVA	1.8	0
	Cases with improved or unchanged BCVA	–	94.4

BCVA, best-corrected visual acuity; D, dioptre; FDA, Food and Drug Administration; UAVA, unaided visual acuity.

Complication rates versus total number of cases (1992 to 2014)

The complication rates of post-refractive surgery have been consistently low, at < 3%, over the audit period (1998 to 2014). Over the last 5 years of audit, the complication rates further decreased to 0.1 to 0.45%.

Latest audit results

In 2014, LASIK procedures were performed and audited in 1,276 eyes from 645 patients. 99.3% of eyes achieved unaided visual acuity of 6/12 or better and 79.7% of eyes achieved that of 6/6 or better. 98.6% of eyes were within +/- 1.0 dioptre of attempted correction.

References

Liu, Y. C., Pujara, T., & Mehta, J. S. (2014). New instruments for lenticule extraction in small incision lenticule extraction (SMILE). *PLoS One*, e113774.

Mohamed-Noriega, K., Riau, A. K., Lwin, N. C., Chaurasia, S. S., Tan, D. T., & Mehta, J. S. (2014). Early corneal nerve damage and recovery following small incision lenticule extraction (SMILE) and laser in situ keratomileusis (LASIK). *Investigative Ophthalmology & Visual Science*, *55*, 1823–1834.

U.S. Food and Drug Administration. (2003). *Summary of safety and effectiveness data for a supplemental premarket approval application*. Retrieved from http://www.accessdata.fda.gov/cdrh_docs/pdf3/P030008b.pdf

10

Medical and Surgical Retina

The Retina Centre is responsible for treating vitreoretinal conditions, developing allied health services (including ophthalmic imaging and visual electrodiagnostic and low vision services) and running the Singapore Integrated Diabetic Retinopathy Programme. Over the past 25 years, the vitreoretinal team has grown in size and expertise, so much so that a dedicated retina centre was set up in 2015 to consolidate and expand the team's capabilities. The centre now has the largest vitreoretinal team in Singapore, is one of the largest centres internationally and is staffed by 18 specialists from the Medical and Surgical Retina Departments.

MEDICAL RETINA

Department overview

The department manages conditions affecting the retina that are not amenable to surgical treatment. Non-surgical treatment options offered include laser and medications. A wide range of conditions are currently under the care of the Medical Retina Department, the most common of which include diabetic eye disease, age-related macular degeneration (AMD) and polypoidal choroidal vasculopathy (PCV). Other conditions managed by the department include retinal complications associated with myopia, heredofamilial retinal dystrophies, myopic retinal degeneration and retinovascular eye disease.

The department is equipped with state-of-the art outpatient suites in the newly opened Retina Centre, and is supported by a comprehensive range of the latest imaging equipment for diagnostic and monitoring purposes. Treatment capabilities range from full-suite laser facilities (including high-speed multispot Pascal lasers and photodynamic therapy) to a purpose-built injection suite with a HEPA filter. The electrophysiology unit is a highly specialised diagnostic unit which supports the services provided by the department by conducting tests including electroretinography (ERG), multifocal ERG, visual evoked potential and electrooculography. The electrophysiology unit is led by doctors who are members of the International Society for Clinical Electrophysiology of Vision and this ensures that the lab meets internationally established high standards.

The Medical Retina Department is led by Associate Professor Ian Yeo (Head and Senior Consultant) and Associate Professor Gemmy Cheung (Deputy Head and Senior Consultant).

Key facts and figures

- Intravitreal (IVT) anti-vascular endothelial growth factor (VEGF) injections are the most commonly used therapy at the department.
- The number of anti-VEGF injections administered increased from 1,000 in 2009 to almost 6,500 in 2014.
- Many doctors of the department are members of prestigious international societies, including the American Society of Retina Specialists, the Macula Society and the American Academy of Ophthalmology.
- The department is internationally renowned, with faculty members regularly invited to speak at international conferences.
- The department conducts educational courses and holds events such as the Retina Symposium on an annual basis. These courses and events attract delegates from many countries.
- The formal audit process began in 2011 on 230 eyes.

Breakthroughs in technology

Since 2009, the department has established an ongoing prospective cohort study to capture clinical information and treatment outcomes of patients with AMD and PCV. This study has enabled the team to investigate important aspects of the conditions, such as risk factors and treatment outcomes. Key findings from this study have been published in several international scientific journals and contributed to the improved clinical care of patients with AMD and PCV. The data demonstrate significant visual improvement following treatment (Cheung et al., 2012; Cheung et al., 2017; Cheung et al., 2014; Ng et al., 2014; Ting et al., 2016). The data also confirm that smoking can increase the risk of AMD and PCV, providing evidence-based information for patient counselling and risk reduction (Cackett et al., 2011).

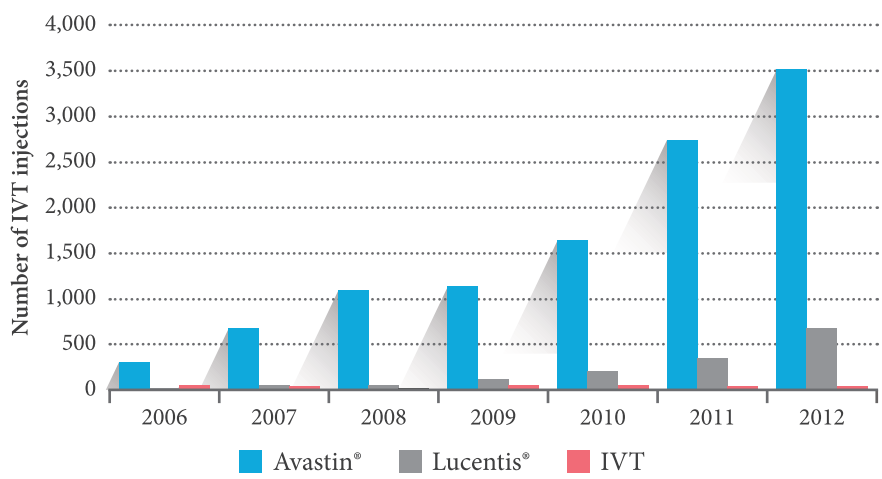
The Medical Retina Department has a long track record of participation in international and multicenter clinical trials which investigate emerging therapies, such as stem cell therapy and novel pharmacological agents. Participation in these clinical trials have provided patients with the opportunity to be treated with novel treatments, prior to them becoming commercially available. The clinical trials have also provided vital data needed for approval of the novel therapies. The Medical Retina Department participates in clinical trials that are conducted with the highest ethical and clinical standards, in accordance with requirements by the Singapore Health Sciences Authority and Good Clinical Practice guidelines.

Almost 6,500 anti-vascular endothelial growth factor injections were administered in 2014; 3 months after treatment, 1 out of 3 patients demonstrated a gain of ≥ 15 letters in their visual acuity (Cheung et al., 2014).

Statistics

The number of IVT injections, diagnoses, visual acuity and safety profiles are shown in Figures 10.1 and 10.2 and in Tables 10.1 and 10.2.

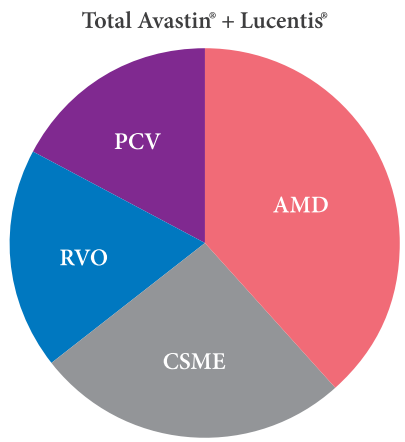
Figure 10.1. Number of IVT injections performed from 2006 to 2012



IVT, intravitreal.

Among the number of IVT injections performed from 2006 to 2012 at SNEC, Avastin® (bevacizumab) injections were the most widely used.

Figure 10.2. Diagnoses treated with anti-VEGF injections from January to March 2011



Total: 1,085 injections

Diagnosis	Number of injections	Percentage of injections (%)
AMD	414	38.5
CSME	285	26.2
RVO	199	18.2
PCV	187	17.1

AMD, age-related macular degeneration; CSME, clinically significant macular oedema; PCV, polypoidal choroidal vasculopathy; RVO, retinal vein occlusion; VEGF, vascular endothelial growth factor.

Of the 1,085 anti-VEGF injections administered, the most common diagnosis treated was AMD.

3 months after treatment, 1 out of 3 patients demonstrated a gain of ≥ 15 letters in their visual acuity (Cheung et al., 2014).

Table 10.1. Visual acuity at 3 and 12 months post-treatment

	All (N = 113)	AMD-CNV (N = 43)	PCV (N = 70)	*P* value*
Baseline, mean (SD)	0.82 (0.57)	0.79 (0.53)	0.83 (0.59)	0.89
3 months, mean (SD)	0.68 (0.65) (n = 75)	0.76 (0.79) (n = 25)	0.64 (0.57) (n = 50)	0.94
12 months, mean (SD)	0.68 (0.6)	0.7 (0.64)	0.67 (0.57)	0.94
Patients with gain ≥ 15 letters at 3 months, N (%)	25 (33.3)	9 (36.0)	16 (32.0)	0.73
Patients with gain ≥ 15 letters at 12 months, N (%)	38 (34.2)	14 (34.1)	24 (34.3)	0.99

**P* value based on the Wilcoxon rank-sum test or the chi-square test.

AMD, age-related macular degeneration; CNV, choroidal neovascularisation; PCV, polypoidal choroidal vasculopathy; SD, standard deviation.

Anti-VEGF injections performed in 1,182 patients demonstrated a good safety profile, with the majority of patients receiving Avastin® (bevacizumab) (n = 1,011) (Ng et al., 2015).

Table 10.2. Incidence of myocardial infarction, stroke and mortality with anti-VEGF injections

	Incidence (SNEC)	Age-adjusted incidence rate	Weighted incidence rates (of Singapore population)
Myocardial infarction	19	350.2 (per 100,000 persons)	427.1 (per 100,000 persons)
Stroke	16	299.3 (per 100,000 persons)	340.4 (per 100,000 persons)
Mortality	43	778.9 (per 100,000 persons)	921.3 (per 100,000 persons)

VEGF, vascular endothelial growth factor.

Endophthalmitis from IVT injections

From January 2005 to September 2013, 16,304 IVT injections were performed. Only 1 case of endophthalmitis (culture-positive) was reported for an overall incidence of 0.006%.

Benchmarks of success

SNEC's patient cohort achieved a significant improvement in visual acuity after 1 year of treatment; however, there was no significant difference in the mean visual acuity change when outcomes were analysed by diagnosis of AMD-choroidal neovascularisation versus PCV.

Table 10.3. Comparison of visual acuity following IVT injections at SNEC versus that in international studies using anti-VEGF injections

Study origin	Sample size	Mean baseline VA ETDRS letters (SD)	Mean VA at 1 year ETDRS letters (SD)	Mean number of injections at 1 year (SD)
USA (2008) (Curtis et al., 2012)	91,628	–	–	–
Germany (2008) (Finger, Wiedemann, Blumhagen, Pohl, & Holz, 2013; Holz et al., 2013)	3,470	48.8 (18.7)	48.0 (11.7)	–
UK (2007) (Pushpoth et al., 2012)	897 (pre-treated, n = 125)	50.4	53.1	6.2 (2.6)
UK (2007) (Pushpoth et al., 2012)	897 (no pre-treatment, n = 772)	54.1	57.9	5.2 (2.7)
Sweden (2007) (Hjelmqvist et al., 2011; Holz et al., 2013)	471	58.3 (12.2)	59.3 (16.2)	–
Belgium (2008) (Holz et al., 2013; Rakic et al., 2013)	253	56.3 (14.2)	58.8 (17.9)	–
Netherlands (2008) (Holz et al., 2013; Rakic et al., 2013)	243	45.1 (21.5)	50.7 (24.0)	–
France (2007) (Cohen et al., 2009)	122	56.2 (14.0)	56.9 (17.0)	–
Beirut (2005) (Bashshur et al., 2008)	60	45.7	53.1	–
Korea (2007) (Kang & Roh, 2011)	41	42.1	46.0	–
Singapore - SNEC (2010) (Cheung et al., 2014)	132 (AMD-CNV, n = 43)	45.5	50.0	4.51 (2.25)
Singapore - SNEC (2010) (Cheung et al., 2014)	132 (PCV, n = 87)	43.5	51.5	3.43 (1.73)

AMD, age-related macular degeneration; CNV, choroidal neovascularisation; ETDRS, Early Treatment Diabetic Retinopathy Study; IVT, intravitreal; PCV, polypoidal choroidal vasculopathy; SD, standard deviation; VA, visual acuity; VEGF, vascular endothelial growth factor.

The pivotal Minimally Classic/Occult Trial of the Anti-VEGF Antibody Ranibizumab in the Treatment of Neovascular Age-Related Macular Degeneration (MARINA) study, carried out in the USA in patients with AMD treated with 0.3 or 0.5 mg Lucentis® (ranibizumab), demonstrated a mean increase in visual acuity of 6.5 letters in the 0.3 mg group and 7.2 letters in the 0.5 mg group (Rosenfeld et al., 2006). Although not a direct comparison, improvement in vision from the SNEC cohort was +8 letters at 3 months and +6.5 letters at 12 months.

The overall incidence rate of endophthalmitis post-IVT injection is very low at 0.018% (3/16,304), which is below the rate reported in a meta-analysis of 0.056% (Fileta, Scott, & Flynn, 2014).

Latest audit results

In the audit period January to March 2011, results from 230 eyes from 185 patients were included, with a follow-up of 2 years and a total of 1,085 injections.

SURGICAL RETINA

Department overview

The department treats common conditions such as retinal tears and detachments, advanced diabetic eye disease (including vitreous haemorrhage, retinal detachment [RD] and advanced fibroproliferative diabetic retinopathy), giant retinal tears (GRT), macular holes, macular puckers, vitreomacular traction, myopic foveoschisis, traumas and proliferative vitreoretinopathies (PVR). Among the array of surgical procedures performed are endoscopic procedures, laser, paediatric surgical retina for retinopathy of prematurity and familial exudative vitreoretinopathy, pneumoretinopexy, scleral buckle and vitrectomies. Surgical tools commonly used in the department include intraoperative lasers, microsurgical wide-field viewing equipment, various intraocular and post-operative tamponade agents, including heavy liquids, silicone oil and gases such as perfluoropropane.

Other surgical vitreoretinal capabilities include no-stitch 23 and 25 gauge (G) vitrectomy macular surgery, peeling of epiretinal membranes (ERM) and macular hole surgery. In addition, the department manages complex posterior segment trauma (including perforating eye surgeries with the use of temporary keratoprosthesis for complex anterior and posterior segment injuries).

The Surgical Retina Department is led by Adjunct Associate Professor Edmund Wong (Head and Senior Consultant) and Adjunct Associate Professor Lee Shu Yen (Deputy Head and Senior Consultant).

Key facts and figures

- More than 1,000 vitreoretinal surgeries are performed annually by the department.
- One of the most commonly treated sight-threatening conditions is rhegmatogenous RD (RRD). Treatment options include scleral buckle, primary vitrectomy or combined buckle-vitrectomy. The department has achieved high success rates of 97.8% for RD surgery, as demonstrated in the 2014 clinical audit.
- Vitrectomy for diabetic eye disease accounts for a fair proportion of the department's cases, including vitreous haemorrhage (39%) and traction RD (43%). From the clinicians' experience, up to 91% of patients with traction RD achieve recovery of anatomy and vision.
- The department also handles a few cases of RD in osteo-odonto keratoprosthesis (also known as "tooth-in-eye" surgery) annually.

1,000 vitreoretinal surgeries are performed annually by the Surgical Retina Department. The success rates for treatment of retinal detachment and peeling of epiretinal membranes are 98.1% (final success) and 67.5% (best-corrected visual acuity of 6/12 or better), respectively.

Breakthroughs in technology

Minimally invasive vitrectomy surgeries (23G and 25G) are routinely performed, with the recent introduction of the 27G. Wide-angle viewing systems, such as the BIOM® lens systems mounted on Zeiss microscopes, Reinverting Operating Lens System with the MiniQuad® lenses and the Topcon Optical Fiber Free Intravitreal Surgery System microscope are used for enhanced surgical visualisation. Together with new chandelier endoillumination, these systems allow advanced bimanual surgeries in challenging cases.

Statistics

The number of surgeries, diagnoses and outcomes for RD and ERM are shown in Figures 10.3 to 10.7 and in Table 10.4.

Figure 10.3. Surgery volume per year (general vitreoretinal procedures) from 2008 to 2015

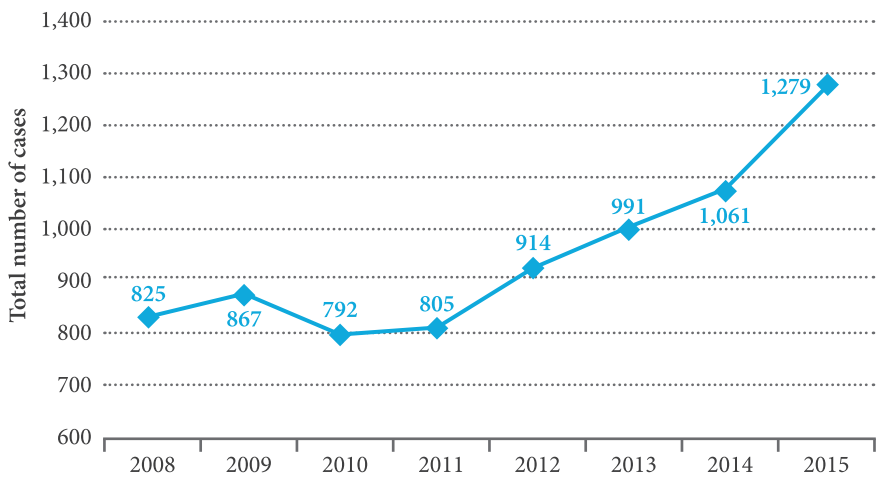
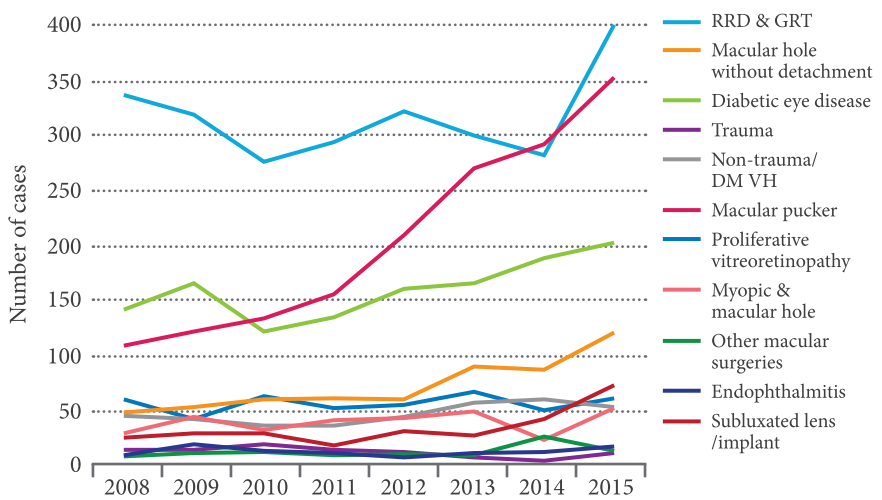


Figure 10.4. Number of diagnoses from 2008 to 2015

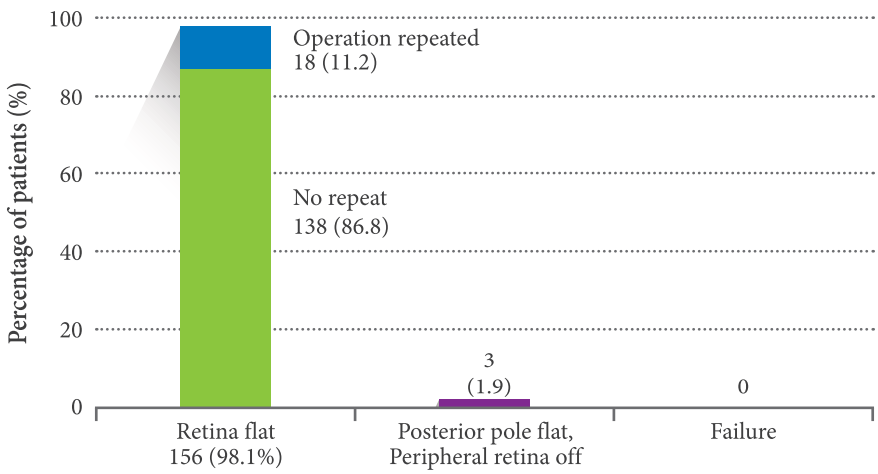


DM, diabetes mellitus; GRT, giant retinal tears; RRD, rhegmatogenous retinal detachment; VH, vitreous haemorrhage.

The most common diagnoses include RRD and GRT, diabetic eye diseases and macular puckers.

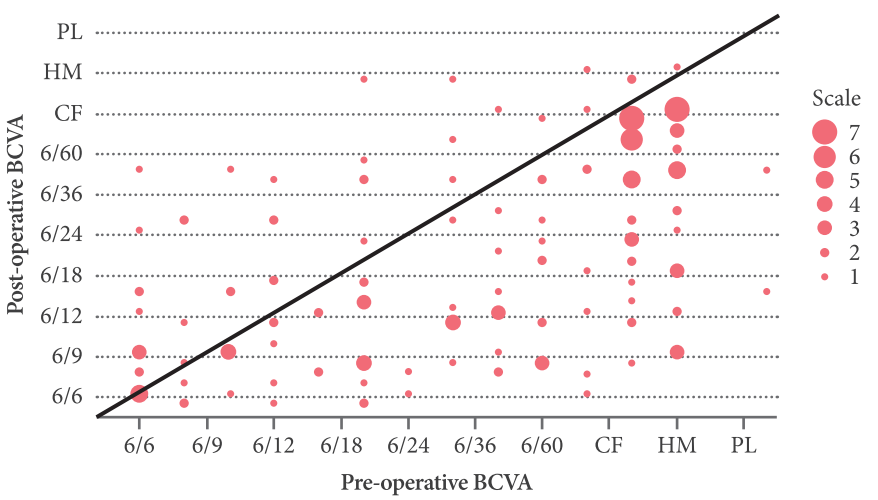
Retinal detachment

Figure 10.5. Post-operative surgical success at the 6-month follow-up in 2013 (N = 159)



Final success (defined as success after 1 or more surgical attempts) was achieved by 98.1% of patients, while primary success (defined as success after 1 surgery attempt) was achieved by 86.8% of patients.

Figure 10.6. Pre-operative BCVA versus 6-month post-operative BCVA in 2013*



41% of patients achieved an overall best-corrected visual acuity (BCVA) of 6/12 or better. Of these patients, 35 of the 65 patients had a detached macula.

*Data points below the diagonal line indicates an improvement in VA.

BCVA, best-corrected visual acuity; CF, counting fingers; HM, hand movements; PL, perception of light; VA, visual acuity.

Table 10.4. Retina surgery: success by macular status in 2013

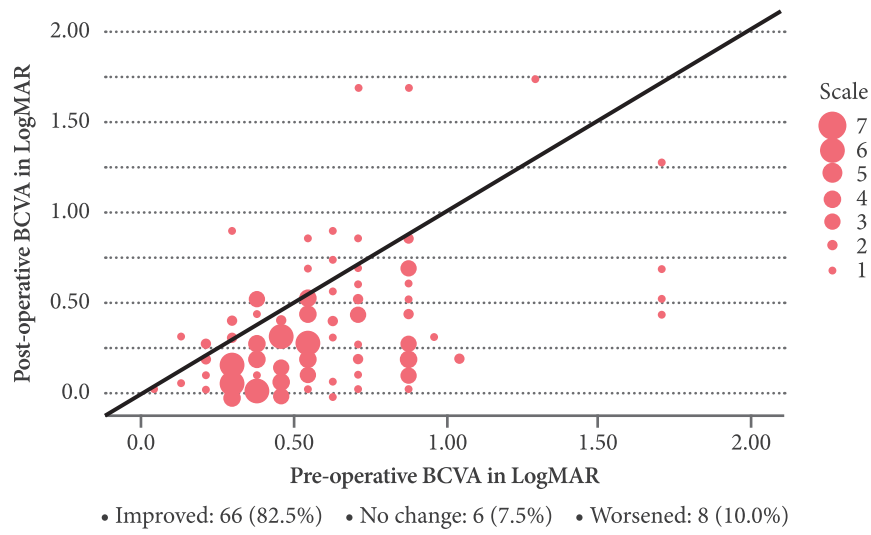
	Retina flat		Retina not flat		
	Count	Mean +/– SD VA LogMAR	Count	Mean +/– SD VA LogMAR	Total count
Macula attached	58	0.45 +/- 0.43	–	–	58
Macula detached	98	0.78 +/- 0.60	3	0.85 +/- 0.75	101
Grand total	156	0.66 +/- 0.57	3	0.85 +/- 0.75	159

LogMAR, Logarithm of the Minimum Angle of Resolution; SD, standard deviation; VA, visual acuity.

Eyes presenting RD with attached macula suggest better visual prognosis and success as 100% achieved flat retina after surgery and better vision as determined by the Logarithm of the Minimum Angle of Resolution scoring system.

Visual outcome at 6 months following surgical peeling of ERM

Figure 10.7. Visual outcome at 6 months (N = 80) in 2012*



*Patients who defaulted follow-up of post-operative BCVA at 6 months are excluded.

BCVA, best-corrected visual acuity; LogMAR, Logarithm of the Minimum Angle of Resolution.

Of the 148 ERM cases in 2012, 54 of the 80 patients (67.5%) achieved a BCVA of 6/12 or better after 6 months.

Benchmarks of success

Success rates of retinal surgeries performed at SNEC are comparable or better than those achieved in multiple international studies.

Table 10.5. Success of RD surgeries performed at SNEC versus those in international studies

	Overall primary success	Overall success
UK Eye Audit, 2002 (Thompson et al., 2002)	77% (95% CI 73.9–80.2)	–
The Retina 1 project: Report 3, 2012 (Spain) (Sanabria et al., 2012)	TPPV 86.4	–
European vitreo-retinal society retinal detachment study report 2, 2013 (Adelman, Parnes, Sipperley, & Ducournau, 2013)	–	SB better than TPPV
Study in Israel (Kinori et al., 2011)	TPPV 81.3% SB/TPPV 87.1%	TPPV 98.9% SB/TPPV 98.8%
Study in Japan (Kobashi et al., 2014)	SB 93.7% TPPV 96.3%	100%
SNEC 2013 SNEC 2014	86.8% 89.9%	98.1% 97.8%

RD, retinal detachment; SB, scleral buckling; TPPV, trans pars plana vitrectomy.

Latest audit results

The latest audit results for RD, ERM and PVR are shown in Table 10.6.

Table 10.6. Audit results for RD, ERM and PVR

	Year(s) of audit	Total number of cases	Cases with primary disease	Cases analysed	Cases with post-operative success (%)	Cases with BCVA of 6/12 or better (%)
RD	2014	279	257	178	89.9	55
ERM	2012	204	148	148	–	66.7
PVR	2009 to 2013	245	71	71	73.2	73.2

BCVA, best-corrected visual acuity; ERM, epiretinal membrane; PVR, proliferative vitreoretinopathies; RD, retinal detachment.

References

Adelman, R. A., Parnes, A. J., Sipperley, J. O., & Ducournau, D. (2013). Strategy for the management of complex retinal detachments: the European vitreo-retinal society retinal detachment study report 2. *Ophthalmology*, *120*, 1809–1813.

Bashshur, Z. F., Haddad, Z. A., Schakal, A., Jaafar, R. F., Saab, M., & Noureddin, B. N. (2008). Intravitreal bevacizumab for treatment of neovascular age-related macular degeneration: a one-year prospective study. *American Journal of Ophthalmology*, *145*, 249–256.

Cackett, P., Yeo, I., Cheung, C. M., Vithana, E. N., Wong, D., Tay, W. T., . . . Wong, T. Y. (2011). Relationship of smoking and cardiovascular risk factors with polypoidal choroidal vasculopathy and age-related macular degeneration in Chinese persons. *Ophthalmology, 118*, 846–852.

Cheung, C. M., Bhargava, M., Laude, A., Koh, A. C., Xiang, L., Wong, D., . . . Wong, T. Y. (2012). Asian age-related macular degeneration phenotyping study: rationale, design and protocol of a prospective cohort study. *Clinical & Experimental Ophthalmology, 40*, 727–735.

Cheung, C. M., Laude, A., Yeo, I., Tan, S. P., Fan, Q., Mathur, R., . . . Wong, T. Y. (2017). Systemic, ocular and genetic risk factors for age-related macular degeneration and polypoidal choroidal vasculopathy in Singaporeans. *Scientific Reports*. doi: 10.1038/srep41386

Cheung, C. M., Li, X., Mathur, R., Lee, S. Y., Chan, C. M., Yeo, I., . . . Wong, T. Y. (2014). A prospective study of treatment patterns and 1-year outcome of Asian age-related macular degeneration and polypoidal choroidal vasculopathy. *PLoS One*, *9*, e101057.

Cohen, S. Y., Dubois, L., Tadayoni, R., Fajnkuchen, F., Nghiem-Buffet, S., Delahaye-Mazza, C., . . . Quentel, G. (2009). Results of one-year's treatment with ranibizumab for exudative age-related macular degeneration in a clinical setting. *American Journal of Ophthalmology*, *148*, 409–413.

Curtis, L. H., Hammill, B. G., Qualls, L. G., DiMartino, L. D., Wang, F., Schulman, K. A., & Cousins, S. W. (2012). Treatment patterns for neovascular age-related macular degeneration: analysis of 284 380 medicare beneficiaries. *American Journal of Ophthalmology*, *153*, 1116–1124.

Fileta, J. B., Scott, I. U., & Flynn, H. W. Jr. (2014). Meta-analysis of infectious endophthalmitis after intravitreal injection of anti-vascular endothelial growth factor agents. *Ophthalmic Surgery, Lasers and Imaging Retina, 45*, 143–149.

Finger, R. P., Wiedemann, P., Blumhagen, F., Pohl, K., & Holz, F. G. (2013). Treatment patterns, visual acuity and quality-of-life outcomes of the WAVE study - a noninterventional study of ranibizumab treatment for neovascular age-related macular degeneration in Germany. *Acta Ophthalmologica*, *91*, 540–546.

Hjelmqvist, L., Lindberg, C., Kanulf, P., Dahlgren, H., Johansson, I., & Siewert, A. (2011). One-year outcomes using ranibizumab for neovascular age-related macular degeneration: results of a prospective and retrospective observational multicentre study. *Journal of Ophthalmology*. doi: 10.1155/2011/405724

Holz, F. G., Bandello, F., Gillies, M., Mitchell, P., Osborne, A., Sheidow, T., . . . Figueroa, M. S. (2013). Safety of ranibizumab in routine clinical practice: 1-year retrospective pooled analysis of four European neovascular AMD registries within the LUMINOUS programme. *British Journal of Ophthalmology*, *97*, 1161–1167.

Kang, S., & Roh, Y. J. (2011). Ranibizumab treatment administered as needed for occult and minimally classic neovascular membranes in age-related macular degeneration. *Japanese Journal of Ophthalmology*, *55*, 123–127.

Kinori, M., Moisseiev, E., Shoshany, N., Fabian, I. D., Skaat, A., Barak, A., . . . Moisseiev, J. (2011). Comparison of pars plana vitrectomy with and without scleral buckle for the repair of primary rhegmatogenous retinal detachment. *American Journal of Ophthalmology*, *152*, 291–297.

Kobashi, H., Takano, M., Yanagita, T., Shiratani, T., Wang, G., Hoshi, K., & Shimizu, K. (2014). Scleral buckling and pars plana vitrectomy for rhegmatogenous retinal detachment: an analysis of 542 eyes. *Current Eye Research*, *39*, 204–211.

Ng, W. Y., Cheung, C. M., Mathur, R., Chan, C. M., Yeo, I. Y., Wong, E., . . . Wong, T. Y. (2014). Trends in age-related macular degeneration management in Singapore. *Optometry & Vision Science, 91*, 872–877.

Ng, W. Y., Tan, G. S., Ong, P. G., Cheng, C. Y., Cheung, C. Y., Wong, D. W., . . . Cheung, G. C. (2015). Incidence of myocardial infarction, stroke, and death in patients with age-related macular degeneration treated with intravitreal anti-vascular endothelial growth factor therapy. *American Journal of Ophthalmology*, *159*, 557–564.

Pushpoth, S., Sykakis, E., Merchant, K., Browning, A. C., Gupta, R., & Talks, S. J. (2012). Measuring the benefit of 4 years of intravitreal ranibizumab treatment for neovascular age-related macular degeneration. *British Journal of Ophthalmology*, *96*, 1469–1473.

Rakic, J. M., Leys, A., Brie, H., Denhaerynck, K., Pacheco, C., Vancayzeele, S., . . . Abraham, I. (2013). Real-world variability in ranibizumab treatment and associated clinical, quality of life, and safety outcomes over 24 months in patients with neovascular age-related macular degeneration: the HELIOS study. *Clinical Ophthalmology*, *7*, 1849–1858.

Rosenfeld, P. J., Brown, D. M., Heier, J. S., Boyer, D. S., Kaiser, P. K., Chung, C. Y., . . . Kim, R. Y. (2006). Ranibizumab for neovascular age-related macular degeneration. *The New England Journal of Medicine*, *355*, 1419–1431.

Sanabria, M. R., Fernández, I., Sala-Puigdollers, A., Rojas, J., Alfaiate, M., Elizalde, J., . . . Pastor, J. C. (2012). A propensity score matching application: indications and results of adding scleral buckle to vitrectomy: The Retina 1 Project: Report 3. *European Journal of Ophthalmology*, *21*, 244–253.

Thompson, J. A., Snead, M. P., Billington, B. M., Barrie, T., Thompson, J. R., & Sparrow, J. M. (2002). National audit of the outcome of primary surgery for rhegmatogenous retinal detachment. II. Clinical outcomes. *Eye*, *16*, 771–777.

Ting, D. S., Ng, W. Y., Ng, S. R., Tan, S.P., Yeo, I. Y., Mathur, R., . . . Cheung, C. M. (2016). Choroidal thickness changes in age-related macular degeneration and polypoidal choroidal vasculopathy: a 12-month prospective study. *American Journal of Ophthalmology, 164*, 128–136.

Wong, C. W., Wong, T. Y., & Cheung, C. M. (2015). Polypoidal choroidal vasculopathy in Asians. *Journal of Clinical Medicine*, *4*, 782–821.

11 Endophthalmitis

Condition overview

Endophthalmitis is a serious, sight-threatening intraocular infection that can occur following cataract surgery or any intraocular surgery. Fortunately, the incidence of this devastating complication is very low. Data are routinely collected by all subspecialty departments at the Singapore National Eye Centre (SNEC) on the occurrence of endophthalmitis following intraocular surgery. The incidence of endophthalmitis following cataract surgery performed at SNEC is described in the sections below.

Direct intracameral cefuroxime injections at the end of cataract surgery have been described to significantly lower endophthalmitis rates, as explained in an American Society of Cataract and Refractive Surgeons Cataract Clinical Committee report (Packer et al., 2011). Additionally, the landmark European Society of Cataract and Refractive Surgeons clinical study of post-operative endophthalmitis demonstrated a 4.92-fold reduction when intracameral cefuroxime was used prophylactically during cataract surgery (Endophthalmitis Study Group, 2007). Another study of more than 480,000 cataract surgeries demonstrated that intracameral cefuroxime injections were 100% effective at preventing endophthalmitis in these patients (Jabbarvand et al., 2016). However, some studies yielded insufficient evidence to support the use of intracameral cefuroxime and the inability of these injections to completely eradicate the occurrence of endophthalmitis after cataract surgery (Mesnard et al., 2016; Sharma, Sahu, Dhillon, Das, & Rath, 2015).

Despite growing evidence of the benefits of intracameral injections, SNEC has yet to adopt this practice due to concerns related to toxicity and bacterial contamination. Furthermore, the commercial formulation of cefuroxime for intracameral use is not yet available in Singapore; therefore, it is prepared in the fashion of a "kitchen pharmacy" and the dilutions are often not prepared accurately (Cakir et al., 2009; Delyfer et al., 2011; Olavi, 2012; S. Ciftci, L. Ciftci, & Dag, 2014; Stenevi & Lundstrom, 2015). Nonetheless, SNEC prides itself on maintaining a very low rate (0.017%) of infectious endophthalmitis as a result of the use of perioperative topical antibiotics, topical povidone-iodine and other means of antimicrobial prophylaxis. *Please refer to Technology in the pipeline and Benchmarks of success below*.

The monitoring of infectious endophthalmitis at SNEC is led by Dr Chan Tat Keong (Senior Consultant and the Chairman of Infection Control).

Key facts and figures

- At SNEC, the rate of endophthalmitis has been very low over the past 25 years. From 1991 to 2015, a total of 93 (0.042%) cases were reported and culture-positive cases occurred in only 58 eyes (0.026%). A total of 223,867 cataract surgeries were performed.
- Over the last 5 years, SNEC has reported an average clinical post-operative endophthalmitis rate of 0.015%, 0.007% of which was attributable to culture-positive infections. This is comparable or even lower than most of the endophthalmitis rates reported in published literature. *Please refer to Table 11.4.*
- In 2008, SNEC had an endophthalmitis rate of 0%.
- The low rate of endophthalmitis at SNEC can be attributed to a number of factors.
  - » Mandatory cataract surgery training for all ophthalmologists, including residents in training: all residents in the centre are required to undergo a formal and rigorous 2.5-year cataract surgery training programme before they are allowed to operate on patients unsupervised. During this training programme, the trainees are taught the finer points of wound construction and wound architecture. These are critical points in preventing post-operative wound leakage.
  - » Aseptic techniques are practised before and during cataract surgeries, including operative-site antisepsis with topical povidone-iodine and draping of lashes.
  - » Perioperative topical antibiotics are administered for all cataract surgical procedures.
  - » All surgical procedures are video-recorded to monitor for any intraoperative and/or post-operative complications.
  - » Success outcomes from surgical procedures are audited by the Clinical Audit Department.
- Good post-operative care: all patients are routinely reminded via a telephone call to use their topical antibiotics according to the recommended dosing schedule.
- Mandatory infection control education: all medical and nursing staff are educated annually about infection control.

Technology in the pipeline

Use of commercially produced cefuroxime (Aprokam) will likely be adopted at SNEC in the near future, following its availability in Singapore. This move will likely reduce endophthalmitis rates even further.

Statistics

The incidence of endophthalmitis, its clinical classification and the types of causative microorganisms and best-corrected visual acuity before and after treatment (BCVA) are shown in Figures 11.1 and 11.2 and Tables 11.1 to 11.3.

At SNEC, the rate of endophthalmitis has been very low over the past 25 years.
In 2008, SNEC had an endophthalmitis rate of 0%.

Figure 11.1. Post-cataract surgery endophthalmitis incidence rates from 1991 to 2015

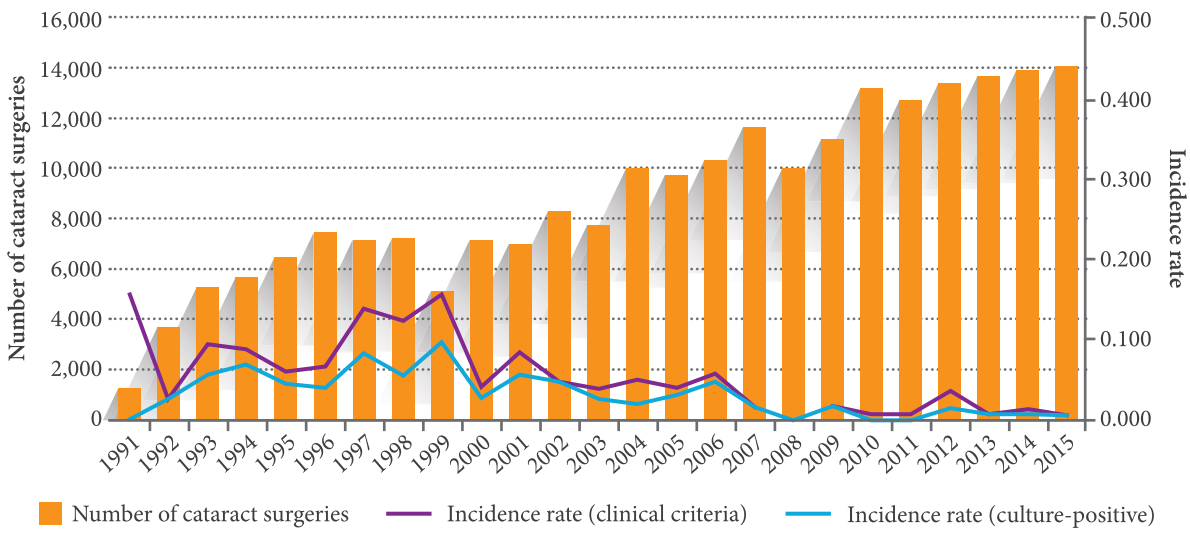


Table 11.1. Cataract surgeries and number of cases of endophthalmitis from 2011 to 2015

Year	Cataract surgeries	Clinical criteria, N (%)	Culture-positive, N (%)
2011	12,738	1 (0.008)	0
2012	13,412	5 (0.039)	2 (0.016)
2013	13,682	1 (0.177)	1 (0.177)
2014	13,920	2 (0.193)	1 (0.186)
2015	14,082	1 (0.007)	1 (0.007)
Total	**67,834**	**10 (0.015)**	**5 (0.007)**

The incidence rates of endophthalmitis after cataract surgeries were extremely low.

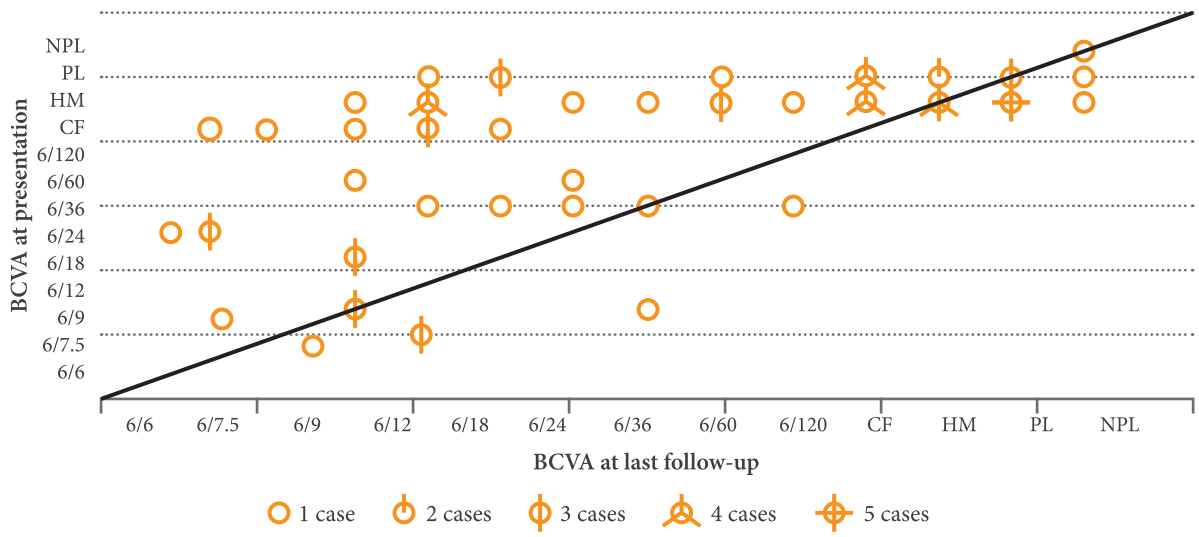
Table 11.2. Clinical classification of endophthalmitis cases

Acute onset (≤ 30 days)	74 cases (80%)
Median time of onset after intraocular surgery	6 days
Chronic or insidious (> 30 days)	19 cases (20%)
Median time of onset after intraocular surgery	70 days

Table 11.3. The top 5 microorganisms causing endophthalmitis

Microbiology culture	N (%)
Coagulase-negative staphylococci	24 (41.4)
Alpha haemolytic streptococcus	7 (12.1)
Pseudomonas aeruginosa	4 (6.9)
Staphlococcus aureus	3 (5.2)
Streptococcus pneumoniae	3 (5.2)

Figure 11.2. BCVA at presentation versus BCVA at last follow-up



BCVA, best-corrected visual acuity; CF, counting fingers; HM, hand movements; NPL, no perception of light; PL, perception of light.

With prompt and aggressive clinical management, nearly all patients had improved BCVA 3 to 6 months after their initial presentation.

Benchmarks of success

Table 11.4. Documented rates and incidence of endophthalmitis at SNEC and in international studies

Country	With intracameral antibiotic	Without intracameral antibiotic	Number of patients	Intracameral antibiotic used
Sweden (Lundstrom, 2006)	0.048%	0.35%	225,000	Cefuroxime
9 countries (Endophthalmitis Study Group, 2007)	0.05%	0.35%	16,000	Cefuroxime
France (Barreau, Mounier, Marin, Adenis, & Robert, 2012)	0.044% (2,289 cases)	1.238% (2,826 cases)	5115	Cefuroxime
South Africa (van der Merwe, Mustak, & Cook, 2012)	0.08% (3,971 cases)	0.55% (4,219 cases)	8190	Cefuroxime
USA (Shorstein, Winthrop, & Herrinton, 2013)	0.014%	0.31%	16,264	Cefuroxime
Spain (Garcia-Saenz, Arias-Puente, Rodriguez-Caravaca, & Banuelos, 2010)	0.043% (7,057 cases)	0.59% (6,595 cases)	13,652	Cefuroxime
Spain (Rodriguez-Caravaca, Garcia-Saenz, Villar-Del-Campo, Andres-Alba, & Arias-Puente, 2013)	0.039% (12,868 cases)	0.59% (6,595 cases)	19,463	Cefuroxime
Sweden (Friling, Lundstrom, Stenevi, & Montan, 2013)	0.027% (455,054 cases)	0.39%	464,996	Cefuroxime
India (Haripriya, Chang, Namburar, Smita, & Ravindran, 2016)	0.02% (38,160 cases)	0.07–0.08% (37,777 and 40,777 cases)	116,714	Moxifloxacin
Singapore, Tan Tock Seng Hospital (Tan, Wong, & Yang, 2012)	0.01% (20,638 cases)	0.064% (29,539 cases)	50,177	Cefazolin
Spain (Romero-Aroca et al., 2012)	0.05% (13,305 cases)	0.63% (11,696 cases)	25,001	Cefazolin
Spain (Garat, Moser, Martin-Baranera, Alonso-Tarres, & Alvarez-Rubio, 2009)	0.047% (12,649 cases)	0.422% (5,930 cases)	18,579	Cefazolin
Singapore (SNEC, data collected from 2011 to 2015)	–	0.015%	67,834	None

Even without the use of intracameral antibiotics, SNEC has maintained an extremely low rate of endophthalmitis (0.015%).

References

Barreau, G., Mounier, M., Marin, B., Adenis, J. P., & Robert, P. Y. (2012). Intracameral cefuroxime injection at the end of cataract surgery to reduce the incidence of endophthalmitis: French study. *Journal of Cataract & Refractive Surgery*, *38*, 1370–1375.

Cakir, M., Imamoğlu, S., Cekiç, O., Bozkurt, E., Alagöz, N., Oksüz, L., & Yilmaz, O. F. (2009). An outbreak of early-onset endophthalmitis caused by Fusarium species following cataract surgery. *Current Eye Research*, *34*, 988–995.

Ciftci, S., Ciftci, L., & Dag, U. (2014). Hemorrhagic retinal infarction due to inadvertent overdose of cefuroxime in cases of complicated cataract surgery: retrospective case series. *American Journal of Ophthalmology*, *157*, 421–425.

Delyfer, M. N., Rougier, M. B., Leoni, S., Zhang, Q., Dalbon, F., Colin, J., & Korobelnik, J. F. (2011). Ocular toxicity after intracameral injection of very high doses of cefuroxime during cataract surgery. *Journal of Cataract & Refractive Surgery*, *37*, 271–278.

Endophthalmitis Study Group & European Society of Cataract & Refractive Surgeons. (2007). Prophylaxis of postoperative endophthalmitis following cataract surgery: results of the ESCRS multicenter study and identification of risk factors. *Journal of Cataract & Refractive Surgery*, *33*, 978–988.

Friling, E., Lundstrom, M., Stenevi, U., & Montan, P. (2013). Six-year incidence of endophthalmitis after cataract surgery: Swedish national study. *Journal of Cataract & Refractive Surgery*, *39*, 15–21.

Garat, M., Moser, C. L., Martin-Baranera, M., Alonso-Tarres, C., & Alvarez-Rubio, L. (2009). Prophylactic intracameral cefazolin after cataract surgery: endophthalmitis risk reduction and safety results in a 6-year study. *Journal of Cataract & Refractive Surgery*, *35*, 637–642.

Garcia-Saenz, M. C., Arias-Puente, A., Rodriguez-Caravaca, G., & Banuelos, J. B. (2010). Effectiveness of intracameral cefuroxime in preventing endophthalmitis after cataract surgery Ten-year comparative study. *Journal of Cataract & Refractive Surgery*, *36*, 203–207.

Haripriya, A., Chang, D. F., Namburar, S., Smita, A., & Ravindran, R. D. (2016). Efficacy of Intracameral Moxifloxacin Endophthalmitis Prophylaxis at Aravind Eye Hospital. *Ophthalmology*, *123*, 302–308.

Jabbarvand, M., Hashemian, H., Khodaparast, M., Jouhari, M., Tabatabaei, A., & Rezaei, S. (2016). Endophthalmitis Occurring after Cataract Surgery: Outcomes of More Than 480 000 Cataract Surgeries, Epidemiologic Features, and Risk Factors. *Ophthalmology*, *123*, 295–301.

Lundstrom, M. (2006). Endophthalmitis and incision construction. *Current Opinion in Ophthalmology*, *17*, 68–71.

Mesnard, C., Beral, L., Hage, R., Merle, H., Fares, S., & David, T. (2016). Endophthalmitis after cataract surgery despite intracameral antibiotic prophylaxis with licensed cefuroxime. *Journal of Cataract & Refractive Surgery*, *42*, 1318–1323.

Olavi, P. (2012). Ocular toxicity in cataract surgery because of inaccurate preparation and erroneous use of 50mg/ml intracameral cefuroxime. *Acta Ophthalmologica*, *90*, e153–e154.

Packer, M., Chang, D. F., Dewey, S. H., Little, B. C., Mamalis, N., Oetting, T. A., . . . Yoo, S.H. (2011). Prevention, diagnosis, and management of acute postoperative bacterial endophthalmitis. *Journal of Cataract & Refractive Surgery*, *37*, 1699–1714.

Rodriguez-Caravaca, G., Garcia-Saenz, M. C., Villar-Del-Campo, M. C., Andres-Alba, Y., & Arias-Puente, A. (2013). Incidence of endophthalmitis and impact of prophylaxis with cefuroxime on cataract surgery. *Journal of Cataract & Refractive Surgery*, *39*, 1399–1403.

Romero-Aroca, P., Méndez-Marin, I., Salvat-Serra, M., Fernández-Ballart, J., Almena-Garcia, M., & Reyes-Torres, J. (2012). Results at seven years after the use of intracamerular cefazolin as an endophthalmitis prophylaxis in cataract surgery. *BMC Ophthalmology*, *12*, 2.

Sharma, S., Sahu, S. K., Dhillon, V., Das, S., & Rath, S. (2015). Reevaluating intracameral cefuroxime as a prophylaxis against endophthalmitis after cataract surgery in India. *Journal of Cataract & Refractive Surgery*, *41*, 393–399.

Shorstein, N. H., Winthrop, K. L., & Herrinton, L. J. (2013). Decreased postoperative endophthalmitis rate after institution of intracameral antibiotics in a Northern California eye department. *Journal of Cataract & Refractive Surgery*, *39*, 8–14.

Stenevi, U. & Lundstrom, M. (2015). Can endophthalmitis be prevented? *Acta Ophthalmologica*, *93*, 301–302.

Tan, C. S., Wong, H. K., & Yang, F. P. (2012). Epidemiology of postoperative endophthalmitis in an Asian population: 11-year incidence and effect of intracameral antibiotic agents. *Journal of Cataract & Refractive Surgery*, *38*, 425–430.

van der Merwe, J., Mustak, H., & Cook, C. (2012). Endophthalmitis prophylaxis with intracameral cefuroxime in South Africa. *Journal of Cataract & Refractive Surgery*, *38*, 2054.

SNEC As the Centre of Eye Care Excellence

Established in 1990, the Singapore National Eye Centre (SNEC) saw its first patient in October 1990, after the old surgical blocks at Singapore General Hospital made way for the new eye centre. Today, SNEC's facilities include an 8-storey tower block and a 4-storey podium block comprising 3 floors of outpatient clinics. It is equipped with state-of-the-art, modern facilities ranging from a full array of consultation clinics, well-integrated diagnostic, imaging and laser systems, modern operating theatres, day recovery suites, sophisticated training and education facilities, dedicated floors to house the Singapore Eye Research Institute's research clinics, laboratories and administrative offices and comprehensive ancillary and support facilities. SNEC has more than 60 consultation suites and 9 operating theatres. These facilities enhance SNEC's capabilities to deliver high-quality and cost-effective care to its patients.


SNEC


SNEC
Singapore National Eye Centre

Ensuring high standards and auditing surgical outcomes have strengthened SNEC's continued excellence. All major surgeries are recorded, and an independent Clinical Audit Department has been set up to review surgical outcomes and to benchmark SNEC against international standards. SNEC's goal is to be the "best-in-class" in the areas of clinical science, research and education. For outstanding research in myopia, corneal transplantation and angle-closure glaucoma, SNEC's doctors have made it into the list of the world's most influential people in ophthalmology according to the *British Journal of Ophthalmology*.
In terms of ophthalmic education, SNEC trains 1 in every 2 ophthalmologists in Singapore. SNEC is the first institution in Singapore and South-East Asia to be accredited by the International Joint Commission

of Allied Health Personnel in Ophthalmology (IJCAHPO). The IJCAHPO provides international accreditation by setting standards for ophthalmic training programmes to enhance the quality and availability of ophthalmic patient care.

SNEC has made continuous efforts to promote awareness of eye health to the general public. Since 2000, SNEC has organised the *National Eye Care Day* – an annual community event to increase awareness of the importance of eye health to the general public. Other community service initiatives include eye screening activities and facilitating the set up of several patient support groups for various eye conditions.

Moving forward, SNEC will strive to continue to be "best-in-class" by providing the best possible clinical care, supported by innovative research, and developing future generations of eye care professionals through comprehensive training and education.

Satellite Branches and Affiliates

Apart from the Singapore National Eye Centre's (SNEC) main centre, which is located at the Singapore General Hospital (SGH) campus, 4 other branches have been established to serve the ophthalmic needs of patients across the island. These branches are located at Changi General Hospital (CGH), Balestier, KK Women's and Children's Hospital (KKH) and Alexandra Hospital.

SNEC Eye Clinic @CGH

About us

The SNEC Eye Clinic@CGH is a partnership between CGH and SNEC, formed to serve the eye care needs of the population in East Singapore. Although the eye division at CGH has been staffed for many years by doctors from SNEC, a new partnership formed in November 2016 has elevated this relationship and allowed for current processes to be improved, facilitating the development of more services.

There are 2 dedicated eye clinics, 1 for subsidised patients and 1 for private patients. The SNEC Eye Clinic@CGH is led by Adjunct Associate Professor Rahat Husain and Dr Sunny Shen with the assistance of 14 consultants and senior consultants.

Services

The clinic offers a 24-hour, 3-tier on-call service staffed by junior and senior ophthalmologists, supplemented by cornea, oculoplastic and vitreoretinal specialists. In collaboration with SingHealth polyclinics, same-day referrals are made possible if clinically indicated.

Clinics are consultant-led, with subspecialities that include general ophthalmology, glaucoma, retina (medical and surgical), cornea, oculoplastic, uveitis and neuro-ophthalmology. The partnership between CGH and SNEC has allowed for development of multidisciplinary teams, such as the facial trauma team, which comprises specialists from ophthalmology, plastics, maxillofacial and otorhinolaryngology.

The CGH clinic is capable of carrying out the majority of investigations. It is currently equipped with optical coherence tomography (OCT), Humphrey visual field analysers, biometry machines and 3 laser machines. The treatment room allows for minor operative procedures to be carried out, and a dedicated day surgery unit functions on weekdays.

In 2015, a total of 3,217 cataract surgeries were performed, the number of which increased each year preceding this. Cases are audited to ensure that standards are maintained, and regular morbidity rounds and peer-reviewed learning sessions are conducted to help improve outcomes. In 2015, the audit reported a visual success rate (best-corrected visual acuity of 6/12 or better) of 97.7%, identical to that at SNEC and better than rates reported in the UK and Sweden. The post-operative endophthalmitis rate for the last 10 years has been 0%. The posterior

capsular rupture rate for 2015 was 0.99%, which was substantially better than rates reported in the UK. The clinic's doctors also perform other surgical procedures, such as glaucoma, vitreoretinal, oculoplastic and corneal surgeries.

In 2018, the SNEC Eye Clinic@CGH is due to move into the new CGH medical centre. The clinic will be larger, will have more consultation rooms and will offer a greater number and range of ophthalmic services. As the population in East Singapore grows, the clinic will continue to expand and enhance its range of services to match residents' needs such that they can expect and receive the highest quality of eye care at a centre close to them.

SNEC Balestier branch

About us

The Balestier eye clinic is a satellite medical centre of SNEC and an integral part of the centre, providing patients with comprehensive eye care. The outpatient clinic started providing services at ParkwayHealth Day Surgery and Medical Centre in 2007, and the operating theatre and day ward were commissioned in October 2011. It is led by Dr Boey Pui Yi with the assistance of a team of 14 eye specialists.

Services

The Balestier branch sees mostly general patients referred from polyclinics and has an important role in providing eye care and treatment for the community. The team of ophthalmologists provide comprehensive eye care as well as subspecialty care in more complex cases, especially in the areas of glaucoma, diabetic retinopathy and oculoplastic services. Outpatient services include comprehensive ophthalmic consultations, investigations and diagnostic procedures such as biometry, B-scan, refraction, Humphrey visual field perimetry, OCT scans and fundus photography. The surgical load consists primarily of cataract surgery but also includes some oculoplastic cases. The branch also houses the Primary Eyecare Clinic, which monitors and manages patients with stable glaucoma, diabetic retinopathy and mild cataracts who do not require regular follow-up by specialists.

This hub-and-spoke relationship with SNEC's main centre has worked efficiently to help reduce the overall clinic load and waiting time at the main centre. This in turn has allowed the main centre to focus on tertiary care for complicated and complex eye diseases.

This branch has grown exponentially in the last few years, with outpatient visits increasing from 12,000 in 2011 to its current load of 30,000 per year. The surgical load has also grown significantly, from 300 surgical cases in 2011 to 2,500 per year currently. The rapid expansion has contributed significantly to the overall growth of SNEC and is, in no small part, due to the efficiency of its dedicated staff, including nurses, clinic assistants, ophthalmic technicians and other allied health professionals.

KKH Eye Clinic

About us

The KKH Eye Clinic was established in 1999 with only 2 consultation rooms; it moved to its current premises in 2007 and now has 6 consultation rooms. Currently, the clinic records approximately 24,000 patient visits per year. This service actively co-manages children from the neonatal, genetic and other subspecialty teams and also provides back-up and follow-up services to the Children's Emergency Department at the hospital.

The clinic is led by Adjunct Associate Professor Audrey Chia who works in conjunction with a team of visiting paediatric ophthalmologists from SNEC, Tan Tock Seng Hospital, and Khoo Teck Puat Hospital and the private sector. It is also supported by its own team of resident physicians and registrars, nurses and optometrists.

Services

Besides managing common paediatric eye disorders (e.g. amblyopia, strabismus and myopia), the KKH Eye Clinic also treats and manages congenital, developmental and genetic eye conditions; retinopathy of prematurity; retinoblastoma; childhood ocular trauma; and childhood oculoplastic and neuro-ophthalmic diseases. It also works in conjunction with SNEC to manage complex childhood anterior segment, glaucoma and retinal conditions.

Clinical audits of the clinic's paediatric cases are combined with those at SNEC and presented annually at SNEC's Quality Assurance Seminars.

SNEC Alexandra branch

About us

The goal of the Alexandra branch is to expand SNEC's mission of providing high-quality, cost-effective and comprehensive eye care to patients within their community. Led by Dr Khor Wei Boon, the team at Alexandra includes 8 SNEC consultants and senior doctors as well as a dedicated group of nurses and allied health and administrative personnel.

Services

Services include the outpatient evaluation and treatment of common eye conditions, such as cataracts, glaucoma and diabetic eye disease, which are supported by a comprehensive suite of investigative equipment and ophthalmic laser machines available at the branch. Patients requiring cataract surgery undergo the procedure in a dedicated operating theatre within Alexandra Hospital. The high surgical standards of SNEC are maintained through the deployment of operating staff, implants and equipment directly from SNEC's main centre. As a partner of Sengkang Health, SNEC doctors also provide urgent consultations and ophthalmic care for patients warded at Alexandra Hospital.

By 2018, the current team at Alexandra Hospital will move to the new Sengkang General Hospital. The SNEC Alexandra branch will regroup in the new hospital as the SNEC Sengkang branch and will have brand new surroundings, clinics and operating theatres. We look forward to expanding access of the SNEC experience in eye care to patients in North-East Singapore.

Singapore Eye Research Institute

Research has been instrumental in establishing the excellent standards of care at the Singapore National Eye Centre (SNEC). The Singapore Eye Research Institute (SERI) was established in 1997 by SNEC's founding Medical Director, the late Professor Arthur Lim. Professor Lim keenly pursued the concept of an institute for eye research even before the value of research was recognised for improving clinical care in Singapore.

SERI's mission is "To be Asia's global centre of excellence in eye and vision research, renowned internationally for translating basic science into clinical applications for the prevention and treatment of sight-threatening disorders."

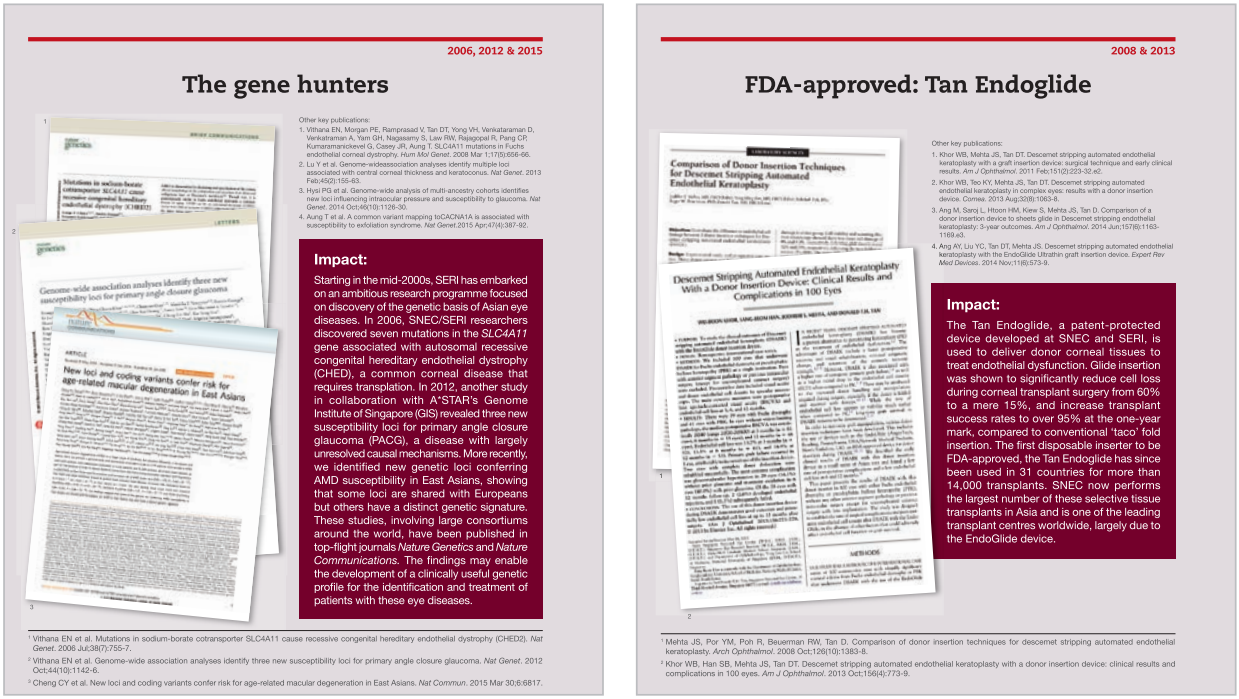
At SERI, there have been 4 Executive Directors over the last 2 decades: the late Professor Chew Sek Jin, Professor Donald Tan, Professor Wong Tien Yin and, currently, Professor Aung Tin. Driven by strong leadership, SERI has attracted top collaborators, advisors and industry partners who work together on strategic research initiatives.

Today SERI is proud to be seen as a premier eye research institute, not only in Asia but internationally as well. The team at SERI has been at the forefront of pivotal ocular research and is responsible for several clinical innovations and public health interventions, thereby positioning both itself and Singapore on the world's ophthalmology roadmap.

Singapore has taken a leading role in ophthalmic research, with a recent independent study ranking it 2nd globally and 1st in the Asia-Pacific region in terms of the number of peer-reviewed scientific articles (published from 2010 to 2014) based on eye disease per capita as well as the 5-year impact factor per article (Boudry, Denion, Mortemousque, & Mouriaux, 2016). SERI has been a key partner in achieving this accolade.

Impressive statistics over the past 2 decades serve as a testament to the success of SERI:

- 2,652 scientific papers published
- SGD221 million in grant funding from 211 grants
- 217 researchers, clinicians, clinician scientists and administrators
- approximately 100 clinical scientists, MD-PhDs, PhD scientists and principal investigators
- 383 national and international awards
- 1,389 studies on all aspects of eye research
- more than 105 patents and 2 spin-off companies.



Source: Singapore Eye Research Institute. 2015. 25 Research Papers with Clinical Impact: In Pursuit of Research Excellence 1990–2015. Singapore: Singapore Eye Research Institute.

The SERI governance structure was based on a premise of sustainability and the optimisation of a robust network of shared resources. This involves core research technology platforms that advance transdisciplinary research productivity through interaction with multiple research groups. SERI comprises 17 research groups supported by 7 core platform technologies. Of these, 5 are major disease research groups:

1. glaucoma, particularly Asian glaucoma phenotypes (e.g. angle-closure glaucoma)
2. myopia and other refractive errors
3. corneal and ocular surface disease
4. diabetic retinopathy and other retinal vascular diseases
5. age-related macular degeneration and other degenerative ocular conditions.

These research groups strategically tackle all the major eye diseases, with particular relevance to Singapore and Asia.

Over the last 19 years SERI has conducted numerous ground-breaking research projects, with tangible positive outcomes in terms of impact and clinical applicability.

Reference

Boudry, C., Denion, E., Mortemousque, B., & Mouriaux, F. (2016). Trends and topics in eye disease research in PubMed from 2010 to 2014. *Peer J.* doi: 10.7717/peerj.1557

SingHealth DukeNUS
ACADEMIC MEDICAL CENTRE
OPHTHALMOLOGY & VISUAL SCIENCES

Singapore National Eye Centre
SingHealth

SINGAPORE EYE RESEARCH INSTITUTE

Published February 2017