Purpose: To quantify the needle tip detection errors in ultrasound images due to bevel-tip orientation in relation to the location on template grid.

Methods: Transrectal ultrasound (TRUS) system (BK Medical) with physical template grid and 18-gauge bevel-tip (20-deg beveled angle) brachytherapy needle (Bard Medical, Covington, GA) were used. The TRUS was set at 6.5MHz in water phantom at 40°C and measurements were taken with 50% and 100% TRUS gains. Needles were oriented with bevel-tip facing up (0-degree) and inserted through template grid-holes. Reference needle depths were measured when needle tip image intensity was bright enough for potentially consistent readings. High-resolution digital vernier caliper was used to measure needle depth. Needle bevel-tip orientation was then changed to bevel down (by rotating 180-degree) and needle depth was adjusted by retracting so that the needle-tip image intensity appeared similar to when the needle bevel-tip was at 0-degree orientation. Clinically relevant locations were considered for needle placement on the template grids (1st row to 9th row, and 'a-f' columns).

Results: For 50% TRUS gain, bevel tip detection errors/differences were 0.69±0.30mm (1st row) to 3.23±0.22mm (9th row) and 0.78±0.71mm (1st row) to 4.14±0.56mm (9th row) in columns 'a' and 'D', respectively. The corresponding errors for 100% TRUS gain were 0.57±0.25mm to 5.24±0.36mm and 0.84±0.30mm to 4.2±0.20mm in columns 'a' and 'D', respectively. These errors/differences varied linearly for grid-hole locations on the rows and columns in between, smaller to large depending on distance from the TRUS probe. Observed no effect of gains (50% vs. 100%) along 'D' column, which was directly above the TRUS probe.

Conclusions: Experiment results revealed that the beveled needle tip orientation could significantly impact the detection accuracy of the needle tips, based on which the seeds might be delivered. These errors may lead to considerable dosimetric deviations in prostate brachytherapy seed implantation.