

Assessment of Applicator Stability in Gynecological Brachytherapy

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PURPOSE

To evaluate the stability of interstitial applicators, secured using a belt and ties, during GYN HDR brachytherapy delivered over 3 days using a single implant.

INTRODUCTION

- High-dose rate brachytherapy (HDRBT) is a standard of care component of radiation therapy for cervical, vaginal, and endometrial cancers.
 - HDRBT can be delivered over multiple fractions using a single implant.
 - Changes in applicator position ≥ 5 mm lead to clinically significant dosimetric deviations.¹
 - Such changes can be prevented via robust applicator and patient immobilization.²
- Interstitial HDRBT for primary vaginal or recurrent cervical, endometrial, or vaginal cancer at BC Cancer — Kelowna:
 - Is delivered over three days via a single-insertion, multi-fractionation b.i.d. scheme.
 - Applicators are fixed in place using a system of belt and ties (Fig. 1).
 - An initial CT scan is obtained post-insertion for 3D image-guided treatment planning.
 - A second CT scan is obtained prior to fraction 3 and is rigidly fused to the initial scan to assess applicator stability.
 - Stability is monitored via marks on the patient's legs and applicators.
 - If changes relative to these marks is noted before any fraction, treatment is postponed until a CT scan is acquired and assessed.

METHODS

- Patient Cohort:**
 - 34 GYN HDR brachytherapy patients treated at BC Cancer—Kelowna between 2020 and 2025 with single-insertion, multi-fraction treatments.
 - All had CT scans acquired immediately post-insertion for planning, and on day 2 of treatment to verify applicator positioning.
- Applicator types:**
 - Commercial intracavitary cylinders + interstitial perineal template needles (n=11)
 - In-house 3D-printed patient-specific cylindrical templates (PSCTs) (n=23) + perineal template needles (n=6/23)
- Applicators were secured the belt-and-ties system (Fig. 1).
- CT scans were registered by a clinical medical physicist.
- Dwell positions were digitized on both scans.
- Applicator stability was evaluated by calculating dwell position displacements (absolute, S-I, A-P, and R-L) between scans.

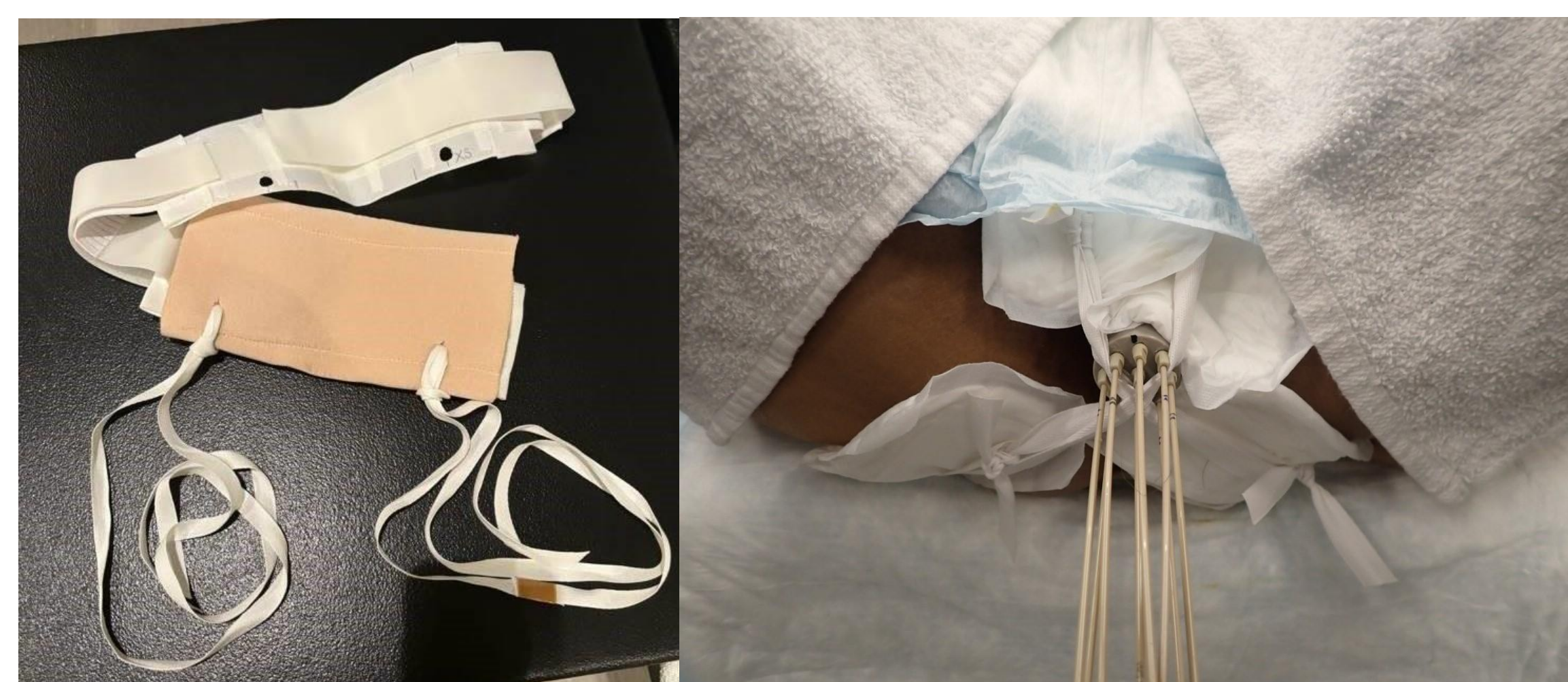


Figure 1. Belt-and-ties system of applicator immobilization. The belt is affixed about the patient's waist at the start of the implant. Four cloth ties are attached to the belt then woven through the needles protruding from the applicator and tied securely.

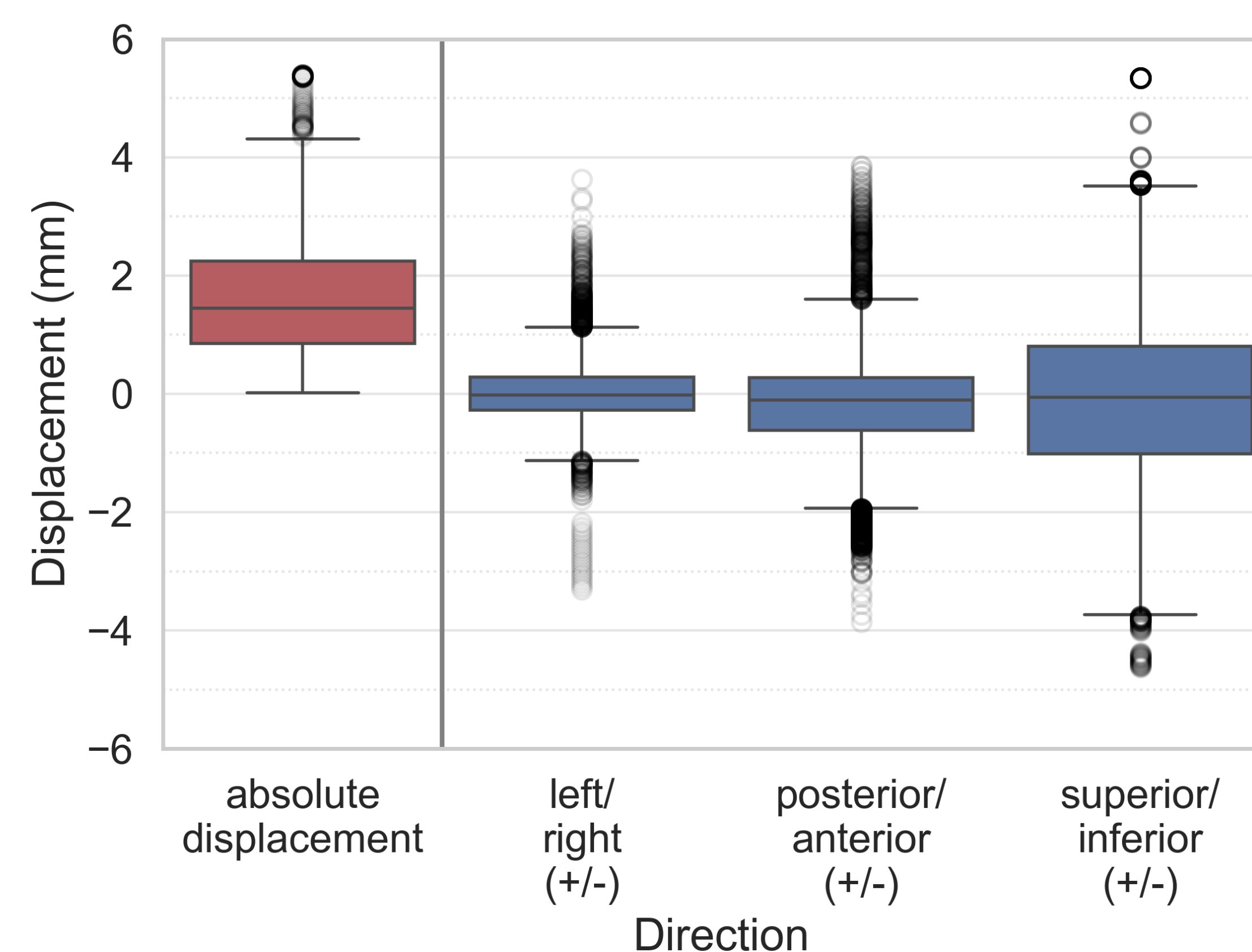


Figure 2. Displacement directions of all applicators.

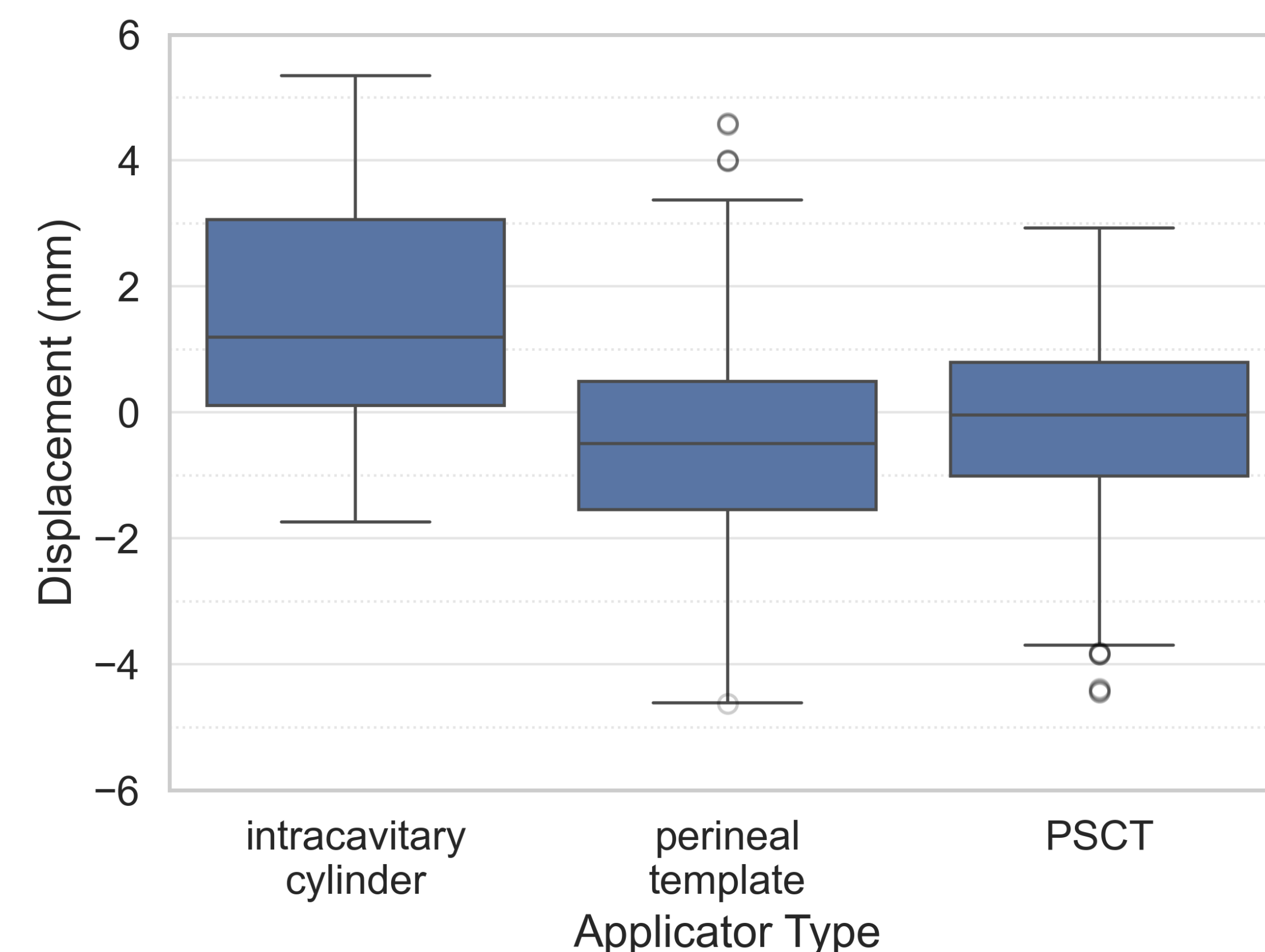


Figure 3. Sup/inf direction displacement according to applicator type.

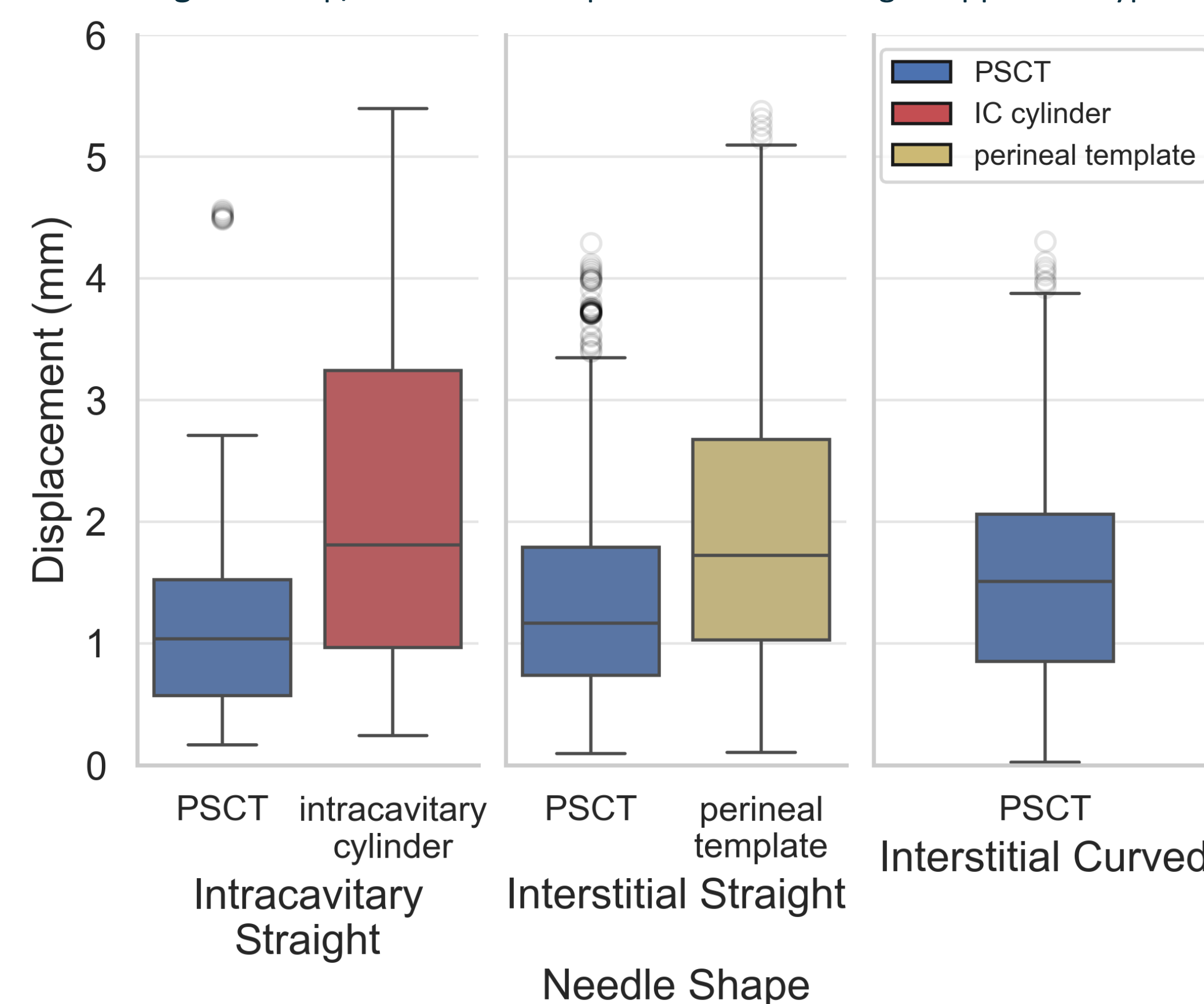


Figure 4. Absolute displacement of various catheter and applicator types.

RESULTS AND DISCUSSION

The median absolute displacement of all dwell positions was 1.5 mm (IQR 0.8, 2.2).

The median displacement of dwell positions by anatomical direction (Fig. 2):

- superior direction: -0.1 mm (IQR -1.0, 0.8);
- posterior direction: -0.1 mm (IQR -0.6, 0.3);
- left direction: 0.0 mm (-0.3, 0.3).

The **superior/inferior direction had the greatest IQR of displacements**, by nearly a factor of two.

The median superior/inferior (+/-) displacement of dwell positions by applicator type (Fig. 3):

- PSCTs: 0.0 mm (IQR -1.0, 0.8);
- commercial intracavitary cylinders: 1.2 mm (IQR 0.1, 3.1);
- perineal template needles: -0.5 mm (IQR -1.5, 0.5).

Needles could be classified as intracavitary (IC) or interstitial (IS), and curved or straight (Fig. 4).

This study demonstrates the **stability of brachytherapy applicators** between fractions when immobilized with a **belt-and-ties system**. Regardless of the applicator type, the belt-and-ties method of securing the applicators resulted in stable implants, with motion uncertainties on the order of 2 mm. PSCTs showed smaller inter-fraction position changes compared to commercially available intracavitary cylinders and perineal templates, though the differences were not statistically significant (Kruskal-Wallis) (Fig. 3). This is the **first study to include PSCT brachytherapy applicators** along with commercial applicators.

These results show that an immobilization system which maintains pressure on the applicator in the superior direction can constrain motion uncertainties on the order of 2 mm.

CONCLUSIONS

The **belt-and-ties method** of securing the applicators resulted in **stable implants**, with motion uncertainties on the order of **2 mm**.

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References:

- S. Jayarathna, M. Hoang, R. Badkul, and A. Hoover, Jcb 15, 334 (2023).
- S. Lang, N. Nesvacil, C. Kirisits, P. Georg, J.C.A. Dimopoulos, M. Federico, and R. Pötter, Radiotherapy and Oncology 107, 26 (2013).

Figures: All boxplots display the median value, the interquartile range (IQR; box), the points within 1.5 IQRs of the lower and upper quartiles (whiskers), and the outliers (points). Ten IC cylinder dwell position outliers are clipped at 12.7 mm, which correspond to a single catheter which had a locking collette loosen overnight. Marks on each catheter are used to verify this does not happen at each treatment.