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|---|---|
| Name (First, last) | Ellis Beld |
| Mailing address (including province/state, country, postal/zip code) | Postbus 85500, 3508 GA, Utrecht, The Netherlands |
| Institution/organization | Department of Radiotherapy, University Medical Center Utrecht |
| Position | PhD candidate |
| Telephone (including country prefix) | +31 88 75 69646 |
| Email | e.beld-2@umcutrecht.nl |

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**PRESENTATION TITLE**

**Towards real-time MR-guided high-dose-rate brachytherapy**

**AUTHOR(S)**

Ellis Beld[1], Peter R. Seevinck[2], Max A. Viergever[2], Jan J. Lagendijk[1], Marinus A. Moerland[1]
[1]*Department of Radiotherapy, University Medical Center Utrecht, Utrecht, The Netherlands*
[2]*Image Sciences Institute, University Medical Center Utrecht, Utrecht, The Netherlands*

**ABSTRACT**

**Purpose:** MRI is recommended for guidance of high-dose-rate (HDR) brachytherapy. MRI provides high soft tissue contrasts, guidance of interventional procedures and visualization/detection of interventional devices. This study describes the development of an MR-guided HDR brachytherapy treatment set-up where the patient remains in the MR bore (and thus in the same position) during the complete process of source dwell position reconstruction, treatment planning and irradiation while MR images are acquired to guide the process.
**Materials&methods:** ***HDR source localization*** We applied a recently described method for MR-based localization of the HDR source[1]. Source localization is accomplished by simulation of the MR artifact induced by the HDR source, and template matching between the MR image and the simulated artifact. This technique enables time scales on the order of real-time localization due to short dynamic scan times and fast reconstruction/post-processing[1].
***MR conditional afterloader*** A prototype MR conditional afterloader was previously developed and tested[2]. This afterloader is an RF shielded prototype provided with a plastic source cable and steel dummy source, which allows simultaneous MR acquisition and employment of the afterloader.
***Phantom study*** A demonstration of the simultaneous MR acquisition and application of the prototype MR conditional afterloader was performed in a phantom study, followed by the above described HDR source localization (for now as a post-processing step), see Figure 1 for more details.
***Clinical workflow*** Figure 2a presents a workflow diagram of the actions performed clinically in our department. We propose a new and improved clinical workflow that includes the above described techniques for MR guidance. This could be performed inside our MRI brachytherapy suite: a bunker suitable for a future treatment set-up with MRI guidance during dose delivery.
**Results&discussion:** Figure 1 demonstrates the ability of applying the prototype MR conditional afterloader for simultaneous stepping of the source and MR acquisition, as well as the source positions determined from the MR images. Figure 2b presents the newly proposed workflow of an MR-guided treatment, where HDR source localization is applied for automatic dwell position reconstruction and (real-time) treatment verification. This workflow eliminates most manual interactions (manual catheter reconstruction and visual catheter positions check) and eliminates repeated movements of the patient table in/out of the MR bore. The proposed treatment set-up offers expected advantages

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important for the treatment quality and the practical clinical workflow. The patient remains in the same position during MR imaging/source position reconstruction, treatment planning and irradiation. The treatment is more accurate (direct source position reconstruction, less motion) and less time-consuming (more automated steps). A decreased number of manual interactions leads to a decreased chance of errors and an easier workflow. Furthermore, possible errors could be detected, such that the treatment can be interrupted when necessary.

**Conclusions:** We proposed an MR-guided HDR brachytherapy workflow where we apply MR-based source localization for reconstruction of the source dwell positions and treatment verification, employing an MR conditional afterloader (currently in development). This workflow allows positioning of the patient in the MR bore during treatment, eliminating additional patient movements and leading to a more straightforward clinical workflow.

**References:** 1.E. Beld et al. Proc. Intl. Mag. Reson. Med. 23 (2015) 4151; 2.E. Beld et al. Radioth. Oncol. (2017) 123:S141-S142.

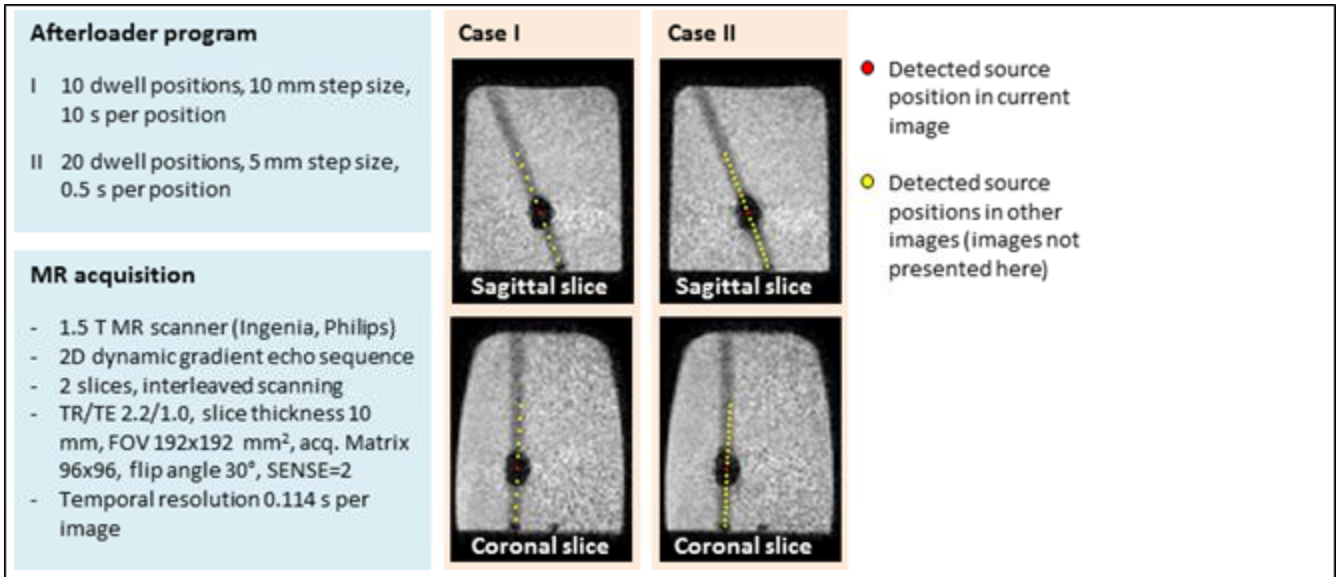


**Figure 1.** A phantom study was performed to demonstrate the simultaneous MR acquisition and employment of the MR conditional afterloader. The afterloader was programmed for two different cases (case I and case II) and MR images were acquired on a 1.5 T MR scanner. The images present the MR images acquired while the afterloader was in use, plus an overlay of the detected source positions from the MR images (current image in red, other images in yellow).

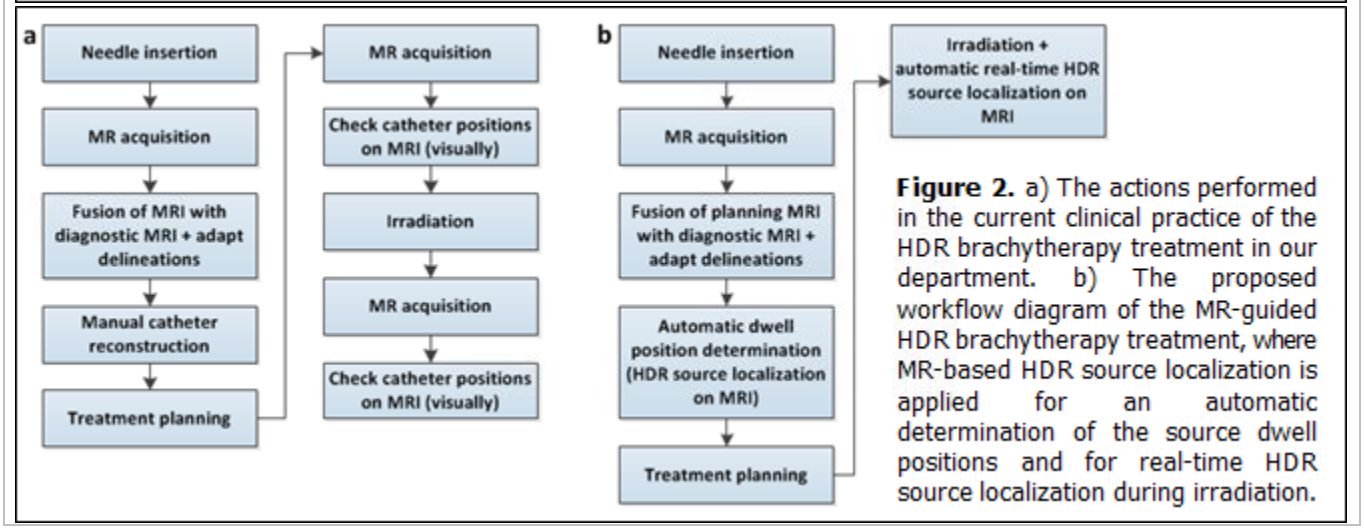


**Figure 2.** a) The actions performed in the current clinical practice of the HDR brachytherapy treatment in our department. b) The proposed workflow diagram of the MR-guided HDR brachytherapy treatment, where MR-based HDR source localization is applied for an automatic determination of the source dwell positions and for real-time HDR source localization during irradiation.