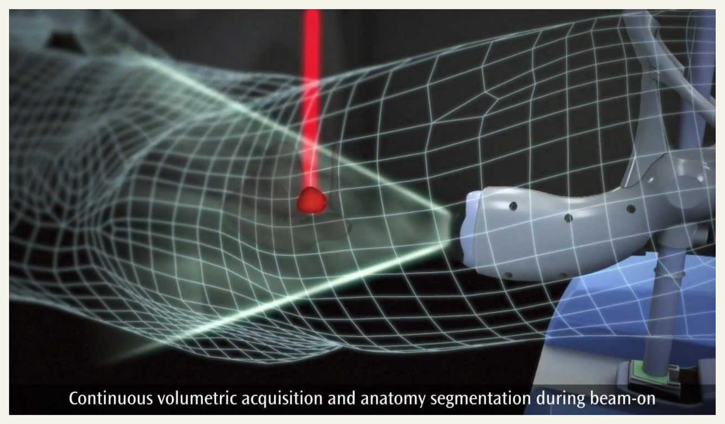
Assessment of intrafraction prostate movement based on ultrasound monitoring



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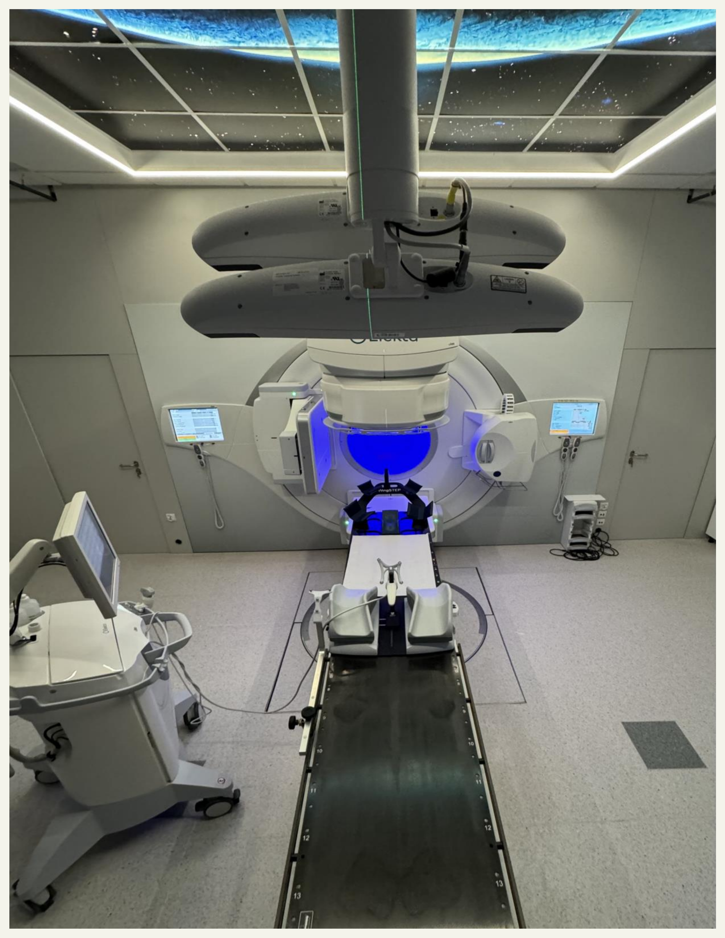

INTRODUCTION

The basic assumption in radiotherapy is the precise delivery of the prescribed dose to the volume of the tumour. Therefore, it is important to control the position of the target during exposure (intrafractional movement) and determine the occurring shifts. This is particularly important in the case of irradiation of the prostate, which is surrounded by the organs at risk (rectum, urinary bladder). One method of checking the position of the prostate is ultrasound monitoring. In our study, we determined the location of the prostate in patients undergoing conventional and hypofractionated therapy, using 4D ultrasound monitoring. The aim of the analysis was to detect the intrafractional prostate movement and determine the frequency, duration and size of the dislocation during irradiation.

METHODS AND MATERIALS

The Clarity® Autoscan (Elekta) Transperineal Ultrasound (TPUS) system was used to monitor 4D prostate movement in real time during treatment. TPUS monitoring data were assessed for 131 fractions for 10 patients (32 trajectories for 5 patients who underwent hypofractionated radiotherapy with dose per fraction 6 and 6.1Gy and 99 for 5 patients treated conventionally with 2.7 and 2.75Gy per fraction). The ultrasound system was used for intrafraction monitoring along the 3 directions: superior-inferior (SI), left-right (LR) and anterior-posterior (AP). Intrafraction prostate displacements exceeding thresholds of 3mm and 5mm were assessed for frequency and duration of motion.

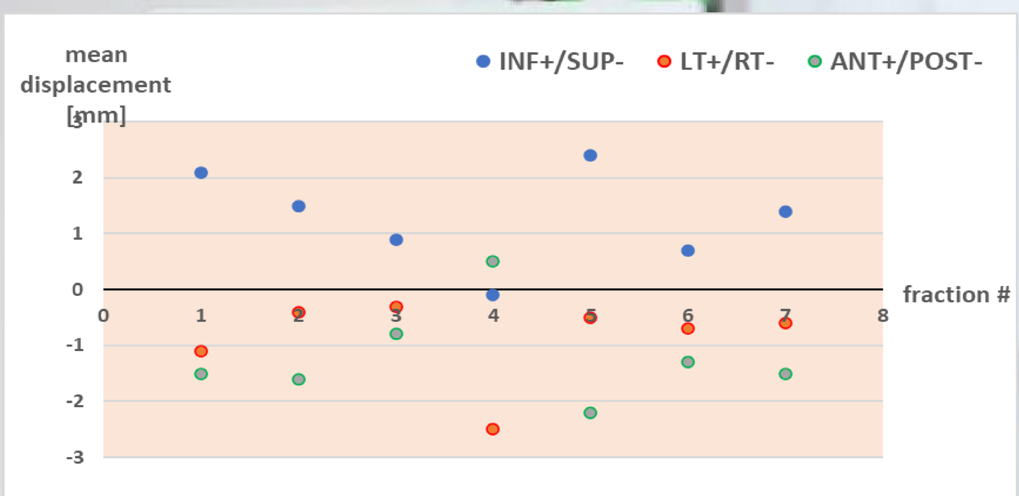

Chart 1. Mean displacement during hypofractionated treatment for an example patient

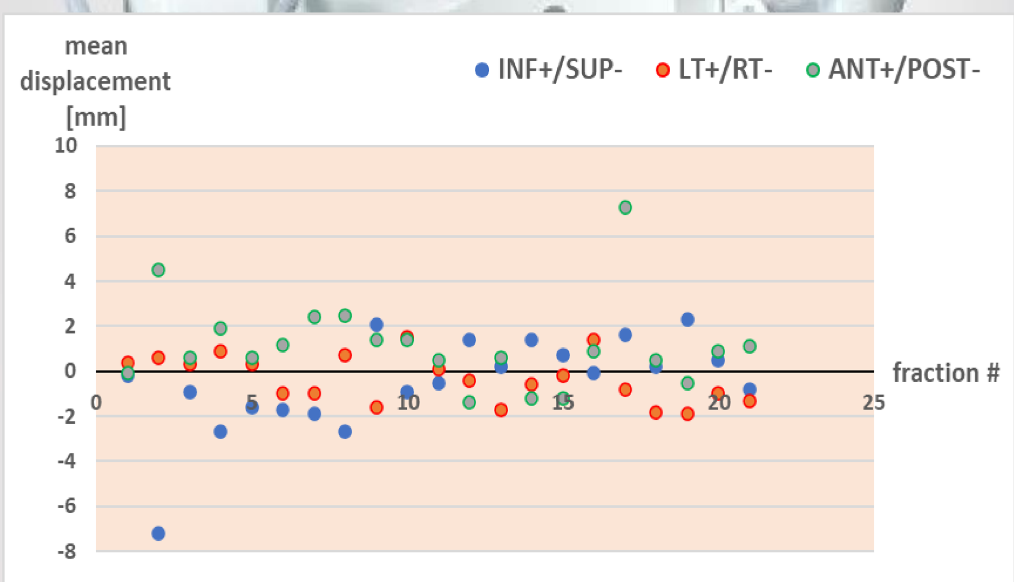

Chart 2. Mean displacement during conventional treatment for an example patient

RESULTS

Prostate motion exceeded the 3 mm threshold during 9 of 32 fractions in patients receiving hypofractionated radiotherapy. For 3 of the 9 cases, the displacement was greater than 5 mm. Movements exceeding 5 mm lasted 50%, 27% and 2% of the irradiation time and occurred only during one fraction, suggesting unusual mobility during this one fraction of irradiation

The displacement greater than 3 mm occurred in 35 of 99 fractions in patients receiving conventional radiotherapy. Exceeding the 5 mm threshold, which lasted an average of 31% of the treatment time (ranging from 4% to 91%), was found in 20 of 35 fractions. Only for one fraction a shift exceeding 5 mm was recorded twice.

The mean prostate displacements of (0.6 ± 0.78)mm, (-0.3 ± 0.64)mm and (-1.0 ± 1.1)mm in the SI, LR and AP directions were determined, respectively for hypofractionated radiotherapy and (0.5 ± 1.1)mm SI, (0.0 ± 1.6)mm LR and (-0.4 ± 1.3)mm AP for conventional radiotherapy.

The recorded movement of the prostate during irradiation was limited to the area defined by the applied margin for each patient and for each fraction.

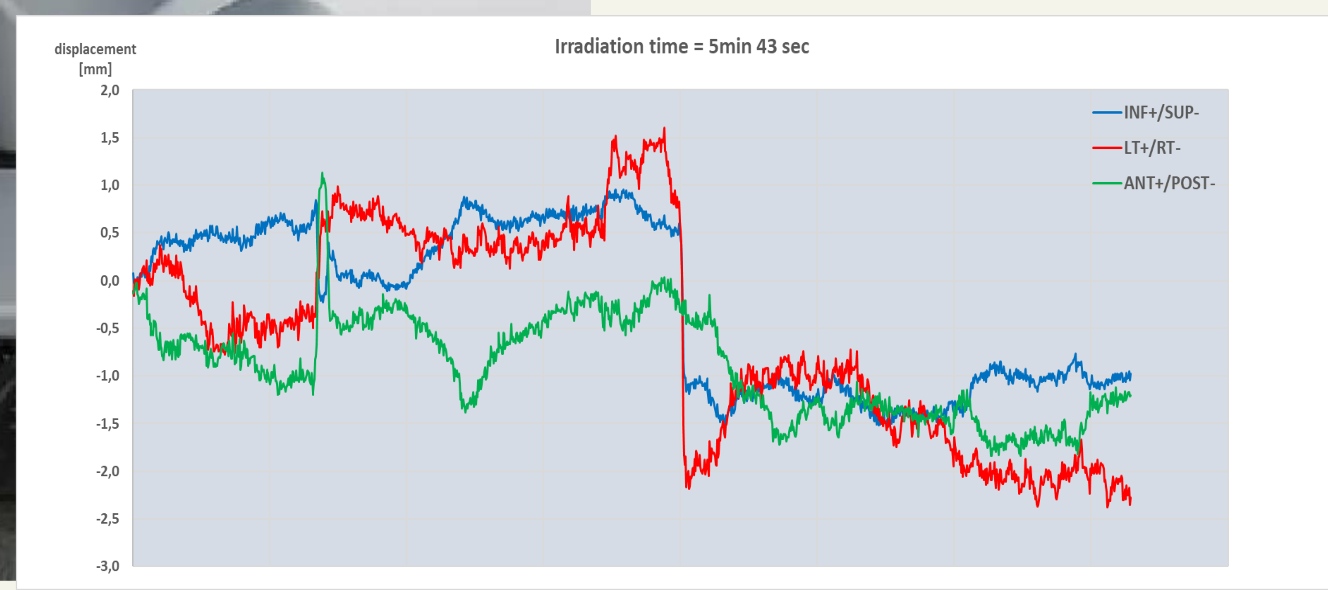

Chart 3. Displacement during a single fraction of irradiation for an example patient

CONCLUSIONS

Intrafraction ultrasound monitoring can increase the accuracy of determining prostate displacement during both conventional and hypofractionated radiotherapy.

Our study confirmed the correctness of the margins used in both therapies. However, it was found that despite small values of average displacements, displacements exceeding 5 mm associated with intrafraction motion are significant. The results suggest the need to expand research to a large group of patients.

The study identified cases in which prostate displacement during fractional irradiation exceeded the accepted margins. This may be due to many factors, most likely a change in pelvic muscle tone that occurred after the initiation of irradiation. This type of displacement cannot be corrected during patient positioning and is only visible when monitoring intrafraction motion. Ultrasound monitoring therefore allows for individual verification of the correct positioning of patients who experience unusual changes in the position of the prostate during irradiation. This may result in a decision to change the size of the margins and implement a new treatment plan.

It should be mentioned that ultrasonic monitoring also allows for the use of motion correction during exposure. This is most beneficial for patients with extremely frequent changes in the position of the prostate who require individual treatment.

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