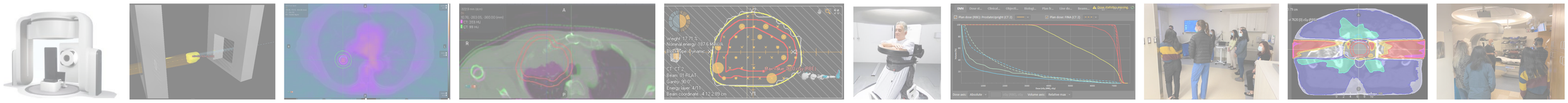

Anatomic and Dosimetric Comparison of Photon-based Supine and Proton-based Upright treatments for Prostate Cancer Patients

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Background

MEVION S250-FIT™ is an ultra-compact proton therapy system that can fit in a photon vault. It features a horizontal proton beam coupled to an upright patient positioning system (Figure 1) and diagnostic fan beam CT, Marie® (Leo Cancer Care).

As our institution prepares to commission the world's first clinical installation of this system, we conducted an evaluation of anatomical and dosimetric differences between conventional photon-based supine treatments and novel proton-based upright treatments for prostate cancer patients

Aims & Objectives

The aim of this study was to 1) compare anatomical differences between patients planned for prostate cancer treatment in an upright vs supine position and 2) dosimetric differences between standard supine VMAT-based treatment vs supine proton-based treatment.

Methodology

Six MRI scans were obtained from three healthy volunteers, with one scan taken in the upright position and one in the supine position for each subject. Corresponding synthetic CT scans were generated for each position and used for contouring and treatment planning.

The clinical target volume (CTV) included the prostate and 1 cm of the proximal seminal vesicles, while the planning target volume (PTV) encompassed the CTV with a 7-mm uniform margin, except 5-mm posteriorly.

VMAT plans were created for the supine scans in the Eclipse treatment planning system (TPS) with our clinically used autoplanning scripts. Each VMAT plan included 2 full arcs and was normalized to achieve 95% PTV coverage at 7020 cGy.

Robust (3.5% density uncertainty and 5 mm uniform position uncertainty) proton plans were developed for the upright scans in the RayStation TPS using 2 lateral beams, with normalization to ensure that 98% of the CTV received 7020 cGyRBE.

Anatomical and dosimetric parameters were compared across photon-based supine and proton-based upright plans.

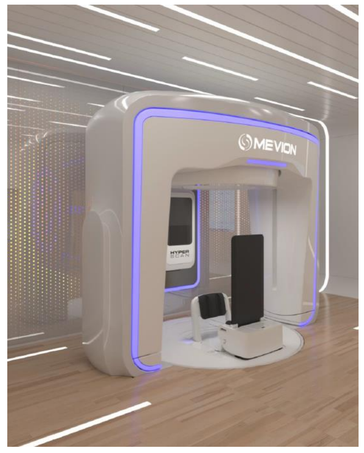

Figure 1. Sample image showing Mevion S250-FIT with upright patient positioning system.

Results

Anatomic analysis showed that upright position resulted in a decrease of rectum and PTV overlap by 16.1% and increase in longitudinal distance between the PTV and penile bulb by 2.5 ± 2.5 mm, whereas the bladder overlap on average remained similar. (Figure 2)

Dosimetric analysis showed both photon supine and proton upright plans met all the planning constraints. With similar target coverage, the proton upright plans resulted in the reduction of volume receiving dose to all organs at risk (OAR) compared to the photon supine plans: rectum V65Gy, V50Gy, and V31Gy by 2.3 cc, 2.8%, and 5.2%; bladder V50Gy and V31Gy by 3.9% and 7.0%; and penile bulb mean dose by 17%. Volume of 50% isodose cloud was also reduced in the proton plans by 23.5% (Figure 3).

No volume of small bowel and femoral heads received a dose of 40Gy or above for all the proton and photon plans.

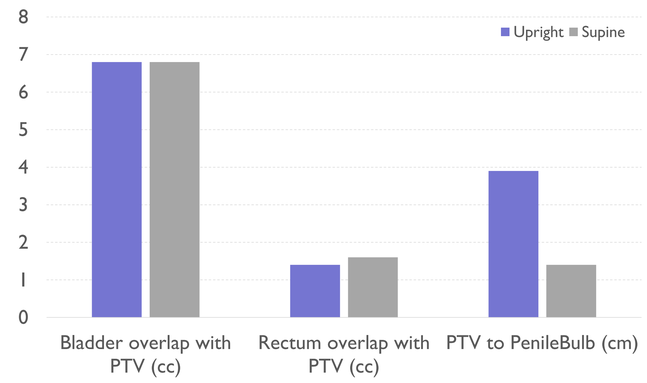

Figure 2. Geometric differences of OARs relative to target for supine vs upright patient position.

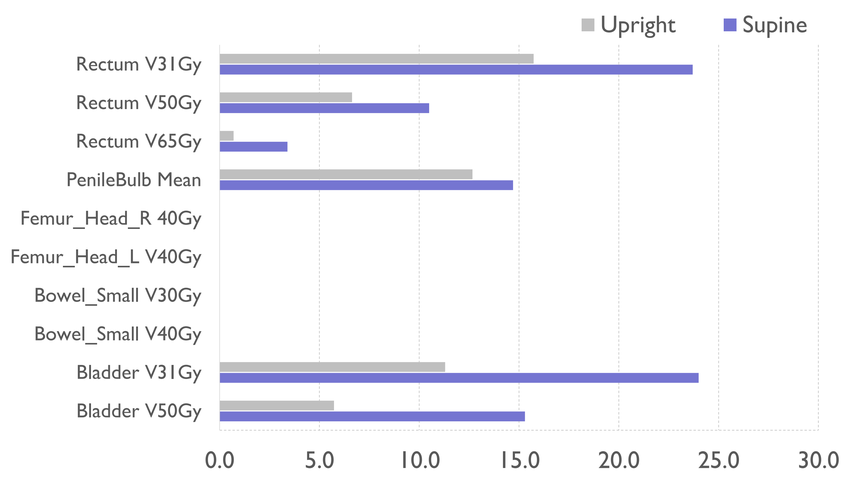

Figure 3. Average dose to organs at risk for proton upright plan vs photon supine plan.

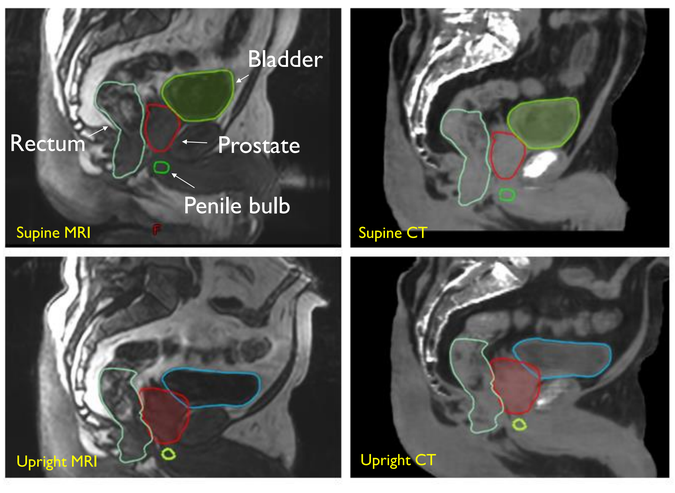

Figure 4. MRI scans acquired in upright and supine positions were converted to synthetic CTs for planning.

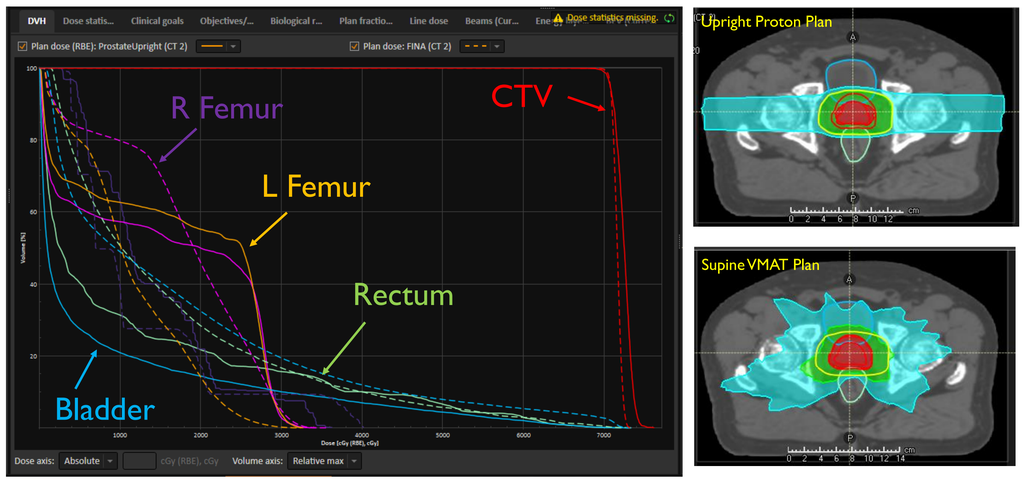

Figure 5. An example of dose to organs at risk for proton upright plan (-) vs photon supine plan (- - -).

Discussion/Conclusions

The results demonstrate that proton therapy with upright positioning, leads to a reduction in all critical organ doses compared to conventional photon therapy in the supine position. Further clinical validation and analysis are required to confirm these findings and assess the long-term impact on treatment outcomes.

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