Customer Perspective

Extending intracranial treatment options with Leksell Gamma Knife® Icon™

Contributors
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About

Department of Radiation Oncology
University Medical Centre Mannheim

Location
Mannheim, Germany

Staff
11 Senior Physicians
11 Resident Physicians
12 Radiotherapists
10 Medical Physicists
6 PhD Students

Technology
6 Linear accelerators
  • 2 Elekta Versa HD™ on site
  • 2 Elekta Synergy® on site
  • 2 Elekta Synergy at satellite centers
1 Leksell Gamma Knife® Icon™
1 Philips CT Big Bore simulator
Elekta Brachytherapy equipment
  • 1 ZEISS INTRABEAM System
  • Elekta MOSAIQ 2.62
  • Elekta Monaco v5.11.01
  • Elekta MasterPlan 4.3
  • Leksell GammaPlan 11.03
Background

Based in the south of Germany, the University Medical Centre Mannheim serves a local population of around 350,000, and beyond to nearly 2.5 million people in the Rhine-Neckar region. In addition to offering standard radiotherapy treatment options, the centre’s Department of Radiation Oncology specializes in a range of complex radiation techniques, including image-guided radiation therapy (IGRT), intensity modulated radiation therapy (IMRT), volumetric modulated arc therapy (VMAT) and flattening filter free (FFF) treatments, stereotactic body radiation therapy (SBRT) and brain stereotactic radiosurgery (SRS), intraoperative radiotherapy (IORT), brachytherapy and total body radiotherapy (TBI), treating 2,800-3,000 patients every year.

The department currently has six linear accelerators (two Elekta Versa HD systems and two Elekta Synergy systems on site at the University Medical Centre Mannheim, and an Elekta Synergy at each of two satellite centres) and a Leksell Gamma Knife Icon. All seven systems are connected to the Elekta MOSAIQ Oncology Information System (OIS).

SRS has been performed at the University Medical Centre Mannheim for over 15 years. Prior to obtaining a Leksell Gamma Knife Perfexion™ in 2015, all cases of cranial SRS were delivered using a linear accelerator. The department had a good linac-based SRS program, treating around 50 patients per year (2013 data). However, the new features that would be available with Leksell Gamma Knife Icon, namely image-guided radiation therapy (IGRT) with stereotactic Cone Beam CT (CBCT) and adaptive planning, combined with the excellent dosimetry provided by Gamma Knife technology, was extremely attractive to the specialists at Mannheim.

“Knowing that we would obtain Gamma Knife Icon as soon as it became available, we decided to install a Gamma Knife Perfexion in the first instance to gain experience with the frame and to establish the Gamma Knife workflow,” says Leading Senior Physician, Dr. Sabine Mai.

Preparation for the new Gamma Knife Perfexion began in 2014. A new bunker was built to house the system, and a small team from the department attended Gamma Knife training in Stockholm, Sweden. In addition, for the first week of using Gamma Knife, Elekta engineers were on site at Mannheim for further training and support, which the team found helpful and reassuring.

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A new workflow

“Leksell Gamma Knife Perfexion required a completely new workflow for us, particularly because of the frame,” continues Dr. Mai. “But it wasn’t difficult for us to adapt. It is simply a matter of organization.”

Previously, with linac SRS, there were two days between the planning CT and the first treatment, during which time contouring, planning and plan acceptance was performed. With Gamma Knife, virtually everything is performed on the same day, apart from a preplanning MRI scan and preplanning, which is performed one to two days before treatment (figure 1). On the day of treatment, the patient has the frame fitted prior to an additional planning CT scan. Then, using the indicator box, adjustments are made according to the situation on the day of treatment before the radiation dose is delivered.

Figure 1.
Example of frame-based Leksell Gamma Knife workflow
Leksell Gamma Knife is fully integrated into MOSAIQ, the centre’s oncology information system (OIS).

“We use MOSAIQ to record and verify all Gamma Knife treatments and we push all our GammaPlan documents to MOSAIQ as well, where all the shots are stored,” says Dr. Florian Stieler, Senior Physicist. “It is managed just like any other irradiation machine within MOSAIQ. All the information from each treatment delivery system and the patient records are stored in one central database and any authorized practitioner can access patient treatment details from anywhere in the department.”

In terms of patient referral, the University Medical Centre Mannheim has a multidisciplinary Tumor Treatment Centre, including neurosurgeons, radiation oncologists and other medical professionals, where all new cancer patients and their treatment options are discussed. Dr. Mai has been able to introduce Gamma Knife radiosurgery as an additional treatment option that can now be delivered on site.

“We have a long and strong collaboration with our neurosurgery department,” explains Dr. Mai. “And we meet, usually once per week, to discuss all cases of brain tumors, whether malignant or benign. Now that we have Leksell Gamma Knife Icon at Mannheim, an increasing number of patients who are suitable for Gamma Knife treatment is presented and discussed. In addition, there was a lot of publicity in the press when we first obtained Gamma Knife Perfexion, so patients are even requesting Gamma Knife treatment from their neurosurgeon.”

“We discuss each case individually and determine together if Gamma Knife is the best option for the patient. In the past, if this was the best option for the patient, they would have been referred to another hospital. But now we can offer this treatment in house, and can work closely with other members of the team if the patient requires multiple modality treatment, which is an advantage.”
High conformality and low extracranial dose

As the team gained experience with Gamma Knife Perfexion, they quickly began to see the benefits of Gamma Knife treatments for patients.

“Firstly, there is evidence that Gamma Knife treatment has very low extracranial dose compared to other modalities, such as a linac or Cyber Knife,” says Dr. Mai. “In addition, we are able to achieve highly conformal plans with steep dose gradients, which is extremely important when high doses are being delivered close to critical structures, such as the optical nerve or chiasm.”

“Another benefit for patients is that we can reduce margins around the target compared to linac SRS,” she continues (figure 2). “When we use the frame, precision is very high and there is no need to use a safety margin around the target volume. This is highly beneficial for patients. Smaller margins mean less irradiation of healthy tissue.”

“In the past, brain metastases patients were often treated using whole brain radiotherapy (WBRT), delivered using a linac,” adds Dr. Stieler. “However, in the literature, there is a clear trend away from WBRT and towards SRS, due to the severe toxicities and poor outcomes associated with WBRT, including cognitive function impairment. German guidelines now recommend that patients in good condition with a limited number of brain metastases should be treated using SRS and this has been the trend at Mannheim, where the largest portion of our intracranial SRS patients is being treated for brain metastases. We now perform less and less WBRT and more brain SRS.”

“Furthermore, when we treated brain metastases using linac SRS, the maximum number of lesions we could treat at one time was three. Now that we are using Gamma Knife, we are able to treat patients with up to 10 metastases in a single session, even when they have had previous treatment with WBRT.”

Figure 2.
No PTV margin with frame-based Gamma Knife treatments
New capabilities with Leksell Gamma Knife Icon

In August 2015, the department upgraded to a Gamma Knife Icon (figure 3). While Gamma Knife Perfexion treatments were performed using the frame for cranial immobilization, Gamma Knife Icon allows frameless stereotactic treatments to be performed through a combination of stereotactic Cone Beam CT (CBCT), a thermoplastic mask system and an infrared-based High Definition Motion Management (HDMM) system for patient tracking during treatment.

“Our department has a long history in IGRT and frameless SRS with linacs, so we were looking forward to upgrading to Gamma Knife Icon with image guidance and the opportunity to use a mask, while retaining the option of frame-based treatments when the situation demands it,” says Dr. Stieler.

“In addition, Gamma Knife Icon offers some other new capabilities that we didn’t have previously, such as adaptive planning and continuous patient monitoring.”
Dr. Stieler goes on to explain that adaptive planning allows treatments to be adjusted according to the daily positional situation. This allows them to perform fractionated treatments on Leksell Gamma Knife Icon. At each treatment, CBCT is used to verify the position of the patient. This is automatically matched to the reference CT or MR scan, and the system provides translational and rotational shifts. Translational and rotational shifts are corrected using shot position, and the dose distribution is recalculated. The whole process (see example in figure 4), including image acquisition, matching and validation, is extremely fast and adds very little time (just 3-4 minutes) to the total treatment time.

“If there is a large shift, depending on the daily situation, and the resulting dose distribution is not as expected, the patient can be repositioned,” continues Dr. Stieler. “And, for added assurance, the system provides information about plan quality at the beginning and at the end of treatment, allowing us to see that we have delivered what we planned.”

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**Adaptive workflow**

- **MRI**
- Choose immobilization
- CBCT scan
- Stereotactic ref.
- Plan
- Co-registered MRI
- Patient Positioning
- CBCT scan
- Correction & Dose Evaluation
- Treat

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**Figure 4.**
Example of adaptive Leksell Gamma Knife Icon workflow. Star indicates flexible steps that can be performed other day than day of treatment.
“The ability to fractionate treatments, whether normal fractionation or hypofractionation, is important to us, particularly for patients with benign disease,” adds Dr. Mai. “In some cases, we have been able to treat benign meningioma with a hypofractionated stereotactic radiotherapy (fSRT) regime (5 x 5 Gy), and we have also been able to treat patients with acoustic neuroma using normal fractionation on Gamma Knife Icon. This allows such patients to benefit from all the other advantages of Gamma Knife treatments, such as the low extracranial dose, conformality and high precision, even with the mask system.”

“After some experience with the mask system on Gamma Knife Icon, we have been able to reduce our safety margins for the majority of acoustic neuromas to just 1 mm. With the linac, we typically use a safety margin of 3 mm. This is a significant reduction in volume when treating benign disease in young patients.”

Speaking about online continuous patient monitoring with Gamma Knife Icon’s HDMM system, Dr. Stieler explains that there are some add-on systems that allow a degree of patient monitoring for linac-based treatments, such as Elekta Clarity® for ultrasound monitoring of the prostate, and the C-Rad Catalyst surface monitoring system. It’s also possible to check patient position using CBCT, but this can only be performed at a certain point in the treatment chain, not throughout the treatment. By contrast, the Gamma Knife Icon HDMM system is not an add-on. It is fully integrated with the delivery system and allows patient motion to be monitored during the entire treatment, which adds to the system’s accuracy and is extremely important for long treatment times.

“When we treat with the frame, we have confidence that there will be no movement of the patient’s head, even if there is slight movement of their arms and legs,” continues Dr. Mai. “However, with long linac-based SRS treatments using a mask, if the patient moves their arms or legs during treatment, you don’t have that same confidence that it has not influenced the position of the head. Now, with Gamma Knife Icon, we are able to monitor patient movement throughout the treatment, which gives us reassurance of the head position. If the patient moves too much, we have the option to stop treatment and to use the frame if necessary.”

Greater flexibility for intracranial treatments

“With Leksell Gamma Knife Icon, we have a specialized tool for treating the brain that is very flexible,” says Dr. Stieler. “We can choose different methods for positioning, with the frame or the mask, and we can perform multiple different fractionation schemes, depending on the indication and the needs of the patient.”

“Gamma Knife Icon extends our options for patients with brain lesions,” agrees Dr. Mai. “For example, we had a patient who required frame treatment but we could only fix three of the frame posts. The CBCT imaging on Gamma Knife Icon allowed us to confirm that the patient was still in the correct position, even with three posts, giving us greater confidence to proceed.

“In another example, we had a patient who was not able to lie on the planning CT couch with the frame in place. This was not a problem because we were able to perform a CBCT with the patient in the frame on the Gamma Knife couch and, on this occasion, we were able to use this for the stereotactic reference.”
“Another advantage of this flexibility is if we find that the patient is moving too much in a fractionated mask treatment, we have the option of switching to the frame and completing the treatment in a single-session fashion. Alternatively, some patients may be claustrophobic and find the mask very difficult. In such cases, we might choose to treat them using the frame. On the other hand, we might have a patient who has had several craniotomies, making it difficult to fix the frame screws, so we could opt to use the mask for such a patient. This flexibility is important for both patients and staff.”

Currently about two thirds of Gamma Knife Icon patients at Mannheim are treated using the frame and about one third in a mask, although the proportion of mask treatments is increasing.

Benefits to patients

“A significant benefit of Leksell Gamma Knife Icon for patients is that we can reduce margins around the target compared to linac SRS,” continues Dr. Mai.

“When we use the frame, precision is very high and there is no need to use a safety margin. When we perform Gamma Knife treatments using a mask, a small margin may be applied, but this is smaller than what we would use for linac SRS. Smaller margins mean that less healthy tissue is irradiated, which reduces toxicity.

“Previously, we treated some benign conditions, such as pituitary adenoma and acoustic neuroma, using the linac, but now we can treat such conditions with even smaller margins on Gamma Knife Icon. Such targets are often located close to critical structures, so reduced margins provide safer treatments for patients.”

“Some patients are nervous of the frame,” she adds, “but once they get used to it, most are very happy. It’s one day of treatment, a non-invasive procedure, with no pain or recovery afterward. To illustrate this, we had one young female patient who was treated previously for pituitary adenoma with surgery. This had been painful and required recovery and medication. When she returned, we were able to treat her on Gamma Knife Icon in one day. It was a very different experience for her and she was extremely happy.”

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The following are some examples of how Gamma Knife Icon has provided the ideal treatment solution for patients at the University Medical Centre Mannheim:

Example 1 - Pituitary Adenoma
A young woman presented with a very small secreting pituitary adenoma. For such a small lesion, this patient would not have been treated using a linac. The linac had more dose to normal tissue with less conformality (figure 5). By comparison, the Gamma Knife Icon plan was very conformal with a steep dose gradient (figure 6), and we were able to treat this young patient with a very high dose using frame-based Gamma Knife SRS.

Combining linac and Gamma Knife treatments

Example 2 - Large Nasopharynx Carcinoma
A young male patient had a large tumor in his nasopharynx (figure 7). Usually such patients are treated on a linac with a very large PTV. After 50 Gy, the PTV would be reduced.

“This was a huge treatment volume and we wanted to treat him with a complex IMRT plan,” recalls Dr. Mai. “However, we encountered a problem. There was a small area of under dosage near the inner ear with the VMAT plan – a cold spot (figure 8). To improve this plan would require a lot of additional treatment time for the patient.”

The team decided to fill the dose with a single treatment on Gamma Knife Icon (figure 9). “This involved just one additional treatment,” says Dr. Mai. “It allowed us to deliver all the dose where we wanted it.”
Figure 7. Nasopharynx carcinoma

Figure 8. Nasopharynx carcinoma VMAT plan

Figure 9. Nasopharynx carcinoma – dose filling with Gamma Knife Icon
Conclusions

“The addition of another treatment machine allows us to treat more patients in general, but in addition to that, Gamma Knife Icon allows us to treat more intracranial indications,” comments Dr. Stieler. “Furthermore, the availability of the Gamma Knife Icon system has been very high. We have had virtually no significant downtime since we have had this machine in our department. It is available 24 hours a day.

“We now treat virtually all patients for intracranial tumors with SRS or fSRT with Gamma Knife Icon. This gives us more linac availability for other special time-consuming treatments, like SBRT, and there is also an advantage to using both modalities for certain patients.”

In 2013, around 50 patients were treated in the department using linac-based SRS. In the first year of having a Gamma Knife system, this number decreased to around 30 patients, while 56 patients were treated using Gamma Knife SRS. In 2016, all cases of cranial SRS or fSRT were delivered using Gamma Knife Icon, and by October 2016, 92 treatments had been performed (including individual treatment fractions in cases of fractionated SRT) – already almost double the number of treatments performed in 2013.

“Not only have we increased the number of patients to receive cranial SRS and fSRT, but we have also been able to increase the number of indications (both malignant and benign disease) that we can treat,” says Dr. Stieler. “We have also begun to treat postoperative cavities following resection of brain metastases using fractionated SRS (3 x 10 Gy every 2 weeks), which has contributed to the high number of treatments that we have performed this year.”

References


