time, the MILP plans exhibit slightly higher V100. Contrarily, DOPSA displays fast and steady convergence.

Caption:
Solution quality (percentage of the target volume receiving the prescribed dose, V100) versus computation time for the proposed algorithm (DOPSA) and existing algorithms (IPIP, MILP). Data for three patients, averaged over 250 replications each.

Conclusions: Our local search algorithm optimizes DVH-criteria and is extendable to additional DVH-constraints. Furthermore, our algorithm outperforms an existing general purpose solver-based algorithm and is generally advantageous in terms of computation speed.

**OC-0093**
Quantification of deformations on 3T MRI for the Utrecht Interstitial CT/MR brachytherapy applicator
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**Purpose/Objective:** MRI is often used in brachytherapy treatment planning of gynaecological cancers. Magnetic field strengths of 1.5T are typically used, as image distortions caused by inhomogeneities of the main magnetic field (Br) are considered acceptable. Lately, there has been an increased interest in 3.0T MRI, as it leads to a higher signal to noise ratio. However, distortions become more pronounced with increasing field strengths. Because little is known about the magnitude of image distortions on the applicator and patient at 3.0T MRI, the aim of this study was to quantify deformations of the Utrecht Interstitial CT/MR applicator (Elekta Brachytherapy) at 3.0T using a homogeneous phantom.

**Materials and Methods:** We built a MRI-compatible phantom that simulated the applicator in water (Fig 1A) and scanned it on a Philips Ingenia 3.0T MRI. Multi-echo images were acquired and from these we calculated a frequency shift (Δf) map of the spins by unwrapping phase differences between two echoes. This map, as a sequence independent measure of image distortions, allowed us to calculate the theoretical shift (Δx) along the length of the intrauterine device for any MR-sequence. T1-weighted images (voxel size 0.75x0.75x3.5mm3, BW-200Hz/voxel) were also acquired. Two scans were obtained using opposing read-out directions as deformations occur primarily in this direction. By rigid matching of these images we determined the applicator shift (Δxmeas) that was caused by deformations, for three different positions along the length of the intrauterine catheter. The theoretical Δx determined from the T1-weighted scan protocol parameters and the Δf map were compared to Δxmeas to verify whether the Δf map can be used to calculate Δx.

Finally, the Δf map of the cervix was acquired in a healthy volunteer without the applicator to determine the susceptibility artifacts in vivo and calculate the mean Δx using the same parameters as used in our T1-weighted sequence.

**Results:** In the phantom, Δf decreased towards the ovoids (Fig 1B), resulting in average Δx=0.29±0.05mm in front of the tip, Δx=0.10±0.04mm at mid intra-uterine and Δx=0.05±0.04mm near the ovoids (Fig 1C). By matching the images with opposing read-out directions on the phantom, the measured shift was 0.1 mm at most, at the tip of the catheter. A mean Δf of 0.36±0.24 mm was found in vivo near the cervix. The Δf spread (1SD) determined in vivo was considerably larger than the spread found in the phantom (76 Hz vs. 41 Hz, Fig 1D).

**Conclusions:** Our phantom study showed that deformations using 3.0T MRI on the applicator are small compared to the imaging pixel size. The range of Δf in the female pelvis without applicator is large compared to the phantom with applicator, as the phantom provides a more homogeneous Br than the anatomy of the patient. However, the determined theoretical shift was found to be small near the cervix (mean 0.36 mm).

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**OC-0094**
Commissioning of a titanium Fletcher applicator for 1.5T and 3T MRI-only based cervical brachytherapy
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**Purpose/Objective:** Development of MR scan protocols for 1.5T and 3T MRI-only based treatment planning using a titanium Fletcher applicator for combined intracavitary and interstitial cervical brachytherapy. Scan protocols were optimized to allow geometrically accurate anatomical delineation and applicator reconstruction, while respecting MR safety limits.

**Materials and Methods:** The MR-conditional/CT-compatible applicator (Fletcher-style, Varian) with titanium intrauterine and ovoid probes and plastic (PEEK) needles was positioned in gel phantoms with plastic markers as reference points. The composition of the phantoms was prepared such that T1 and
T2 relaxation times corresponded to cervix tissue at 1.5T and 3T.\textsuperscript{1,2} MRI scans were performed on a 1.5T Ingenia and a 3T Achieva Philips system using 2D Spin Echo (SE) and 3D Spoiled Gradient Echo (SPGR) sequences. CT scans were acquired using our standard clinical protocol and were used as the gold standard for applicator reconstruction. Geometrical distortion was quantitatively assessed after non-deformable MR to CT image registration.

**Results:** On both 1.5T and 3T the multiplanar T2-weighted SE scans provided good soft tissue contrast. However, on 3T, the T2-weighted SE scans showed detrimental distortion artifacts, making them unsuitable for accurate anatomical delineation and applicator reconstruction. On 1.5T, these artifacts were significantly reduced and the image quality was expected to be adequate for delineation. For applicator reconstruction a new 3D sequence with an extremely short TE was developed called '3D_applicator', based on the SPGR sequence by Petit et al.\textsuperscript{1} The intrauterine and ovoid probes, as well as the needles were clearly visualized using this sequence (Figure 1). The total scan time of the MRI protocol, consisting of a survey scan, three multiplanar T2-weighted SE scans and the '3D_applicator' scan, was less than 17 minutes. The specific absorption rate (SAR) of all sequences was amply below the limits set by the applicator manufacturer.

**Conclusions:** For 1.5T MRI a high image quality scan protocol was developed that allows for accurate MRI-only based treatment planning of combined intracavitary and interstitial cervical brachytherapy with a titanium Fletcher-style applicator. For 3T, such a protocol remains to be established.

**References**


**Award Lecture: Van der Schuurn Award Lecture**

**SP-0095**

Access to evidence-based radiotherapy in Europe 2020 – are we on the right track?

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Radiotherapy is an important modality in the multidisciplinary approach towards cancer; and it is the vision of ESTRO for the 2020 horizon that “Every cancer patient in Europe will have access to state-of-the-art radiation therapy, as part of a multidisciplinary approach where treatment is individualized for the specific patient’s cancer, taking account of the patient’s personal circumstances” But how many patients should receive radiotherapy, and what is the current access to state-of-the-art radiotherapy resources in the European countries? And how will these parameters evolve towards 2020? These topics are currently addressed in the ESTRO Health Economics in Radiation Oncology (HERO) project. HERO has the overall aim to develop a knowledge base of the provision of radiotherapy in Europe and build a model for health economic evaluation of radiation treatments at the European level. The current access to radiotherapy resources in Europe were recently documented by HERO in collaboration with the European national radiotherapy societies. High income countries especially in Northern-Western Europe are well-served with radiotherapy resources; other countries are facing important shortages of equipment in general and especially machines capable of delivering high precision conformal treatments (IMRT, IGRT). Despite these variations, the results demonstrated a considerable positive evolution in radiotherapy resources since the ESTRO-QUARTS study in 2005, with higher equipment levels and lower patient loads per unit of equipment or per radiotherapy professional than recommended a decade ago. This evolution has not been the same in all European countries, which to some degree explain the variation seen between countries.

Planning for the optimal radiotherapy service on e.g. a national level is a challenge. First of all, detailed estimation of the projected need for radiotherapy, in terms of number of cancer patients requiring radiotherapy now and in the future, is required. This involves merging epidemiological data with evidence-based clinical decision trees. Secondly, solid data on the anticipated throughput (patients per machine, with relevant staff) is needed. Productivity and efficiency is variable from country to country, and is dynamically changing as novel techniques and equipment are introduced. Despite these challenges, early planning is needed as it takes several years from the decision to build or extend a radiotherapy facility is made to the first patient can be treated: equipment must be procured, installed and commissioned, and the staff properly educated. A particularly difficult example is planning for particle radiotherapy, where the indications and future needs are more uncertain, the capital costs higher and the construction times much longer than for conventional radiotherapy.

The need for radiotherapy, expressed in terms of the proportion of cancer patients who will have an evidence-based indication for radiotherapy, is not straightforward to assess. The Australian CCORE studies have indicated that about 50% of all cancer patients will at some point in their disease need radiotherapy. In a recent HERO study these estimates have been refined with details about tumor site and stage relevant for each of the European countries. The results indicate that 51% of the 3.4 million new European cancer patients in 2012 were candidates for radiotherapy. A comparison to the actually delivered radiotherapy courses published in the HERO studies revealed that the optimal benchmark is not met in the vast majority of countries, not even the most affluent and well-served countries.

In conclusion, despite improvements in equipment and staffing there is today still a significant underutilization of radiotherapy in most European countries. Combined with the anticipated significant increase in new cancer cases over the next years, this unmet need represents a real challenge to the ESTRO vision for 2020. There is still a long way before every cancer patient in Europe will have access to state-of-the-art radiotherapy.

**Symposium: Palliation towards the future, it is time for individualised treatment**

**SP-0098**

Prediction of prognosis and outcome after palliative radiotherapy; the scientific basis for tailored care