Purpose:

The purpose was to investigate the interplay of residual motion in realistically delivered respiratory gated spot scanning proton beam by a synchrotron.

Methods:

A MatriXX 2D ion-chamber array detector was placed on a moving platform. The platform with the 2D ion-chamber array detector was moved based on sin4 motion with 3s and 5s cycle and 20 mm amplitude. Its motion was monitored by a laser displacement sensor (ZS-LDS2VT, omron, Japan). The respiration gate threshold level was set at 30% duty cycle and the residual motion within the gate window was approximately 6 mm. A 10x10 cm2 uniform field was delivered by a matrix of 13x13 spots with ~ 8 mm spot size (s) and 8 mm spot spacing. Measurements were done for the field delivered with a single painting and multiple re-painting, from 2 to 12 times, for both orthogonal and parallel scan directions. The same field was also measured without moving the detector, defined as the static reference dose. Dose homogeneity was compared between with gated and the static dose distributions.

Results:

The worst single painting result of the dose homogeneity ratio was 0.90 in 3s motion cycle and 0.93 in 5s motion cycle with the orthogonal scan pattern, and 0.97 in 3s and 0.98 in 5s motion with the parallel scan pattern, respectively. The homogeneity ratio improved to over 0.98 by 4~6 times re-painting in orthogonal and only 2 times re-painting with the parallel scan.

Conclusions:

The respiratory gated spot scanning proton beam delivery is sensitive to spot movement direction relative to the residual motion of the target. A proper selection of the number of repainting and the scan direction can improve beam delivery quality. The study offers a basic understanding when implementing respiratory gated spot scanning proton beam treatment.