Elekta

Elekta Unity for Magnetic Resonance Radiation Therapy (MR/RT)

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Preface

Radiation therapy, an important therapy option for cancer patients, has two conflicting goals: to deliver sufficient dose to the treatment target to achieve local control and to keep the dose to organs at risk (OAR) at sufficiently low levels to achieve acceptable toxicity. Furthermore, these two goals are confounded by two uncertainties: the exact boundaries of the target and precisely where it is located at the time of treatment. These uncertainties are managed by deliberately irradiating a larger volume than desired to ensure that the first goal—delivering therapeutic dose to the target—is achieved. This creates a high

dose 'bath' around the target, which often includes a significant volume of healthy tissue. The larger volume, the planning target volume (PTV), is typically created by adding safety margins to the intended clinical target volume (CTV). These safety margins are driven by the uncertainties in target definition and localization at the time of treatment.

Over the years, improvements in imaging associated with treatment planning have advanced the ability to define target boundaries and significantly reduced uncertainty in definition of the CTV. In parallel, image-guided radiation therapy (IGRT) has significantly reduced uncertainty in the delivery

The primary goal of image guidance is to reduce uncertainty in delivery of radiation therapy.

of radiation to the target. By diminishing these uncertainties, reductions in the safety margins (and consequent PTV) and better dose discrimination are permitted, resulting in improved tumor control and reduced toxicity.[1]

But, even with the current state of technology, uncertainty still remains about the precise position, shape and motion of the target at the time of treatment. The imaging information used for targeting or adapting dose at the time of treatment is of insufficient quality and is not in real time. To increase precision, there is a need for accurate, real-time information on which to base the precise targeting and retargeting of dose at any time during treatment delivery.

This white paper describes how Elekta Unity, with integrated high-field MR imaging capabilities, addresses this need. Elekta Unity provides high-quality detailed images of patient anatomy in real time and allows non-invasive, dose-free target motion monitoring during treatment delivery to enable online plan adaptation. This groundbreaking technology will ensure precise real-time target definition at every fraction and will even provide access to functional information for future biological response-based treatment adaptation.

1. Challenges for image-guided radiation therapy today

The dominant technology for IGRT today is cone beam CT (CBCT). CBCT produces three-dimensional images of patient anatomy. This was a great improvement over previous technologies in terms of the ability to visualize certain anatomies, and has been a breakthrough for some targets. But, for many targets, CBCT image quality is inadequate to determine target shape and position with confidence. CBCT is susceptible to motion-related artefacts and gives no real-time information about moving targets.

Ultrasound is capable of producing three-dimensional images and providing real-time information about moving targets. It is suitable for certain anatomies but, again, the image quality can be inadequate for confident determination of target shape and position.

Radiographic imaging technologies (either MV or kV) give little or no soft tissue information. Target position has to be determined from the position of either bony anatomy or implanted markers, and it is unlikely that changes in target shape are detectable. Radiographic imaging is capable of determining the position of markers in real time but has the disadvantage of delivering unwanted dose.

Active implanted markers, such as RF beacons, give real-time positional information without additional dose. As they are typically larger than gold markers, the risks related to the implantation procedure are higher. Visualization with both types of marker is indirect, and the boundaries of the target and position of surrounding OAR have to be inferred.

Other real-time technologies monitor the surface of the patient or other surrogates. These are even more susceptible to changes in the relationship between the position of the target and the surrogate being measured. Respiratory patterns linked to target motion are not always regular and do not always correlate with external anatomy.[2]

Challenges exist in image-guided delivery today due to limited information about tumor and critical organ position, shape and motion at the time of dose delivery.

Continuous monitoring of the exact morphology and location of the tumor, relative to surrounding normal tissue and at every fraction, represents a fundamental treatment delivery challenge. The consequential use of large PTV margins can be challenging and may even preclude radiation treatment for some indications due to the close proximity of OAR. In some cases, for example where the tumor is located in the abdominal or pelvic region, the target will be subjected to respiratory and peristaltic motion and difficult to localize during irradiation. This lack of direct and immediate targeting information is a primary limitation to the reduction of margins and dose escalation in many cases.

Another issue is that radiation treatment planning is currently based on a snapshot dataset of patient anatomy at the time of simulation. This is typically acquired one to two weeks before treatment delivery starts and the same information is usually used for the entire course of treatment. Although image guidance with CBCT assists in accurate and reproducible patient positioning, this is

often based only on bony anatomy and largely limited to rigid body matching. It does not account for day-to-day changes in the patient's anatomy or tumor—for example, changes caused by weight loss, internal motion, bowel or bladder filling or tumor shrinkage.[3,4]

To address the current challenges in image-guided radiation therapy, there is a need for improved target and OAR visualization at the time of treatment, with the patient in the treatment position. There is also a need for better insight into tumor motion and patient anatomy during treatment delivery. These improvements could provide the information needed to reduce PTVs, extend treatment opportunities and allow further dose escalation and hypofractionation.

2. Magnetic Resonance Radiation Therapy (MR/RT): precision treatment through simultaneous MR imaging and radiation delivery

Magnetic Resonance (MR) imaging is widely recognized as the best imaging modality for visualizing soft tissue and lesions. It is well established in diagnostic settings and its use in radiation therapy has grown over the years, becoming an important imaging tool for diagnosis, staging, simulation, planning and post-treatment follow-up[5-7] (Figure 1).
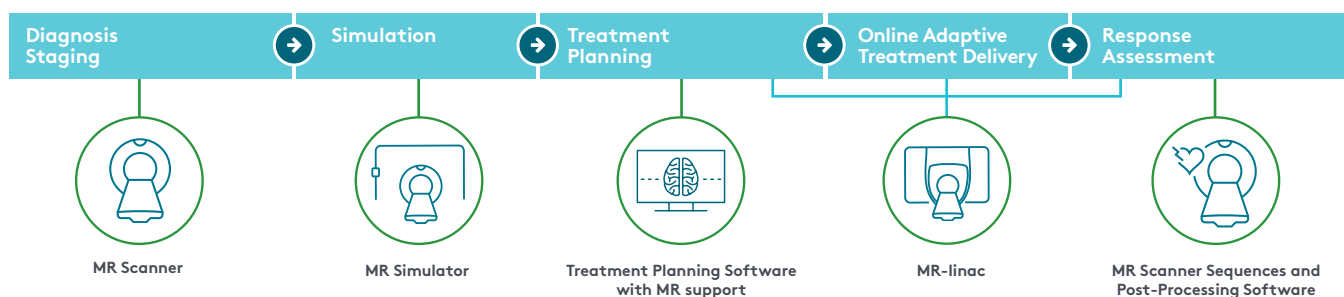

Figure 1
The roles of MR imaging in the radiation therapy patient journey

MR/RT provides the opportunity to improve tumor targeting and normal tissue sparing.

The use of MR imaging in radiation treatment simulation and planning has been associated with improvements in clinical outcomes[8-10] and has merited its incorporation as a standard in radiation therapy guidelines and protocols.[11-14]

Advantages of MR imaging for radiation therapy include:

- excellent soft tissue visualization
- absence of associated ionizing radiation; non-invasive
- exquisite image quality and relatively high acquisition speed when using higher MR field strengths
- geometrical flexibility to acquire images in 2D (any desired plane, e.g. beam's eye view) and 3D
- access to functional and quantitative capabilities (subject to MR field strength)

MR imaging during treatment delivery allows internal movement to be monitored directly and avoids the need for surrogate markers.

MR guidance integrated with dose delivery has the potential to render almost all tumor and tissue types visible in real time, virtually eliminating target uncertainty and offering further potential for PTV margin reduction and dose escalation.[15-17] This means the high dose bath typically received by normal tissue immediately surrounding the tumor can be significantly diminished (Figure 2). Elekta Unity introduces a new paradigm in radiation treatment—MR/RT—that provides the opportunity to adapt dose online to the actual anatomy, improving tumor targeting and normal tissue sparing.[18-20] These capabilities will potentially change the way tumors are treated today and may offer important advantages for tumors that are difficult to visualize and track with existing IGRT methods.
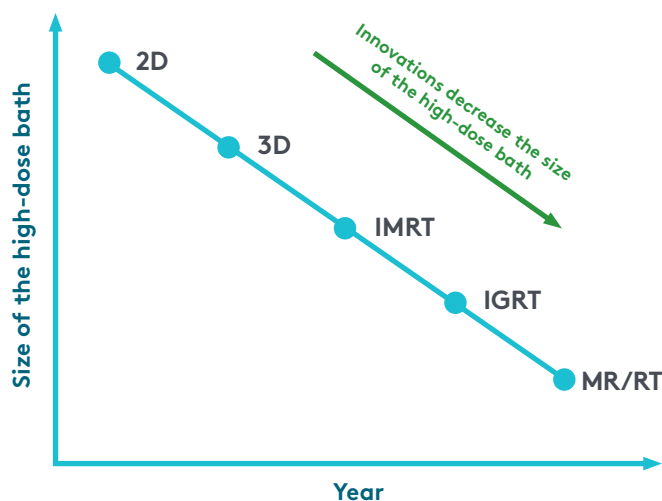

Figure 2
Integrating MR imaging with dose delivery eliminates target uncertainty at the time of treatment and offers potential for PTV margin reduction, resulting in a decrease of the high dose bath [Adapted from 23]

MR imaging during treatment delivery allows internal movement of the target and adjacent tissue to be monitored directly and avoids the need for invasive fiducials markers. By doing so, MR/RT may expand therapy options for patients who are not eligible for fiducial implants due to anticoagulant medications or tumor location. And, direct measurement of patient anatomy will result in more accurate gating and tracking strategies. Online MR imaging of tumor motion could lead to a further decrease of target margins.[15] Indeed, a prospective comparison of liver motion management techniques found MR-based tracking to be more accurate than surface surrogates.[21]

The ability of MR/RT to monitor tumor size, shape, location and motion during dose delivery will also enhance capabilities for online adaptive planning during treatment and may even allow real-time, segment-by-segment plan adaptation. This will facilitate the most personalized treatment delivery currently possible and, consequently, is likely to further enhance the efficacy and safety of radiation therapy. Already, adaptive radiation therapy has been shown to improve OAR sparing in certain indications[22] and it is anticipated that many additional indications for radiation therapy would benefit from MR/RT-based adaptive planning.

Biological MR/RT supports the possibility of biological response-based dose adaptation during treatment.

In addition to these anatomical image-guidance enhancements, high-field MR/RT also provides easy access to functional imaging capabilities between, during and after treatment. Among other things, the capture of such biological information during the course of treatment may allow tumor response to be seen, even before anatomical changes are evident, which would allow for assessment of the treatment strategy. Biological MR/RT may enable the possibility of further therapy personalization through biological response-based dose adaptation during treatment.[23] The ease with which this additional information is acquired and used will enable the fundamental research required to demonstrate the value of these or other hypotheses.

3. Elekta Unity: a high-field MR/RT solution

Elekta Unity overcomes many of the challenges and limitations of current radiation therapy technology, to offer a new level of accuracy and precision for advanced radiation dose delivery. Plus, it allows this to be achieved within a timescale that remains acceptable from a departmental efficiency perspective. The system was designed from scratch, with clinical needs and the desire to improve clinical outcomes in mind.

Elekta Unity offers a new level of accuracy and precision for advanced radiation dose delivery.

Elekta Unity fully integrates two very different technologies in a single platform (Figure 3): a state-of-the-art, high-field (wide bore 1.5 Tesla) MR imaging system, based on the Philips Ingenia MR scanner; and a next generation Elekta linear accelerator. These two technologies are controlled and powered by integrated software with responsive workflow solutions.

The linear accelerator is mounted on an intrinsically stable ring gantry, enabling highly precise treatment delivery, while a state-of-the-art slip ring mechanism allows the linac to rotate 360° around the MR imaging system at a maximum speed of six rpm. At the same time, high-quality MR images are acquired at any point before, during or after treatment delivery (Table 1, next page). These images are acquired rapidly, e.g. at five frames per second in sagittal, coronal and axial planes (or any combination thereof), facilitating adaptive radiation therapy on a daily basis.

Patient comfort and operator needs have been considered wherever possible in the design of Elekta Unity, including: the open layout and short, wide bore (Ø70 cm, 132 cm) with flared covers; the loading height of the treatment table and soft mattress; the height and location of screens and controls; and the clinically developed software and intuitive workflows.

The modular design of Elekta Unity ensures ease of servicing and minimizes downtime. A beam stopper eliminates requirements for primary shielding in the bunker walls and allows installation of Elekta Unity into existing standard linac bunkers.[24] Plus, active magnetic shielding technology minimizes the range of the fringe field, allowing the system to easily co-exist with other linear accelerators within a typical RT department.[25]
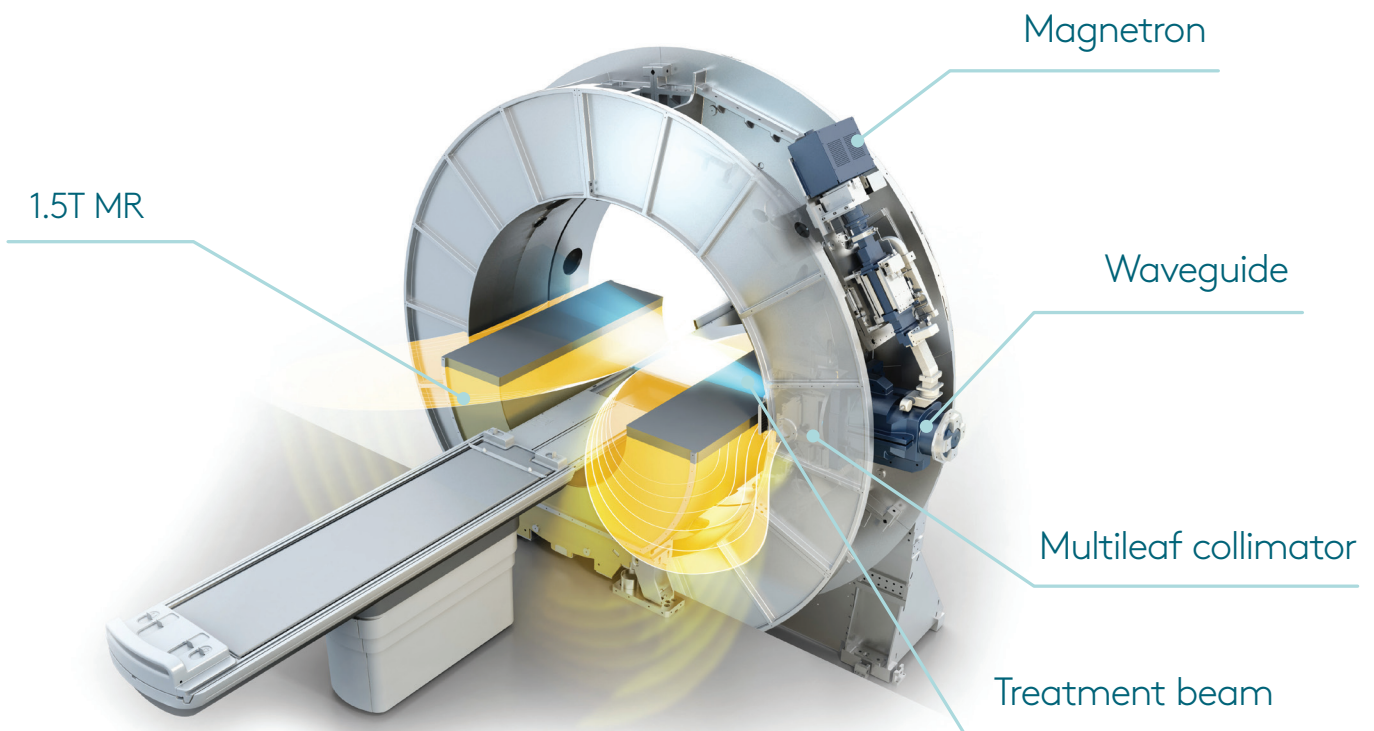

Figure 3
Elekta Unity

Stage	Purpose of MR imaging	Advantage of 1.5T high-field MRI
Pre-treatment	**Plan adaptation to current patient anatomy** On the day of treatment, a 3D MR image is obtained. If required, the treatment plan is adapted according to current anatomy. A new PTV is created using deformable registration and manual input, allowing a new dose distribution to be created on the fly.	Short imaging time and excellent image quality expedite the interpretation and replanning process. Images acquired will have similar contrast and resolution characteristics compared to MR-sim or diagnostic high-field images.
Intrafraction	**Target motion management** Real-time 2D images are displayed simultaneously to dose delivery, enabling direct monitoring of tumor/OAR position and motion relative to the beam position. This is particularly important for tumors in the thorax, abdomen and pelvic region that may be affected by respiratory or other physiologic motion. Elekta Unity is able to pause radiation delivery when target position exceeds certain boundaries (gating by exception).	Rapid acquisition of high-quality images, obtained with high resolution at five frames/second and using thin slices of 5 mm or less, ensure clear visualization of moving target, without motion artefacts.
	Imaging during online adaptation During plan optimization, advanced imaging protocols can be applied to determine treatment effects.	High-field imaging techniques (proven in state-of-the-art diagnostic imaging) provide the opportunity to truly personalize treatments based on real-time information.
Post treatment	**Treatment assessment** Following dose delivery, the patient can remain on the table for further imaging that may serve as input for subsequent fractions. Advanced high-field MR capabilities, such as functional imaging, may be used to assess treatment efficacy and amend fractionation regimens over the course of the treatment.	Advanced high-field imaging techniques (proven in state-of-the-art diagnostic imaging) provide the opportunity to truly tailor treatments to a patient's treatment response, based on real-time anatomical and biological information.

Table 1
MR images can be obtained at any point before, during or after dose delivery on Elekta Unity

3.1 The benefits of integrated high-field MR imaging

Elekta Unity is the first MR/RT system to provide high-field MR imaging, with image quality comparable to that of MRI scanners used in diagnostic imaging.[24] Elekta Unity will benefit from several distinct features of 1.5T MR imaging technology:

- The algorithms developed to autosegment structures will ultimately depend on image quality. Given the goals of MR/RT (i.e. to localize targets, avoid critical structures and adapt online to inter/intrafraction changes as rapidly as possible), we anticipate that the high image quality and short image acquisition times of Elekta Unity will lead will lead to the most accurate and reliable results.

- High-field MR systems inherently have higher signal-to-noise (SNR)[28] and contrast-to-noise (CNR) ratios than lower field systems. This can lead to higher temporal and spatial resolution of images and faster image acquisition. Higher resolution, also enabled by the use of thin slices, is beneficial for imaging small structures by avoiding partial volumes effects, and higher acceleration factors produce fewer motion artifacts when scanning moving structures.

- High-field MR systems have greater flexibility for sequence utilization, such as high b-value diffusion weighted imaging (DWI) and dynamic susceptibility contrast (DSC), enabling biological MR/RT. Such capabilities may offer advantages in a wide range of circumstances. For example, it has been shown that DWI over the course of a treatment can be used to predict response to treatment.[29]

- Roughly 90 percent of diagnostic MR imaging systems are 1.5T or higher.[30] Consequently, diagnostic radiology research relating to functional/non-functional sequence development, image analysis and response assessment is derived almost exclusively from high-field MR systems. Radiation oncology can more easily benefit from this research when similar high-field MR technology is used in MR/RT.

- MR systems used in radiation therapy treatment simulation and planning are usually high-field (1.5T or 3.0T) systems[31] and consensus recommendations support the adoption of 1.5T units for MR simulation.[7] This allows planning and treatment information derived from such high-field systems to more naturally pair with a high-field MR-linac. Plus, the use of high field systems can accelerate learning curves for clinical staff and enhance consistency in clinical workflows, and potentially allows for an MR-only planning workflow.

3.2 Merging two incompatible technologies: high-field MR imaging and radiation dose delivery

The integration of high-field MR and advanced radiation therapy technologies to allow simultaneous imaging and treatment delivery presented significant physical and technical challenges. Collaboration with clinical experts around the world and diagnostic MR imaging experts at Philips has been key to the successful development of Elekta Unity technology.
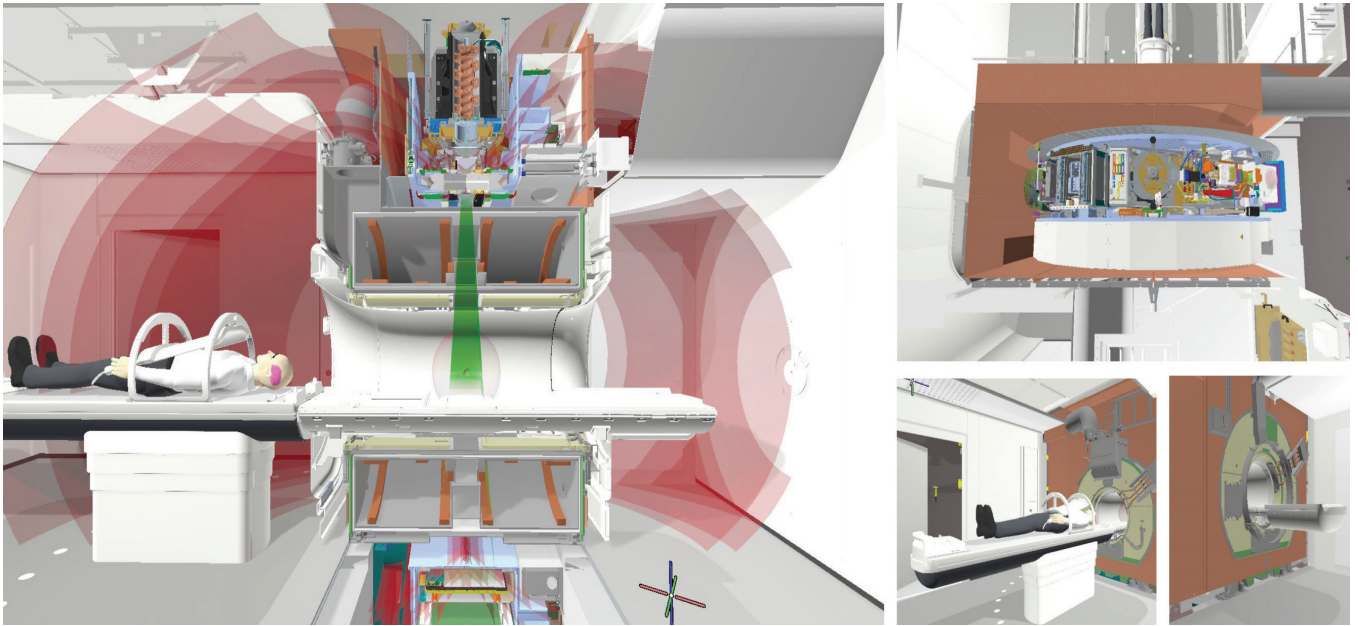
Figure 4
Elekta Unity magnetic coils produce a magnetic field shape (left, red shading) that accommodates the linac beam (left, green shading); the RF cage is integral to the MR scanner (right)

The two main challenges relate to the effect of the magnetic field on radiation beam generation and the mutual effect of strong radiofrequency (RF) fields (produced by both the linear accelerator and the MR scanner) on treatment delivery and image quality.

The high-field MR scanner and linear accelerator maintain their full functionality without compromise.

In order to mitigate the influence of the high magnetic field on the linear accelerator, the active shielding of the MR magnet has been modified to create a concentric low-field area in the middle, which is used to accommodate the linac beam (Figure 4, left) and other magnetically susceptible components. In addition, the RF cage that shields the environment from MR RF signals (normally integrated in the bunker wall in a standard MR imaging room) is an integral part of the MR scanner (Figure 4, right). This isolates the MR scanner from the linear accelerator and other external interference. By the same mechanism, the linear accelerator is isolated from the transmitted RF from the MRI, enabling both systems to maintain full functionality without compromise.

3.3 Treatment planning in a magnetic field environment

The Elekta Unity Monte Carlo-based treatment planning software provides specific intelligence for MR/RT.

With regard to the effect of the magnetic field on dose delivery, the Elekta Unity Monte Carlo-based treatment planning software (TPS)[32] provides specific intelligence for MR/RT and has been validated experimentally.[33] The effects of a magnetic field on dose distributions have been studied extensively[33-41] and depend on a number of factors, including beam energy, tissue density, magnetic field strength, field size and field geometry. Employment of innovative Particle Transport Algorithm (PTA) technology allows Elekta Unity TPS to account for dose effects due to the behavior of secondary electrons in the MR-linac environment, namely the electron return effect (ERE).[42-43]

PTA models the effect of the magnetic field on dose distribution. It also models cryostat and modified scattering, as well as how the beam travels through the coil, patient positioning devices and table.

In addition, optimized beam setups and commonly used delivery techniques, including the use of opposing beams and intensity modulated radiotherapy (IMRT),[39,44] generally compensate for magnetic field dose effects (Figure 5). It has been shown that nearly identical dose distributions, with or without a magnetic field, can be obtained using multiple beam directions in a step-and-shoot IMRT delivery that would typically be employed on Elekta Unity.[37,45]
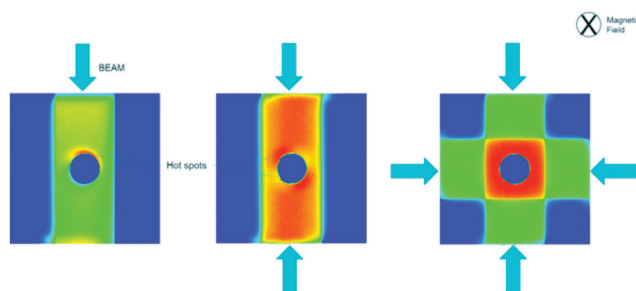

Figure 5

The use of multiple beam directions dramatically reduces the effect of the magnetic field on secondary electrons. Only four beams are enough to make the effect insignificant. Modern IMRT uses seven to nine beams as standard practice. Dose effects in the MR-linac environment are modeled by Particle Transport Algorithm (PTA) technology included in Elekta Unity treatment planning software [Adapted from 35]

Treatment planning studies have demonstrated clinically satisfactory results for 1.5T Elekta Unity treatment of a variety of sites including rectal cancer,[46] lung SBRT,[47] head and neck, prostate cancer[37,48] and partial breast irradiation (APBI) (Figure 6).[40]
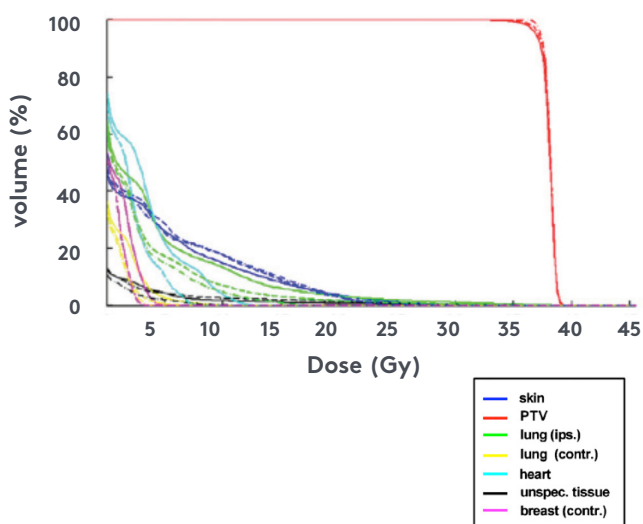
APBI-7

Figure 6

A seven-field IMRT-optimized partial breast irradiation plan was found to be acceptable for Elekta Unity; skin dose effects are negligible

3.4 Online adaptive clinical workflow

Elekta Unity incorporates sophisticated software to enable online adaptive workflows. The system's offline capabilities allow physicians to prepare reference plans in advance and communicate physician intent to the clinical team involved in the treatment delivery. This simplifies online decisions and facilitates the adaptive workflow.

The clinical workflow for online adaptive radiation therapy on Elekta Unity will involve the following steps, as shown in Figure 7, right:

1. MR checks
MR eligibility of the patient is a new concept for radiation therapy. Eligibility must be verified and recorded at the time of consultation, at simulation (if using MR) and at every treatment session on Elekta Unity. MR safety education and training will be required for radiation therapy staff.

2. Patient setup
The simulation process is supported by replicating the Elekta Unity table top in the CT scanner. MR-compatible patient positioning devices are provided. Indexing positions are recorded. A reference plan is generated (CT and/or MR reference data can be used) and provides a starting point for the adaptive workflow. Electron densities for each structure are predefined at this stage to permit dose calculation on the daily MR images. Additional defaults can be set to streamline the online adaptive process.

3. Image acquisition
Image acquisition is based on sequences typically predetermined in the patient's plan of care, without the need for replicating the patient's setup position. The 1.5T MR images provide a wealth of information never before available in the online environment. Elekta software tools streamline and automate the process as much as possible, so that the physician can focus on important clinical decisions.

4. Continuous monitoring
As soon as 3D image acquisition has finished, live 2D motion monitoring images can be acquired continuously in up to three planes at any point in the adaptive and treatment delivery workflow. The anatomical structure(s) of choice is displayed on these images, allowing the user to assess shifts in anatomy and whether intervention is necessary.

5. Image registration
Pretreatment 3D images are automatically registered to the reference image. Depending on the variations in anatomy that are visible and the clinical indication, the user can select the adaptive path to take.

6. Plan adaptation
Different clinical cases have different objectives, depending on the dose being delivered and whether anatomy of interest is subject to deformations. Consequently, Elekta Unity supports two adaptive workflows: Adapt to position, where the reference dose is shifted to the daily target position, is an efficient workflow in terms of time and expertise required in the online environment; adapt to shape, where the dose is adjusted to conform to the daily deformed anatomical structures, is more resource-intense and will improve conformity when high doses per fraction are being delivered.

During plan adaptation, advanced imaging protocols can be applied to collect real-time anatomical or biological information regarding treatment effects on the tumor and surrounding tissue.

7. Dose delivery
Once the user is satisfied that the adapted plan meets the specified criteria, it can be approved for delivery. Additional 3D MR images may be acquired for verification of patient position or for offline analysis.
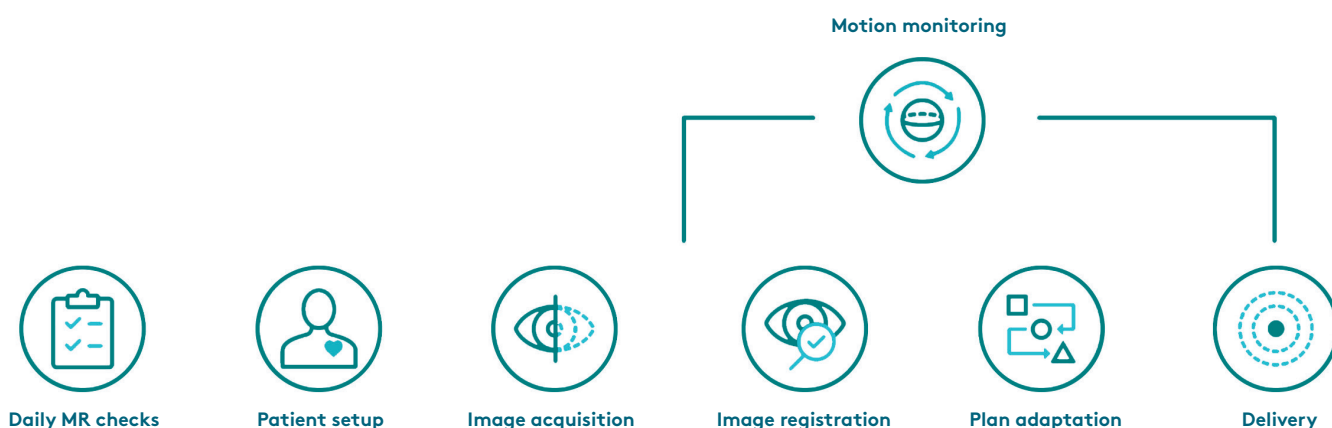
Motion monitoring

Daily MR checks | Patient setup | Image acquisition | Image registration | Plan adaptation | Delivery

Figure 7
Elekta Unity online adaptive radiation therapy workflow

3.5 Achieving clinical accuracy

In 2017, patients were treated successfully on an MR-linac for the first time. Performed using Elekta Unity at the University Medical Center Utrecht, this study demonstrated the accuracy and clinical feasibility of high-precision, high-field MR/RT. Trial subjects were patients with spinal bone metastases. This indication was selected because of the clear benefit of MR imaging for visualizing the tumor in contrast to bone and spinal cord. IMRT plans were created while the patients were on the treatment table using online MR images. The pretreatment CT was deformably registered to these images to obtain Hounsfield values needed for treatment planning.

The feasibility of generating plans that meet or exceed clinical objectives using Elekta Unity has been demonstrated for a number of indications.

In addition, the feasibility of generating plans that meet or exceed clinical objectives using Elekta Unity has been demonstrated for a number of indications. For example, Pathmanathan et al. demonstrated that prostate SBRT IMRT plans are possible for Elekta Unity using PACE trial constraints;[49] Tseng et al. demonstrated that it is feasible to generate stereotactic plans for single brain metastases using Elekta Unity, concluding that the dosimetric impact of the magnetic field is minor and does not negatively impact target conformity or dose gradient;[50] and Bainbridge et al. demonstrated the feasibility of generating plans for locally advanced NSCLC using MR-linac. This group demonstrated the ability to reduce margins with the MR-guided workflow, which could enable increased OAR sparing and isotoxic dose escalation.[16]

Charaghvandi et al. also proposed MR-guided single dose ablative APBI as a potential, non-invasive alternative to breast-conserving therapy. They suggest that in the future, the Elekta Unity targeted approach will allow smaller target volumes, reduce radiation therapy-related toxicity and facilitate dose escalation in the treatment of early-stage breast cancer.[17]

4. Developing the evidence: the Elekta MR-linac Consortium

Evidence to support the use of Elekta Unity is growing fast. The Elekta MR-linac Consortium was established in 2012 by seven internationally renowned cancer centers, Elekta and its MRI technology partner Philips, for the clinically driven development and evidence-based clinical introduction of the device.[51] The input of the consortium ensures that Elekta Unity is designed to achieve clinical and operational needs of radiation oncology departments, and that the new technology can be implemented and used with ease. This group is joined by an expanding community of clinicians, scientists and researchers at more cancer centers, who are committed to an evidence-based introduction. The goal is to optimize MR/RT to improve patient outcomes. Focus is also on optimizing MR image sequences for anatomical and biological MR/RT; patient and machine QA procedures; developing adaptive elements around online treatment planning and image management; and designing the clinical workflow.

A wealth of evidence supporting the use of Elekta Unity in a number of areas has already been published:

- proof of concept[45]
- potential clinical benefits for treating kidney,[52-53] breast,[40] liver,[54] bladder,[20] rectum,[46,55] pancreas and prostate[56]
- the use of Elekta Unity in online adaptive radiation therapy and motion management[21,26,54,57-60]
- rapid and accurate dose calculation[42,44,61-62]
- patient and machine QA[63]
- radiobiological safety[64]
- consensus on pancreas target and OAR definition[65]
- benefits of MLC tracking, e.g. for the treatment of central lung tumors[66]

In addition, disease sites have been prioritized for clinical studies and organized by Tumor Site Group (TSG). A systematic approach was used to identify the indications that benefit most from MR/RT.[67] Prioritized TSG indications currently include prostate, breast, esophagus, lung, gynecological, pancreas, head and neck, brain, rectum, bladder, gastric and liver cancers. Studies have been designed to prove the benefits of MR/RT for these sites. Also, imaging studies on human volunteers are being performed to optimize sequences and to assess the various phases of the Elekta Unity clinical workflow (Figure 8). Clinical data collection in the prioritized disease sites will follow these exploratory studies. An important output from these studies will be a series of Clinical and Technical Profiles (CTP) for each indication studied. These CTPs will serve as "protocols" that can be leveraged by new Elekta Unity users to facilitate the introduction of the technology in their clinical programs.

The expanding Elekta MR-linac Consortium is at the center of a knowledge—sharing clinical community aimed at further exploring and implementing the full benefits of MR-linac-based MR/RT.

As the field of MR/RT advances and Elekta Unity install-base grows, the international Elekta MR-linac Consortium will continue to serve as the center of a knowledge-sharing clinical community aimed at further exploring and implementing the full benefits of MR-linac-based MR/RT.
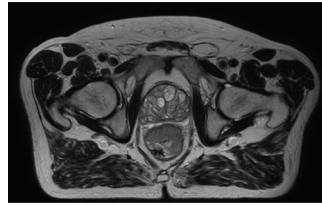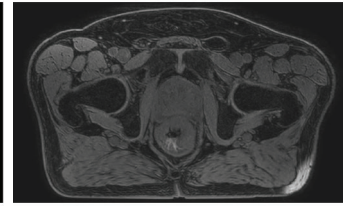
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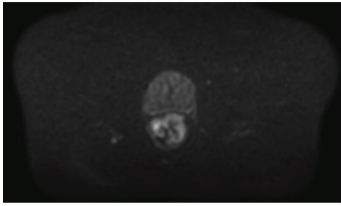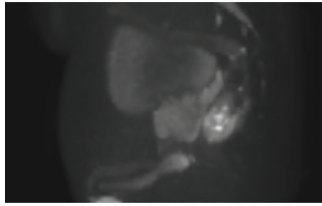
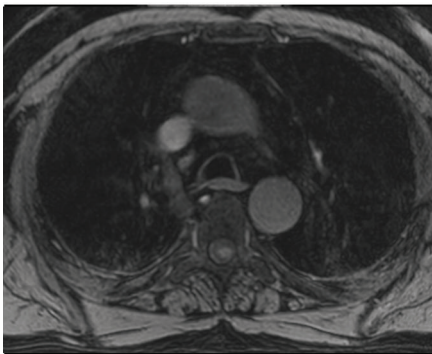DWI (EPI), b 800–TE 90 ms, 4 mm Sl. Thck   DWI (EPI), b 800–TE 90 ms, 4 mm Sl. Thck T_2w, TE 140 ms, 3.5 mm Sl. Thck, 1.1 mm x 1.1 mm   T1w, mDixon, 2.3 mm Sl. Thck, 1.1 mm x 1.1 mm
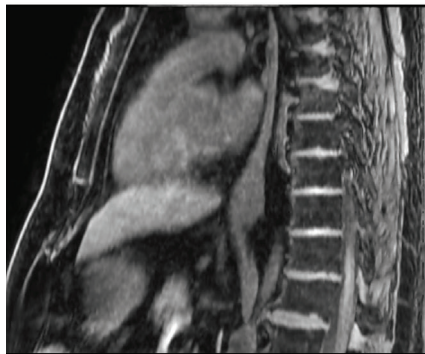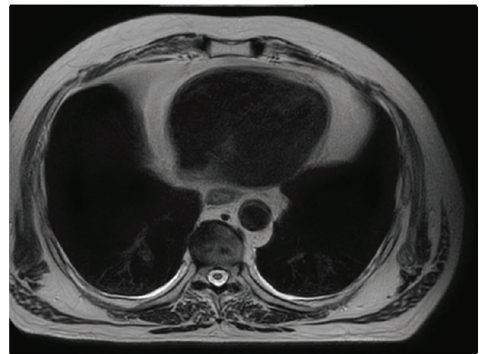
Esophagus

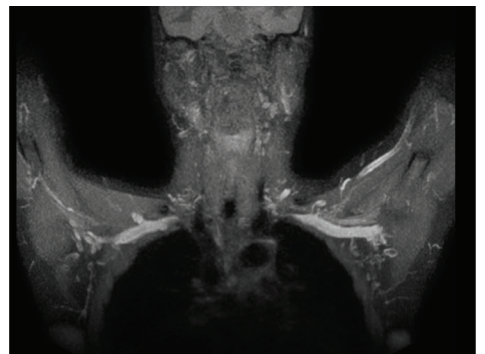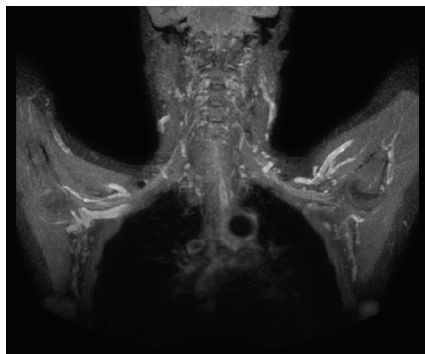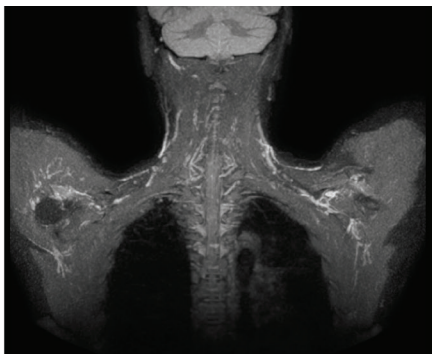T_1w, mDixon, 2.3 mm Sl. Thck, 1.1 mm x 1.1 mm T_1w, mDixon, Sag. reconstruction T_2w, TE 140ms, 3.5 mm Sl. Thck, 1.1 mm x 1.1 mm

Axilla

3D T2w STIR, 1.5 mm Sl. Thck, 1.5 mm x 1.5 mm

Figure 8
Volunteer patient images captured on Elekta Unity; images courtesy of University Medical Center Utrecht

5. Elekta Unity equipped for the needs of today and tomorrow

Elekta Unity is fully equipped to build on the most advanced radiation therapy techniques that are available today and explore new possibilities in radiation therapy. These include: clinical efficacies and new indications; the possibility of online functional imaging for biological MR/RT; expansion of the use of online data analytics; and the fast-emerging use of artificial intelligence applications for treatment decision support.

Elekta Unity is uniquely positioned to address future biological response-based MR/RT.

The high-field functional MR imaging capabilities of Elekta Unity create the potential to obtain deeper insight into biologic and cellular activity within tumors, assess treatment response and amend fractionation regimes during the course of treatment. Many studies are underway to substantiate the use of functional imaging during radiation therapy and the systems dedicated to this research are largely 1.5T and 3.0T.[31] As we learn more about the interpretation and use of functional and quantitative imaging in diagnostic radiology, it may be desirable to exploit these capabilities in the radiation therapy delivery domain. MR data from elsewhere in the patient journey will be more readily interpreted, fused and coregistered on a high-field MR-linac. Plus, high-field MR imaging enables the use of functional and spectroscopic sequences that are more difficult to perform using low-field systems. The ability to do this in time frames and with image quality that best meet online adaptive treatment delivery requirements make Elekta Unity uniquely positioned to address the needs of both currently emerging anatomical MR/RT and future biological response-based MR/RT.

Conclusion

Elekta Unity combines advanced linear accelerator technology with high-field MR-imaging and a collaborative and highly systematic approach to clinical introduction. The whole of this powerful system is far greater than the sum of its parts. It is uniquely positioned to overcome many of the challenges that currently limit the continuing evolution of IGRT and introduce advanced online adaptive radiation therapy. The high-field Elekta Unity will enable diagnostic-standard soft tissue visualization at the time of treatment, as well as providing opportunities for direct motion monitoring and treatment adaptation based on day-to-day real-time anatomical and biological information.

Elekta Unity has the potential to improve clinical outcomes by taking full advantage of online adaptive radiation therapy.

By reducing treatment uncertainties associated with the current spectrum of radiation therapy technologies and by allowing more precise CTV coverage and improved OAR sparing, Elekta Unity is expected to reduce treatment toxicity and improve clinical outcomes.

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