Purpose:

In spot scanning proton therapy, accurate patient positioning before and during treatment is essential. A small gold ball marker is suitable as a fiducial for prostate treatment. However, it has been pointed out that the marker causes dose shadowing because the protons are scattered with their energy quickly diminished. In this research we explore the possibility that the biological effect of dose shadowing can be mitigated with a limited number of fields.

Methods:

The proton dose distribution in prostate was simulated using Geant4. The simulations include the Hokkaido University spot scanning nozzle and a water phantom positioned isocentrically. The PTV was delineated at the center of the phantom and a gold ball of 2 mm in diameter was placed at the middle of the PTV. The plan was created by single-field optimization and each of the following beam arrangements was investigated; (1) single lateral field (2) two lateral fields (3) two lateral + one anterior fields (4) four-field box. The dose prescription was $D_{95} = 74$ GyE (37 fr). The minimum dose and tumor control probability (TCP) were compared for the four beam arrangements.

Results:

For (1)-(4), the minimum dose values were 55%, 77%, 78%, and 84% of the prescribed dose, respectively. The reduction of the TCP values from those in the absence of the gold marker were 50%, 2%, 1.1%, and 0.7%, using the TCP model by Wang et al. (Int.J.Radiat.Oncol.Biol.Phys. 55, 2003) and 2%, 0.7%, 0.5%, and 0.4%, using the biological parameters in LevegrÃ¼n et al. (Int.J.Radiat.Oncol.Biol.Phys. 51, 2001), respectively.

Conclusions:

Although dose shadowing by the gold marker is locally non-negligible, the size of the affected domain is tiny. It was found that with a minimum number of fields, the TCP nearly recovers to the value without the gold marker.