Purpose: To correct for errors due to metallic implants in CT-based patient simulation imaging. To quantify the impact of these imaging errors on treatment planning for 3D conformal and intensity modulated proton therapy (IMPT).

Methods: Several methods were developed to correct for imaging errors in treatment plans for patients with metallic implants. CT metal artifact reduction methods were applied, the implant sizes were verified using CT-based radiographs instead of reconstructed images, and implant-specific CT to proton stopping-power conversion curves were designed using an extended CT number range. 3D conformal proton therapy plans for chordoma patients with various implants were studied in retrospect. IMPT plans were designed in addition based on the original clinical prescriptions. After applying the corrections, all dose distributions were recalculated and compared to the original plans.

Results: High-density implants such as platinum coiling introduced significant errors in both 3D conformal proton therapy and IMPT. Proton range shifts > 1 cm were observed due to errors in the originally estimated size and material of the implant. CT artifacts resulted in range shifts of ~ 5 mm. Treatment planning for patients with titanium implants was mainly affected by CT artifacts. Range shifts in the IMPT plans were again on the order of 5 mm. The impact of titanium on 3D conformal therapy was limited.

Conclusions: Metallic implants result in uncertainty in CT simulation imaging for proton therapy planning and may compromise the accuracy and precision of treatment. The impact depends on the implant material and the proton delivery method. IMPT is more sensitive to these issues as compared to 3D conformal proton therapy. Implants with higher density also result in larger errors. Novel CT reconstruction and segmentation methods provide a significant reduction of errors.