Purpose:To quantify and correct the geometric accuracy of an x-ray micro-CT scanner to improve fiducial localization in image-guided needle positioning systems.

Methods:A geometric accuracy phantom was constructed by creating a one-inch cube consisting of a 4×4×4 3D matrix of calibrated ¼" diameter spherical beads alternating between two materials. The phantom was imaged at both the isocenter and at the edge of the field of view of a micro-CT scanner. All bead positions were measured in sets of five images and averaged. An automated algorithm evaluated the geometric accuracy of the scanner by comparing the known position of the beads in the phantom to their positions in the images. The algorithm used a least-squares solution to determine scaling factors in the horizontal, vertical and axial directions of the images to correct the geometric inaccuracies. The accuracy of localizing a fiducial marker mounted onto a needle positioning system was determined with and without using the calculated scaling factors.

Results:Use of the scaling factors reduced the geometric error of the measured bead positions within the phantom by a factor of two at both the isocenter and the offset position. The mean bead position errors were reduced from 54 μm to 27 μm at the isocenter and from 68 μm to 26 μm at the offset position. Localization of the fiducial mounted onto the needle positioning system was also improved by applying the scaling factors. The mean error of the measured fiducial position was reduced from 108 μm to 38 μm.

Conclusions:Application of a geometric accuracy phantom in micro-CT image-guided needle positioning systems can improve fiducial localization and should reduce the overall needle positioning error of these systems. Further study will be required to determine optimal use of the phantom and its utility in image-guided interventions.