Purpose: The dosimetric advantage of particle therapy comes with a much higher infrastructure investment and operation costs. Increasing patient throughput is a key factor to manage operation costs. We investigate the impact of variable beam spot sizes on treatment time and discuss the tradeoffs involved.

Methods: The following realistic assumptions were used. (1) The beam traveling speed is independent of the beam spot size. (2) The beam spot is a 2D Gaussian. Changing the beam spot size implies varying the standard deviation. (3) The maximum beam intensity is a constant independent of the beam spot size. Increasing the beam spot reduces the fluence. (4) Varying the beam spot size incurs a reset time penalty.

A 2D tumor was used in the study. Dose calculations were based on pencil beam kernels from GEANT4. The total treatment time is divided into the beam travel time, the beam-on time, and the time for changing the spot size.

Results: We found that: (1) Changing the beam spot size has no impact on the beam-on time, because the maximum beam intensity is independent of the beam spot and increasing the beam spot only reduces the fluence. (2) Larger beam spot size shortens the total travel time inversely proportional to the radius of the beam spot. (3) Plans with different beam spot sizes have similar dosimetric qualities. (4) If higher beam intensity could be used for larger beam spot size, savings in beam-on time would be inversely proportional to the intensity available.

Conclusions: We have studied the interplay among beam intensity, travel time, and beam size reset time for a scanning beam with variable beam spot size. Our initial studies show necessary conditions for and limitations on savings in total treatment times. Further studies are being carried out to find additional time saving sources.

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