Customer Perspective

Improving planning workflows and freeing physicists’ time with the Monaco® treatment planning system

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About

Department of Radiotherapy
South Tees Hospitals NHS Foundation Trust

Location
James Cook University Hospital
Middlesbrough, U.K.

Staff
14 Clinical Scientists
(Physicists)
1 QMS manager (physics)
9 Technologists (machine,
IT and mould room)
8 Dosimetrists
47 Radiographers
14 Clinical Oncologists

Technology
5 Elekta linear accelerators
with Agility™ and XVI
version 5.0
3 with Flattening Filter Free
(FFF)
1 microSelectron® HDR
Afterloader
MOSAIQ® Oncology
Information System (OIS)
version 2.6
Monaco® Treatment Planning
System (TPS) version 5.11
Oncentra® MasterPlan
Treatment Planning System
(TPS) version 4.3
1 TomoTherapy System
2 CT scanners (Siemens
Sensation Open and
Toshiba Aquilion)

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Head of Radiotherapy Physics

Helen Curtis
Clinical Scientist, Radiotherapy
Physics

Photographs courtesy of South Tees Hospitals NHS Foundation Trust
Background

South Tees Hospitals NHS Foundation Trust provides a specialist cancer treatment center for the Teesside region and surrounding areas in North East England. Based at the James Cook University Hospital (JCUH) in Middlesbrough, the cancer center serves a very mixed population of over 1.1 million people that stretches from industrial Teesside, where there is a high incidence of smoking and obesity, and higher than average rates of lung, head and neck cancers, to the more rural Yorkshire Dales.

The Radiotherapy Department at JCUH has a strong national and international reputation as a leading center in the delivery of cutting-edge radiotherapy techniques, treating the majority of indications, and with one of the most advanced SABR programs in the country.

With an annual patient throughput of about 3,000 per annum, the department delivers around 40,000 radiotherapy fractions every year.

Although radiotherapy clinical hours are from 8:00-18:00 Monday through Friday, the Radiotherapy Physics Department provides a seven-day service. This moderate-sized physics team is responsible for treatment planning, as well as maintaining equipment performance and quality assurance, working outside of regular hours during the week to carry out delivery (pre-treatment) quality assurance (DQA) and performing equipment maintenance on weekends.

Like several centers in the U.K., treatment planning at JCUH is dosimetrist-led with specially trained radiographers routinely generating treatment plans.

“The development of Monaco class solutions has helped to simplify and standardize the use of this powerful treatment planning system for the dosimetrist-led planning service at the James Cook University Hospital in Middlesbrough, U.K. In addition, the consistent accuracy of Monaco to predict the dose delivered by the linac has provided the confidence to streamline pretreatment quality assurance for certain indications, which has freed physicists to develop more advanced techniques for a wider range of treatment sites.”

Kevin Burke
Head of Radiotherapy Physics
Introducing Monaco

In April 2012, as part of their plan to increase intensity modulated radiation therapy (IMRT) activity and introduce volumetric modulated arc therapy (VMAT) as a treatment option, the department installed the Monaco treatment planning system (TPS) version 3.2.

“Previously, we used Oncentra MasterPlan for 3D conformal plans,” explains Kevin Burke, Head of Radiotherapy Physics. “We obtained Monaco when we installed three new Elekta linacs in 2012. Monaco was commissioned and evaluated alongside MasterPlan. Prior to installing Monaco, IMRT was restricted to a handful of step-and-shoot deliveries and TomoTherapy, which we had installed in 2010.”

Monaco was used clinically for the first time at the James Cook University Hospital in August 2012, when the first prostate patient was treated using VMAT. By May the following year, all the center’s prostate patients were treated using VMAT.

“It quickly became apparent that the dose algorithm in Monaco was much more accurate than our previous TPS,” Burke continues. “We were achieving much better plans with improved QA performance. Not only does the Monte Carlo algorithm predict the dose delivered by the linac very well, but the leaf sequences are also straightforward, with minimal interdigitation and good (wide) average leaf pair opening, making the sequences easy to calculate and deliver. In addition, we found Monaco to be very open and flexible. There is a wealth of tools to interact with the software, and the optimization process is very well described as it proceeds. However, in the early days of having Monaco, we were limited by having only one workstation.”

The department obtained two additional workstations early in 2013, as well as a research and education workstation that was bought through charitable funds. Then a fourth Monaco workstation was added in October 2014, when Monaco was upgraded to version 5.0 (going clinical in January 2015), and a fifth in September 2015, when the department piloted Monaco version 5.1.

“As we increased the number of workstations (we now have five workstations plus one for education and research), and as the PC hardware became more powerful, our planning capacity grew and it was much easier to experience the full benefits of Monaco,” Burke adds.

The addition of further, more powerful workstations had a significant impact on IMRT activity within the department. With each additional workstation, the number of monthly IMRT plans continued to grow year over year (Figure 1). By April 2015, the center treated 44 percent of cases using IMRT (well above the NHS target of greater than 24 percent), and by the end of 2016 the James Cook University Hospital was in the top three sites in the country for IMRT activity, at

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by the middle of 2017 JCHU averaged 62 percent of all cases treated with IMRT, currently the second highest in England. JCHU has consistently remained in the top 10 percent of all English sites delivering VMAT.

Developing class solutions

One of the key steps in the rapid adoption of Monaco at JCUH has been the development of robust class solutions (or templates) for specific indications, which has simplified and standardized the use of the TPS for the dosimetrists, while satisfying clinical requirements and producing optimal dose distributions.

The physicists undertake the development work for each class solution, determining how certain changes affect other factors and cost functions and providing guidance to the dosimetrists, so they know what they can change to produce the best plan.

“We wanted to ensure the dosimetrists were comfortable with the TPS to allow high volume planning quickly,” Burke comments. “In developing class solutions, we began with prostate VMAT plans because we see a high number of prostate cancer cases at Middlesbrough, and we had established trial protocols to follow (CHHIP and PIVOTAL). In addition, prostate plans are technically relatively simple and image guided radiotherapy (IGRT) is well established at this site.

“We delivered over 100 prostate VMAT plans to phantoms, achieving a global gamma tolerance of > 98% at 3%/2 mm, before treating our first patient. This provided a massive amount of information to demonstrate that our
“Monaco class solutions have helped us to make good progress in streamlining our workflows ... This has been vital in helping us to achieve our IMRT activity targets.”

Kevin Burke
Head of Radiotherapy Physics

Figure 2. JCUH prostate class solution template in Monaco showing biological cost functions

“Monaco class solutions were good and enabled us to start from a position of confidence.

“Absolutely vital in the smooth adoption of Monaco has been the enthusiasm and commitment of the dosimetrists in embracing the system," Burke adds.

“We have a very motivated team here and, with good training on the product as grounding, they have been quick to gain confidence in using Monaco class solutions. The dosimetrist-led planning service is an efficient way of working for us because it allows the physicists to develop new techniques.”

The development of class solutions has been achieved successfully for several treatment sites at JCUH, providing a well-defined starting point for treatment planning for the majority of patients (Figure 2).

“Monaco class solutions have helped us in streamlining our workflows for prostate and bladder VMAT treatments, as well as breast DMLC,” Burke continues. “Our class solutions for other sites (e.g. lung SABR, esophagus and gynecology VMAT plans) have been vital in helping us to achieve our IMRT activity targets. If we weren’t able to perform the bulk of our IMRT treatments quickly and easily, we wouldn’t have had time to develop the other sites that we now treat routinely.”

QA for Prostate

IMRT involves very complex planning and delivery, so it is common practice for centers to develop per patient QA tests (called delivery QA, or DQA at JCUH), which must be performed prior to delivering a patient’s first treatment. In fact, such pretreatment QA is mandatory in many countries.

“Developing our prostate DQA program provided confidence in the accuracy and reproducibility of treatment delivery, Burke says. “Initially, with version 3.2, we performed physical DQA measurements for every patient. Prior to upgrading to Monaco version 5.0, we were already considering moving to a more efficient software based QA procedure.”
“When we upgraded to Monaco version 5.0, we noticed a significant change in the modulation complexity of our prostate plans. Monaco 5.0 required fewer MUs and less modulation to achieve the same degree of target coverage (Figure 4), and we noticed even higher DQA quality, although it was already high with version 3.2 (Figure 3).”

“We performed physical QA measurements out of hours,” he continues. “We were at full stretch, spending all our time on prostate QA measurements and they were all passing. There were other treatment sites that we wanted to develop and so we made the decision to move to a software based QA system in February 2015.”

Moving to software based QA has enabled the physics team to develop, treat and perform DQA for additional treatment sites. Now, with equally high pass rates, this, in turn, has allowed them to increase their fractionated lung, head and neck, gynecology VMAT, and most recently, rectum workloads.

“We wouldn’t have been able to expand in these areas if we hadn’t streamlined DQA for every patient,” Burke explains. “And we wouldn’t have been able to streamline DQA if we didn’t have confidence in the accuracy of Monaco. The decision to streamline was driven by a wealth of evidence over several years.”

“It has been a virtuous circle,” he adds. “We use Monaco plans that are within the linac performance limits and we can develop class solutions and perform DQA for additional treatment sites, which means we can treat more patients.”

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Developing breast DMLC

The time made available to the physicists at JCUH enabled them to develop the use of the dynamic MLC (DMLC) technique to improve the treatment of left-sided breast cancer. Around 600 radical breast treatments are performed at the James Cook University Hospital each year. In the past, conformal plans were generated by Oncentra MasterPlan, delivering 40 Gy in 15 fractions using a field-based technique with tangentially wedged fields, a couch twist and field in field if required. The aim of the DMLC development work for left-sided breast treatments, with plans generated by Monaco, was to improve heart spare with voluntary deep inspiration breath hold (vDIBH).

Helen Curtis, the lead physicist for this project, noted that “We wanted to adapt the combined DMLC tangents plus VMAT boost approach we used for IMPORT HIGH2 patients. The technique, which involves tangential DMLC fields with a VMAT partial arc to boost, makes treatment planning simpler, by removing the physical wedge and couch rotation, and also makes the delivery faster. We developed a Monaco class solution for left-sided breast treatment using DMLC tangential fields alongside vDIBH for suitable patients for improved heart spare.”
“The 3D conformal plans we produced previously for breast met our criteria,” she says. “However, the breast DMLC plans achieved with Monaco are even better. They are delivered more quickly, with more homogenous dose, and they provide improved heart sparing with vDIBH (Figure 5). We can also use the optimizers within Monaco to further reduce dose to the heart or lung, if required.”

“At the moment we select suitable patients for vDIBH,” Curtis continues. “We require that they can hold their breath comfortably for at least 25 seconds, so that the beam can be delivered in a single breath hold. In the near future, we will use Flattening Filter Free (FFF) beams, which will reduce beam-on time even further and allow us to perform this technique with vDIBH for the majority of left-sided breast patients, even with larger fraction sizes, such as 5.2 Gy or 5.4 Gy fractions, should the FAST FORWARD trial regime be introduced (Table 1).”

“In the long term, we hope to treat all breast patients using the DMLC technique,” she adds. “We now have robust, straightforward Monaco class solutions for left-sided and right-sided breast DMLC. DQA results for breast DMLC have been excellent, and our OAR constraints have all been well within IMPORT HIGH tolerances.”

**Table 1.**
Delivery times in seconds (s) for flattened wedged, flattened DMLC and FFF DMLC beams

<table>
<thead>
<tr>
<th>Fraction size</th>
<th>Flattened, wedged, FIF 6x (600 MU/min)</th>
<th>Flattened, DMLC 6x (600 MU/min)</th>
<th>FFF, DMLC 6x (1800 MU/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.67 Gy</td>
<td>220 MU; 57 s</td>
<td>200 MU; 23 s</td>
<td>240 MU; 11 s</td>
</tr>
<tr>
<td>5.4 Gy</td>
<td>445 MU; 115 s</td>
<td>405 MU; 44 s</td>
<td>480 MU; 19 s</td>
</tr>
</tbody>
</table>

“The calculation speed of Monaco 5.11 is extremely fast without any loss in accuracy.”

Kevin Burke  
Head of Radiotherapy Physics
“Monaco 5.0 required fewer MUs and less modulation to achieve the same degree of target coverage.”

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Continuing progress

“The calculation speed of Monaco 5.11 is extremely fast without any loss in accuracy,” Burke comments. “To illustrate this, we looked at the log files and compared prostate planning CPU time for three months prior to and after upgrading to Monaco 5.11, and found that CPU time more than halved. In the time leading up to version 5.11, we generated 80 plans in around 80 hours. In the first three months since version 5.11 was installed, we were able to generate plans for 79 patients in just 35 hours. Furthermore, there was a higher proportion of SABR plans in the second three-month period. This speed and accuracy of planning has been instrumental in us being the largest recruiter of patients in the U.K. for the PACE (arm B) trial in 2016.5

“The rapid calculation speed we enjoy now will allow us to try a number of different iterations in the planning process to ensure the very best treatments for patients,” he adds. “With the speed and accuracy of Monaco 5.11, with workflow automation tools available in MOSAIQ, we will be able to consider adaptive planning, which shows great promise for certain treatments (e.g. bladder or gynecological sites).”

“Monaco provides an honest statement of what will be delivered to patients, which gives us confidence in our treatments,” Burke concludes.

“By being better, quicker and more efficient for our high throughput indications, such as prostate, Monaco has helped to free up our time to develop other things, and to do this well,” adds Curtis. “This has allowed us to offer advanced techniques for a wider range of treatment sites, which, ultimately, is better for patients.”
Disclaimer

This customer perspective is based on the experience and application of medical experts, and is intended as an illustration of an innovative use of Elekta solutions. It is not intended to promote or exclude any particular treatment approach to the management of a condition. Any such approach should be determined by a qualified medical practitioner.

It is important to note that radiation treatments, while usually beneficial, may also cause side effects that vary depending on the area being treated along with other medical circumstances. The most frequent side effects are typically temporary and may include, but are not limited to, skin redness and irritation, hair loss, respiratory, digestive, urinary or reproductive system irritation, rib, bone, joint or soft tissue (muscle) pain, fatigue, nausea and vomiting. In some patients, these side effects may be severe. Treatment sessions may also vary in frequency, complexity and duration. Finally, radiation treatments are not appropriate for all cancers, and their use along with the potential benefits and risks should be discussed before treatment.

References

[1] For further information, see http://www.icr.ac.uk/our-research/our-research-centres/clinical-trials-and-statistics-unit/clinical-trials/chhip

[2] For further information, see http://www.icr.ac.uk/our-research/our-research-centres/clinical-trials-and-statistics-unit/clinical-trials/pivotal

[3] For further information, see http://www.icr.ac.uk/our-research/our-research-centres/clinical-trials-and-statistics-unit/clinical-trials/import_high


[5] For further information, see http://www.icr.ac.uk/our-research/our-research-centres/clinical-trials-and-statistics-unit/clinical-trials/pace
We are healthcare technology innovators, specializing in radiotherapy treatments for cancer and brain disorders.

We help clinicians improve patients’ lives through our forward-thinking treatment solutions and oncology informatics, creating focus where it matters to achieve better outcomes.