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PRESENTATION TITLE
MR-guided needle implant device for HDR brachytherapy: in air and phantom measurements of spatial accuracy.

AUTHOR(S)
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ABSTRACT

Purpose: A robotic needle implant device for high dose rate (HDR) prostate brachytherapy is being developed at the University Medical Center Utrecht. The purpose of this study was to measure the accuracy of the robot needle angulation and to test the image-based workflow.

Materials & Methods: The needle implant device is MR conditional and allows online MRI guidance during needle insertion. The robot fits in a 1.5 T MR scanner and can be placed between the patient’s legs. The needle is stepwise inserted using a pneumatic-tapping device to reduce prostate deformation and thereby improve needle trajectory control. The tapping part can angulate and rotate around its length axis. Alignment is such that the rotation point is near the needle tip at the patient’s perineum. From this point the needle can be inserted at different angles to have access to the prostate while avoiding the pubic bone.

As a preclinical test the accuracy of the needle angulations was tested in air and in an agar phantom with plastic spheres that served as target points. For the in-air measurements, the needle was inserted into a styrofoam slab phantom with mm grid paper attached, at a distance of 120 mm (average prostate depth from perineum). Target points were chosen and required arc and axis angles were calculated and set for needle insertion (fig 1a). From these measurements, corrections to adjust for errors in robot alignment (e.g. caused by sag) were calculated. Next, phantom measurements were performed in a 1.5T MR scanner (fig 2a). The phantom consisted of a water-based 20 g/L agarose gel mixed with 25 mg/L MnCl2. In the phantom a 3D printed structure was placed. This structure constituted of 5 spheres (diameter 3 mm) on thin pillars. First, the target position (one of the spheres) was visualized and measured on a 3D MRI scan, then the required robot angulation was calculated taking the aforementioned corrections into account. Subsequently, the needle was
inserted under continuous monitoring using 2D cine-MRI. Finally the target and needle position were visualized using a 3D MRI measurement (resolution 0.5x0.5x2 mm). All image-based measurements were performed using our clinical delineation and visualization program (Volumetool).

**Results:** The uncorrected in-air measurement data showed deviations amounting 5.0±1.6 mm (mean±1st dev). Misalignment of the needle could be partially corrected with an offset in the arc angle. Furthermore, a sag of the robot tapping part could be reduced by applying a shift that is linearly dependent on the set y-coordinate. With these 2 corrections, the deviations were reduced to 0.5±0.3 mm in the in-air measurements, see figure 1b. Using this correction algorithm, three MR guided needle insertions in the MR scanner were performed with three different spheres as targets. The MRI phantom measurements showed deviations amounting 2.5-3.6 mm measured as target-to-needle distance (figure 2b).

**Conclusions:** The use of the MR-guided robotic device for accurate needle placement seems feasible. After correction for systematic alignment errors, the deviations between set and measured target points were in the range of 2.5-3.6 mm in an agar phantom. We anticipate that the tested image-based workflow is also feasible for in vivo validation of the robotic device.