Purpose: Neutron exposure is of concern in proton therapy, and varies with beam delivery technique and treatment conditions. The purpose of this study is to investigate the neutron dose equivalent per therapeutic dose, H/D, under various treatment conditions for uniform scanning beams employed at our proton therapy center.

Methods:Using a wide energy neutron dose equivalent detector (SWENDI-II, ThermoScientific, MA), we measured the neutron dose equivalent as a function of proton range, modulation width, beam scanning area, collimation aperture size and snout position. The influence of other factors on neutron dose equivalent, such as aperture material and the presence of a compensator were also evaluated. Neutron dose equivalents for various treatment sites were estimated. Comparison among different proton facilities and modalities (passive scattering, uniform scanning and pencil beam scanning) was performed.

Results:The H/D values for uniform scanning beams varied from about 0.2 mSv/Gy for a 5 cm range and 2 cm SOBP width beam to 2.3 mSv/Gy for 30 cm range and 30 cm modulation width beam. H/D increased rapidly with proton range and modulation width, and decreased slowly with aperture size and snout retraction. H/D increased almost proportionally to the beam scanning area. The presence of a compensator actually reduced the H/D compared to that without a compensator present. Aperture material and compensator material also has an influence on neutron dose equivalent, but the influence is relatively small.

Conclusions:This study presents H/D as a function of treatment parameters for uniform scanning proton beams. For similar treatment conditions, the H/D value was slightly lower than that from the passive scattering beam but higher than that from a spot scanning beam. Minimizing the beam scanning area could effectively reduce neutron dose equivalent for uniform scanning beams, down to the level of that generated in spot scanning.