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Precision-targeted dynamic prostate low dose rate brachytherapy

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Introduction: Biochemical control of prostate cancer increases with higher delivered doses of radiotherapy. Using a combination of transperineal sector mapping biopsies (TPSMB) and multi-parametric magnetic resonance imaging (mpMRI) areas of clinically significant prostate cancer can be accurately located. The diagnostic mpMRI sequences can then be fused with the procedural brachytherapy ultra-sound scan (USS) image. We have previously demonstrated how customised dose prescription (with a boost to dominant sectors of disease) is technically achievable based on TPSMB. There is increased interest in the development of focal prostate treatments, possibly allowing safe treatment de-escalation for selected patients. This planning study investigates the feasibility of using mpMRI-USS fusion and a dynamic brachytherapy planning procedure to provide personalised precision-targeted brachytherapy depending on the sites and volume of disease, but also includes the up-front planning of salvage therapy to maximise possible future therapy options.

Methods: This feasibility study was completed on the brachytherapy plans of patients treated with our real-time dynamic dose feedback (4D) technique. All patients with low risk prostate cancer underwent a pre-implant mpMRI scan and TPSMB using the Guy's Hospital technique to assess their suitability for either Active Surveillance or Brachytherapy, and to exclude any adverse features not identified on the transrectal biopsy. In addition, any dominant lesions seen on MRI had targeted biopsies using the mpMRI-USS fusion available on the Variseed Software. Dynamic brachytherapy plans were created using the Variseed 8 software, ensuring conventional prostate brachytherapy dose constraints.

Treatment planning options explored (depending on histological/MRI findings):

1. Precision-targeted focal brachytherapy with simultaneous salvage brachytherapy planning
 - Isolated sector with clinically significant disease treated with 145Gy; simultaneous salvage brachytherapy plan produced.
2. Precision-targeted hemi-gland brachytherapy with simultaneous salvage brachytherapy planning
 - Unilateral disease only; treated to 145Gy with option of precision-targeted boost to dominant sector(s) (max 2).
3. Precision-targeted boost brachytherapy in combination with external beam radiotherapy (EBRT)
 - Whole gland treated to 45Gy with EBRT, followed by brachytherapy boost to 110Gy to the whole gland, with dominant sector(s) (max 2) boosted to >200Gy

Results: This planning study has demonstrated that all three of the brachytherapy options are achievable with maintenance of accepted normal tissue constraints, with the addition of up-front planning of salvage brachytherapy treatment, again maintaining normal tissue constraints. The fusion of the diagnostic MRI with the brachytherapy USS, and the development of sector outlining protocols, has enabled efficient and accurate target volume definition.

Conclusion: There is scope for further individualisation of prostate brachytherapy, and the development of precision-targeted brachytherapy techniques (focal, hemi-gland, or boost), with the benefit of up-front salvage treatment planning to maximise future treatment options if necessary whilst keeping within safe tissue constraints.