

Theme: Clinical

Abstract No.: PTCOG-AO2025-ABS-0085

Abstract Title: Clinical implementation of real-time gated proton therapy combined with Active Breathing Coordinator-assisted deep inspiration breath hold for liver cancer: A case report

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Background / Aims:

While Active Breathing Coordinator (Elekta, Stockholm, Sweden)-assisted deep inspiration breath hold (ABC-DIBH) is commonly used in liver radiotherapy, intra- and inter-fractional motion during ABC-DIBH remain a concern in pencil beam scanning proton therapy. Fiducial marker-based real-time gated proton therapy (RGPT) is another effective method to manage tumor motion. This study is to report the first clinical implementation of combining RGPT and ABC-DIBH for liver cancer in our institution.

Subjects and Methods:

A hepatocellular carcinoma patient was prescribed with 60Gy in 15 fractions using proton therapy on Hitachi Probeat-V. Four gold fiducial markers were implanted surrounding the lesion three days before the simulation scan. Patient was trained for 30-second ABC-DIBH. Clinical target volume (CTV) was delineated based on contrast CT, MRI and PETCT images. The two-field treatment plan was created on ABC-DIBH planning CT (PLCT) in RayStation (RaySearch Laboratories, Stockholm, Sweden) utilizing robust optimization with 5mm setup and 3% range uncertainties. Two fiducial markers (F1, F2) were selected for RGPT tracking, with optimized X-ray exposure settings to ensure clear views in the fluoroscopy of both orthogonal X-rays at the treatment position for different beam angles, respectively. A ± 3 mm gating window was adopted to ensure the treatment delivery accuracy. Machine log files were extracted for post-treatment analysis.

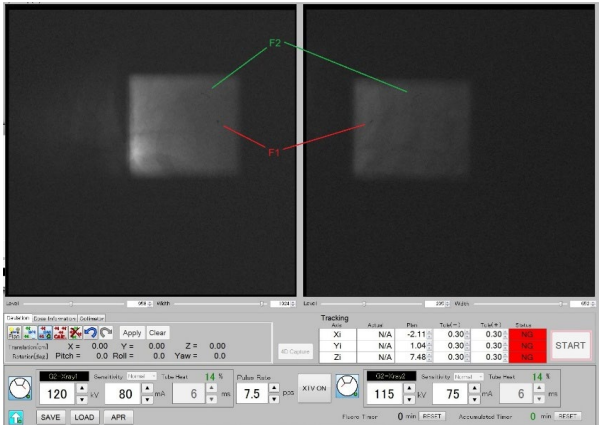


Figure 1. Visualization of two fiducial markers (F1, F2) using RGPT.

Result:

Chest deflation was observed, causing a consistent drift of liver to superior direction. The average drift speed was found to be 0.24 (Range: 0.08-0.49) mm/s in superior-inferior (SI) direction, resulting in a theoretical maximum duty cycle of 83%. The displacement in left-right (LR) and anterior-posterior (AP) directions were within 1.5 mm during ABC-DIBH. Thus, the intra-fractional baseline shift of ABC-DIBH could be within 3mm in SI direction and within 1.5mm in LR and AP directions. R^2 of displacement against time and matching score for F1 were significantly higher than that for F2 (Welch's t-test with $p<0.05$), while average drift speed for both markers were 0.24mm/s and average matching score for F1 and F2 were 36.208 and 16.670, respectively. Larger fluctuation in displacement for F2 was visually observed compared with F1. This implied fiducial marker geometry might affect RGPT tracking accuracy, reducing the duty cycle and thus treatment delivery efficiency.

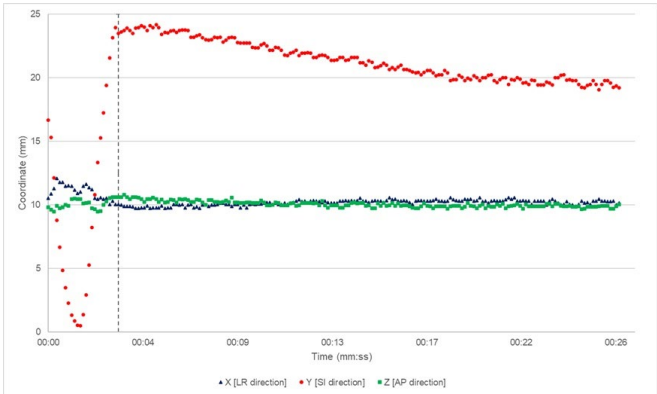


Figure 2. Position of RGPT-tracked fiducial marker F1 during one cycle of ABC-DIBH. The vertical-dashed line indicates the start of ABC-DIBH.