A World-Class Stereotactic Center of Excellence

Leksell Gamma Knife® Icon™ and Elekta linear accelerators help Princess Alexandra Hospital gain an international reputation as a center of excellence for stereotactic radiosurgery and radiation therapy

Contributors

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About
Princess Alexandra Hospital

Location
Brisbane, Queensland, Australia

Staff
9.3 radiation oncologists
.4 neurosurgeon (Leksell Gamma Knife® Icon™)
65 radiation therapists
10 medical physicists
16.3 nurses
16 administrative personnel

Patients
2,100 radiation oncology patients per year

Technology
1 Leksell Gamma Knife Icon
5 Elekta linear accelerators with XVI Symmetry™ and intrafraction imaging:
   • 4 with Agility™
   • 2 with Flattening Filter Free (FFF)
   • 1 with HexaPOD™ evo RT System
   • 1 with ExacTrac
3 Elekta Active Breathing Coordinator™ (ABC) trolleys for DIBH and EEBH
   MOSAIQ® v2.64
2 dedicated wide bore CT scanners:
   • Philips Brilliance CT Big Bore
   • Toshiba Aquilion CT Large Bore (LB)
Pneumatic compression belts
Elekta BodyFIX® bags for SBRT
CIVCO and Macromedics vac bags
CIVCO thermoplastic shell system
Treatment Planning Software:
   • Leksell GammaPlan® v11.1.1
   • Pinnacle v16.2

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Growing need for dedicated intracranial SRS treatment

Princess Alexandra Hospital (PAH)—a tertiary healthcare facility in Queensland, Australia—is one of Australia’s leading academic and research centers for health. The hospital’s radiation oncology center is one of the busiest in the country, delivering highly specialized treatments for common and rare cancers with varying degrees of complexity. With state-of-the-art equipment and an established intracranial and extracranial stereotactic program, PAH has gained an international reputation as a center of excellence in the delivery of stereotactic body radiation therapy (SBRT), brain stereotactic radiation therapy (SRT) and stereotactic radiosurgery (SRS).

PAH began performing linac-based SRS in 2012, using an Elekta linear accelerator fitted with ExacTrac x-ray monitoring. “We experienced an increasing demand for intracranial SRS that was only going to continue upwards,” comments Dr. Matthew Foote, Radiation Oncologist and Co-Director of the Gamma Knife® Centre of Queensland. “There were also practical limitations that needed to be considered. In a busy radiation oncology center, it was very hard to justify treatment of benign intracranial conditions on a machine where there was a wait time for treatment of malignant diseases.”

The center had the advantage of a strong engagement with neurosurgeons who wanted to explore the use of SRS in the vascular/functional/benign space—something that Dr. Foote considers one of the key factors in the success of the center’s intracranial SRS program.

Figure 1 illustrates the fast uptake of SRT and SRS at PAH, which presented the need—and the right opportunity—to acquire a system specifically for intracranial SRS.

Figure 1.
Fast uptake of precision stereotactic radiation therapy at Princess Alexandra Hospital
Introducing the Gamma Knife program at PAH

The Gamma Knife Centre of Queensland at PAH opened in October 2015, with the installation of Leksell Gamma Knife® Perfexion™. This was the first and only Gamma Knife service available in Queensland, and the first to be available in Australia’s public health system.

Demand far exceeded what was anticipated, allowing the center to break even by the second year instead of after four years, as forecast. Three years after Gamma Knife Perfexion was installed, PAH upgraded to Leksell Gamma Knife Icon in May 2018. Since then, PAH has seen a significant increase in the number of intracranial cases treated year over year (Figure 2).

In January 2019, the center reached the milestone of treating 1,000 patients on Gamma Knife—half of these treatments were for non-malignant conditions (Figure 3).

“Overall, Gamma Knife has had a major impact on the number of intracranial stereotactic patients we have been able to treat,” says Dr. Foote. “In a relatively short time, we have also seen the impact of upgrading to Leksell Gamma Knife Icon. In 2019, we expect to treat over 500 patients using Gamma Knife, which is beyond what we anticipated.”

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**Figure 2.** Intracranial stereotactic treatments at PAH since 2012

**Figure 3.** Breakdown of 1000 Gamma Knife Centre of Queensland treatments at Princess Alexandra Hospital
Michael Jenkins, Assistant Director of Radiation Therapy Services, says that having a dedicated intracranial radiosurgery device in their arsenal helped quickly ease a lot of machine pressure, and they were able to dedicate the linacs for mostly extracranial treatment and some specific intracranial cases. Another key advantage was that many patients with certain intracranial conditions were moved to Gamma Knife treatment, which improved access to surgical procedures and significantly reduced waiting times for patients who needed that treatment. This helped save considerable costs for neurosurgical procedures and associated care.

“The low integral body dose is very important, particularly since we have a large benign workload for intracranial patients.”

Dr. Matthew Foote
Associate Professor, Radiation Oncologist

Same accuracy, more flexibility

With stereotactic cone beam CT, Online Adaptive DoseControl™ and real-time high-definition motion management (HDMM), Leksell Gamma Knife Icon gives clinicians at PAH the option to perform single-session or fractionated, frame-based or frameless intracranial SRS treatments. This allows more individualized treatment of patients without sacrificing precision and accuracy. (Previously, with Perfexion, all treatments were frame-based, single sessions.)

In addition, after the upgrade to Leksell Gamma Knife Icon, many of the hypofractionated cases were shifted from linacs. This came at a crucial time, as the increasing number of metastatic cases had presented a different set of challenges for the team at PAH. Previously, treating patients with multiple metastases or large tumors in a single session required a longer treatment time. Now, with the option of frameless deliveries on Leksell Gamma Knife Icon, those cases can be treated over a few days, if necessary, which significantly improves patient comfort.

The team at PAH was impressed with the efficiency of the workflow and by the dosimetric advantages of Gamma Knife radiosurgery. Using up to 192 low-intensity radiation beams, dose is concentrated at the target with extreme accuracy and rapid dose dropoff that results in 2–4x lower dose to normal brain and lower integral dose than other SRS modalities.¹

“The low integral body dose is very important, particularly since we have a large benign workload for intracranial patients,” notes Dr. Foote.

Efficiency of same-day service

The Gamma Knife Centre of Queensland is a statewide public health service, so providing the best possible access to a large population within the area was critical. Before the introduction of Gamma Knife, intracranial SRS/SRT patients had to travel multiple times to the center: once for their MRI scan, and then subsequent visits for their linac-based treatment. This could be very challenging for those living in remote areas, as it required them to be away from home for extended periods, disrupting their daily activities and livelihoods, as well as creating additional travel and accommodation costs.

Leksell Gamma Knife Icon has changed that experience by enhancing hospital efficiency and patient comfort. “It is a very slick process for intracranial SRS patients. We scan them, create a plan and treat them on a single day, even for multiple targets,” explains Dr. Foote. “The
Gamma Knife Centre offers these patients a minimally invasive treatment in a single visit.

“A same-day service is also an advantage for patients with particularly aggressive tumors,” he continues. “In a recent study, we found that intracranial progression between diagnosis and the day of SRS occurred in 60% of patients. The ability to perform an MRI scan on the same day as treatment helps us be confident that we have been able to treat the complete extent of the patient’s intracranial disease.”

Managing the center’s throughput

The ability to use various workflows with Leksell Gamma Knife Icon has helped the center meet the sharp increase in direct referrals from oncologists, neurosurgeons and neurologists, for an array of conditions including vascular, benign and metastatic disease.

“If we have a very busy week where perhaps 10 brain metastases cases have been referred, we now have the option to choose either a mask or the frame, or a combination of both,” explains Jenkins. “It is also helpful to offer patients a choice. Some who have had a previous craniotomy or are not comfortable with the frame may prefer a mask-based approach, while others actually prefer frame-based fixation. The most Gamma Knife treatments we’ve performed on a single day was seven, which included three frame patients and four mask patients treated very efficiently in one day, between 7:00am and 4:30pm.”

Figure 4. Extracranial SABR cases treated at PAH in 2018 (total = 238)

Optimized use of linacs for SBRT/ Stereotactic Ablative Radiotherapy (SABR)

“We have also seen an explosion in the number of extracranial SABR treatments that we perform,” says Jenkins. “Our department has gained a reputation in the stereotactic space. Around 40% of our case load is stereotactic treatment, including intracranial and extracranial cases. Our SABR program has expanded through additional indications and increased throughput.

Lung is the biggest part of our extracranial SABR program, with over 100 patients treated in 2018. Our liver SABR program is one of the busiest in Australia, and we also have SABR programs for spine, kidney, prostate and pancreas (Figure 4). Plus, we still have a pretty active linac-based intracranial program. It would have been difficult to maintain this workload if we didn’t have a dedicated intracranial machine. The Gamma Knife service has enabled us to free up our linac capacity.”

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Dr. Matthew Foote
Associate Professor, Radiation Oncologist
A site for precision radiation medicine

“Since the implementation of our Gamma Knife service, we have developed a reputation as a stereotactic center of excellence in our region,” notes Jenkins. “Because of this, we receive a lot of referrals for difficult or complicated cases, and we often lead the way in taking on new indications.

“Looking to the future, we will expand our prostate and pancreas SABR programs, and we hope to widen our intracranial service in the treatment of functional indications, with the ongoing engagement of our neurologists and neurosurgeons,” he concludes.

“We provide a telehealth service as well, and it gives us immense satisfaction that we are able to fulfill our hospital’s purpose of partnering for high-quality, connected, patient-centered and sustainable care.”

A combined balanced approach with linacs and Gamma Knife

Having Leksell Gamma Knife Icon and precision linear accelerators in the department means that certain cases can still be treated on a linac, if needed. One linac of the five PAH operates only treats stereotactic cases and is fitted with ExacTrac, Agility MLC, FFF and HexaPOD evo RT Couchtop.

“We still treat postoperative metastatic cavities on the linac,” says Dr. Foote. “Additionally, where tumors have wrapped around critical structures and need a fully fractionated course of treatment, we prefer to deliver linac treatment. There are also cases where we have treated multiple small metastases in the same patient on a Gamma Knife, and then treated post-operative cavities of the larger metastases on a linac—combining three approaches to deliver the best quality of treatment possible to the patient.”

Michael Jenkins
Radiation Therapist
Assistant Director of Radiation Therapy Services
Case example: Treatment of metastatic melanoma with surgery, linac-based SRT and Gamma Knife surgery

A 64-year-old male patient presented with generalized seizure. Investigations revealed minimal extracranial disease and several brain metastases—a large 45 mm right frontal mass (Figure 5) and two lesions in the right frontotemporal region measuring 11 mm and 18 mm (Figure 6). The patient lived a one-hour drive from treatment center but had limited transportation options.

The patient underwent gross total resection of the large frontal lesion with histology confirming a diagnosis of metastatic melanoma, BRAF wild-type.

After reviewing the case at the Gamma Knife multidisciplinary meeting, the postoperative plan was to treat with radiosurgery for the two intact metastases and linac-based stereotactic radiotherapy for the surgical cavity. The planning MRI revealed the known lesions, plus a new right occipital lesion measuring 4 mm (Figures 7–9).

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The planning MRI was used for Leksell Gamma Knife Icon treatment of the intact metastases, as well as image fusion for linac-based stereotactic radiotherapy planning for the surgical cavity.
Figure 7.
Planning MRI: right frontal surgical cavity

Figure 8.
Planning MRI: two intact right frontotemporal lesions and new right occipital lesion

Figure 9.
Planning MRI: new right occipital lesion
The intact metastases were treated first.

The two right frontotemporal lesions were adjacent to each other, had grown significantly and were relatively close to the large right frontal cavity. A Leksell Gamma Knife Icon hypofractionated approach was adopted with a prescription dose of 30 Gy in five fractions at the 50% isodose line. During the five fractions, the small occipital metastasis was treated to 20 Gy in a single fraction (Figure 10).

One week following completion of Leksell Gamma Knife Icon treatment, the patient received linac-based stereotactic radiotherapy of the surgical cavity to a dose of 27.5 Gy in five fractions (Figure 11).

This multi-modality treatment approach offered several advantages for this patient:

- Only one planning MRI was needed for the Leksell Gamma Knife Icon and linac treatments, which was significant considering the patient’s travel issues
- There was minimal delay in treating the intact metastases
- Shorter overall treatment time allowed systemic therapy to begin earlier
- A highly conformal treatment to the right frontotemporal lesions minimized dose interaction with the right frontal cavity

The patient received a course of prophylactic dexamethasone during radiotherapy and didn’t have any side effects apart from minor fatigue. He began immunotherapy a week after radiotherapy was completed and will receive further follow-up imaging.
Disclaimer

According to Leksell Gamma Knife intended use, limitation of tumor sizes is from a few millimeters to several centimeters.

References


For almost five decades, Elekta has been a leader in precision radiation medicine.

Our nearly 4,000 employees worldwide are committed to ensuring everyone in the world with cancer has access to—and benefits from—more precise, personalized radiotherapy treatments.