Dosimetric Comparison between Hydrogel and Liquid-Filled Rectal Spacers in PBT for Primary Prostate Cancer

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2026 JULY 19–22 VANCOUVER, BC
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Purpose

Prostate cancer is one of the most commonly diagnosed malignancies in men [1]. Proton therapy is an effective treatment option for primary prostate cancer [2]. Due to the close anatomical proximity of the prostate and rectum, radiation therapy can expose rectal tissue to high doses, increasing the risk of treatment-related adverse effects [3-4]. Rectal spacers may be implanted to increase prostate–rectum separation and reduce rectal dose while maintaining target coverage [5].

Both hydrogel (SpaceOAR) and liquid-filled balloon (BioProtect) spacer systems are clinically utilized at Willis Knighton Cancer Center (WKCC, Shreveport, LA); however, their comparative dosimetric performance in pencil beam scanning (PBS) proton therapy remains an area of ongoing investigation. This study compares the dosimetric performance of these spacer systems using clinically relevant dose-volume histogram (DVH) metrics.

Methods

Patient Cohort
- 10 patients: 5 with BioProtect (BioProtect Ltd), 5 with SpaceOAR Vue (Boston Scientific)

Treatment Planning
- Patients were treated using an IBA ProteusOne pencil beam scanning (PBS) proton therapy system.
- Treatment plans used opposed lateral beam arrangements with a prescription dose of 70 Gy (RBE 1.1) to the prostate gland and 45 Gy (RBE) to the seminal vesicles.

Dosimetric Evaluation
- Primary metrics included rectal D7cc, rectal V15, rectal V55, spacer volume, and rectal volume.

Statistical Analysis
- Independent *t*-tests compared BioProtect and SpaceOAR, with effect size reported as Cohen's d.
- Statistical significance taken as $p<0.05$.

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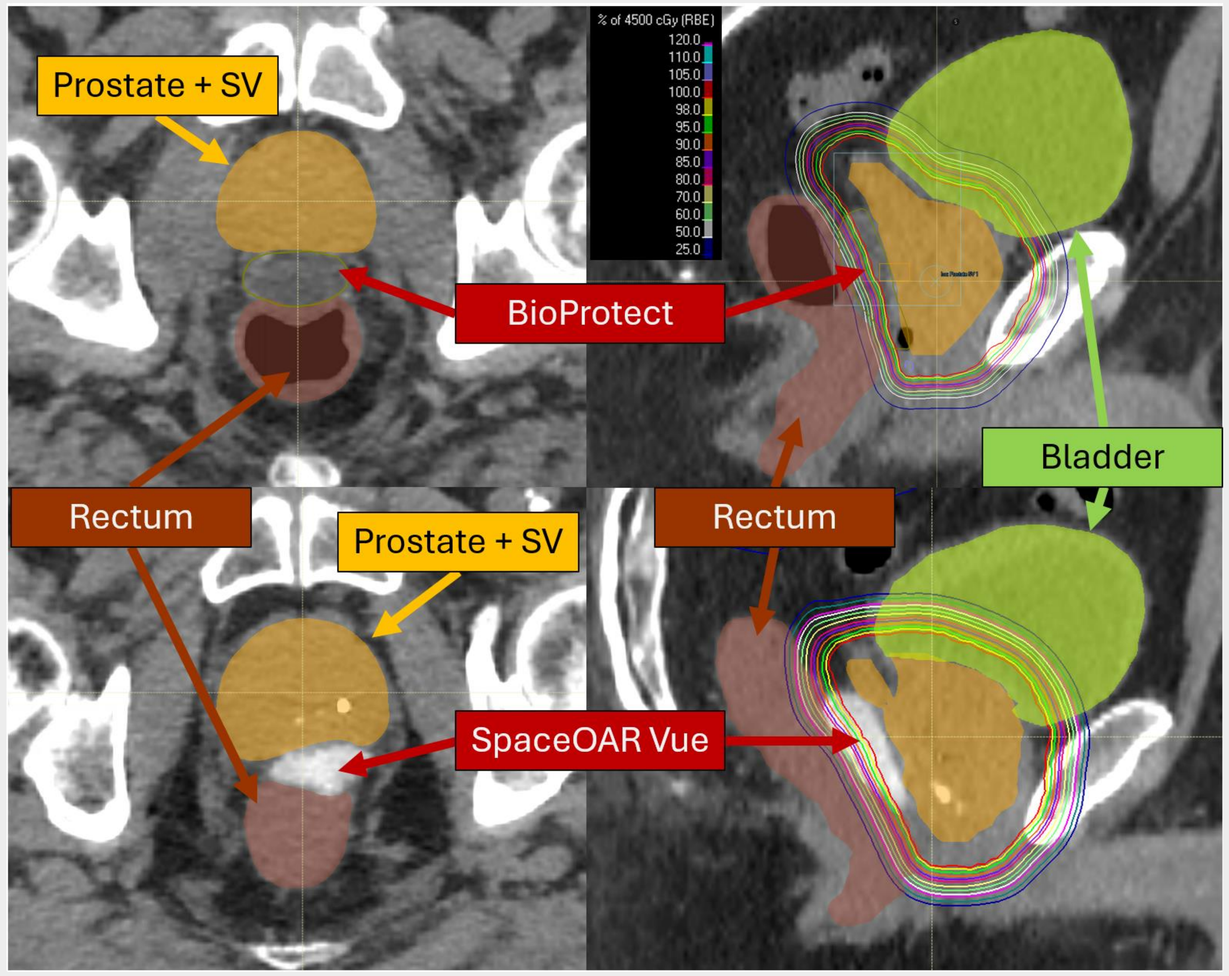


Figure 1: CT scan of representative patients with implanted BioProtect (top) and SpaceOAR Vue (bottom) spacers. Axial views (left) show anatomical separation, while sagittal views (right) show dose distributions.

RESULTS

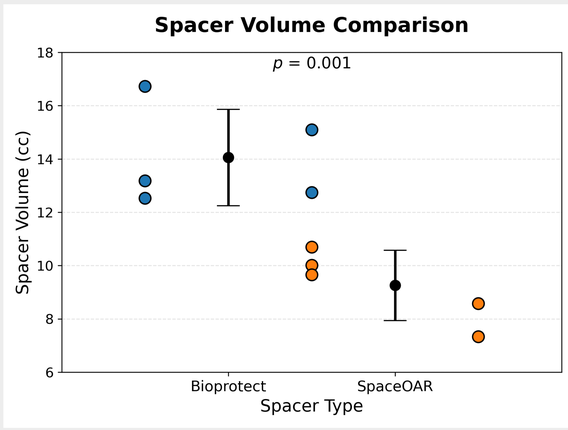
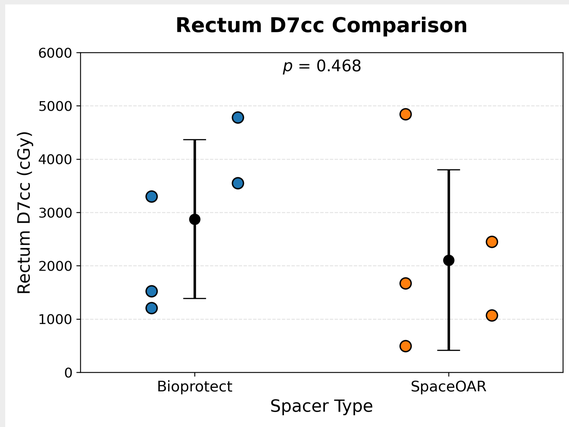


Figure 2 (left): Spacer Volume Comparison
- BioProtect produced significantly larger spacer volumes than SpaceOAR ($p = 0.001$, d=3.03).



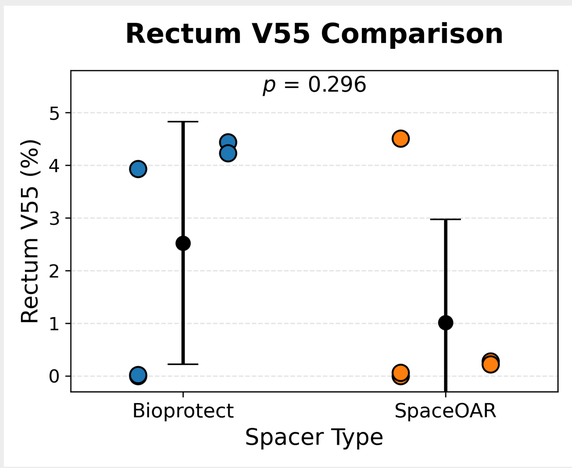


Figure 3 (above): Rectal V55 Comparison
- Both BioProtect and SpaceOAR maintained rectal V55 well below accepted clinical constraints [6].
- Many patients exhibited little to no rectal volume receiving 55 Gy, demonstrating excellent rectal sparing.
- No statistically significant difference was observed between spacer systems ($p = 0.296$).

Figure 4 (above): Rectal D7cc Comparison
- No statistically significant difference was observed between BioProtect and SpaceOAR ($p = 0.468$).
- Both spacer systems maintained rectal D7cc well below the clinical constraint [6].
- BioProtect demonstrated a slightly higher mean D7cc, though the difference was not statistically significant.

DISCUSSION

- BioProtect created significantly larger spacer volumes than SpaceOAR, demonstrating greater prostate–rectum separation.
- Despite this anatomical difference, no statistically significant differences were observed in rectal D7cc or V55, indicating comparable rectal dose reduction between spacer systems.
- Both spacer systems maintained rectal dose well below accepted clinical constraints, supporting effective rectal sparing during PBS proton therapy.
- These findings suggest that increased spacer volume alone does not necessarily provide additional rectal dose reduction.

CLINICAL SIGNIFICANCE

- Approximately 40% of patients undergoing PBT at WKCC are treated for prostate or prostate bed [7].
- Both BioProtect and SpaceOAR provided effective rectal sparing during PBS proton therapy while maintaining rectal dose well below accepted clinical constraints.
- Although BioProtect produced significantly larger spacer volumes, no additional reduction in rectal dose was observed, suggesting that spacer volume alone may not predict dosimetric benefit.
- These findings support the clinical use of either spacer system for rectal protection under the evaluated treatment conditions.
- Selection between spacer systems should consider factors beyond spacer volume and dosimetric performance alone.
- Future studies with larger patient cohorts are warranted to further evaluate long-term clinical outcomes and potential differences between rectal spacer systems.

ACKNOWLEDGMENTS

We thank Dr. H. Lee Sawyer, Dr. Pedro Derosa, and members of the Department of Radiation Oncology at Willis Knighton Cancer Center for Contributions to this work.

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