the aim to improve loco-regional control and survival, however not at the expense of treatment related morbidity. Besides nodal disease detection, monitoring nodal disease during treatment provides a remaining challenge. Node positions and volumes can change during the course of treatment asking for EBRT strategies that are able to follow these changes in order to allow tight treatment margins. Unfortunately the visibility of lymph nodes on cone beam CT images is limited and shifted and shrunken lymph nodes can be missed. The superior soft tissue contrast of MRI based position verification as realized in the concept of integrated MRI and linear accelerator (MR-Linac) decreases the uncertainties around nodal disease development during the course of radiotherapy, allows a more precise definition of novel target volumes and enables lower margins and might allow an additional boost to individual lymph nodes. Currently, an MR-Linac system is built at the radiation oncology department at the UMC Utrecht, bringing the ultimate combination of MRI guided brachytherapy, advanced adapted external beam treatment with concurrent cisplatin based chemotherapy and MR-Linac treatment for nodal disease within reach for the treatment of patients with advanced cervical cancer.

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Clinical implementation of ART for cervix
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For patients with cervical cancer, despite the improved dose conformity enabled by IMRT and VMAT, sparing of bladder, rectum and small bowel is still challenging because all organs at risk (OAR) in the pelvic area change shape and position on a daily basis due to variations in filling. With the introduction of cone-beam CT scanners it became possible to observe the internal organ variations of patients during each treatment fraction. Theoretically, this enables re-adaptation of plans according to tumour shrinkage and changes in OAR morphology, resulting in reduction of toxicity [1,2] and better target coverage. Full online plan adaptation requires that re-delineation, re-optimizing of dose distributions and repetition of all legally required quality assurance steps should be performed in a few minutes. These workload intensive procedures would require a high degree of automation and workflow-integration that is currently absent in off-the-shelf products. Nonetheless, by finding a well-balanced compromise between full automation and degree of plan adaptation, it is possible to apply a simplified scheme of adaptation that provides improved adaptation. Based on our own experience and that of other research groups [3], patients can be divided into two groups: the first group consists of patients who show uterus motion as a function of bladder filling (called “Movers”) and the second group are those patients whose uterus position stays relatively stable, regardless of bladder volume (“Non-Movers”). With a model for the uterus position, a pre-determined set of plans (library) can be constructed for the “Movers” and the most appropriate treatment plan can be selected on a daily basis with the help of CBCT scans, while for the “Non-Movers” a single plan will suffice. A strategy with multiple plans made prior to treatment tailored to a range of possible shapes can mitigate the variations in target volume, by selecting the best-fitting plan based on daily Cone Beam CT (CBCT) scans. This strategy has been successfully applied in the treatment of bladder and cervical cancer where bladder filling is the predominant factor of shape changes. To create multiple plans a full and empty bladder pretreatment CT scan is acquired from which a patient specific motion model is derived which is used to create intermediate target volume structures.

Implementation of daily plan selection in rectum
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The standard of care for non-metastasized locally advanced rectal cancer is chemo-radiotherapy combined with surgery. Sparing the organs at risk (OAR) with the use of state-of-the-art planning techniques like intensity-modulated radiation therapy (IMRT) or volumetric modulated arc therapy (VMAT) is compromised by the large population-based margins that are necessary to compensate for the shape changes of the target volume over the time of treatment. In rectum patients, day-to-day variation in rectum and bladder filling often causes large deformation of the target volume, especially the mesorectal fat (mesorectum), which cannot be corrected for with a table adjustment. Minimizing shape changes with the use of drinking protocols to manage bladder filling or dietary instruction to manage bowel motion have been unsuccessful. A strategy with multiple plans made prior to treatment tailored to a range of possible shapes can mitigate the variations in target volume, by selecting the best-fitting plan based on daily Cone Beam CT (CBCT) scans. This strategy has been successfully applied in the treatment of bladder and cervical cancer where bladder filling is the predominant factor of shape changes. To create multiple plans a full and empty bladder pretreatment CT scan is acquired from which a patient specific motion model is derived which is used to create intermediate target volume structures. In rectum cancer, however, shape changes are mostly driven by changes in rectum volume and shape and to a much lesser extent by bladder filling. Because of this creating multiple plans based on varying bladder filling is not useful. Therefore our strategy to create multiple plans for plan selection is to apply different PTV margins to the ventral side of the mesorectum based on a single CT scan. This will also cope with the shape changes that are encountered. Plan selection based on daily Cone Beam CT (CBCT) images require adequate visibility of the regions of interest. In the pelvic region CBCT image quality can be hampered by imaging artefacts caused by moving air or bowel. At the same time identifying the boundaries of a complex target volume such as the target volume for rectum cancer can be challenging. Uniform plan selection is realized by participation in an observer study where all observers