AbstractID: 13725 Title: Cone-Beam CT for Guidance of Spine Surgery: Performance and Integration of a New High-Performance C-Arm Prototype

Purpose: A prototype mobile C-arm incorporating a flat-panel detector (FPD) for high-quality cone-beam CT (CBCT) is under investigation for spine surgery. This work describes the image quality and dose in cervical, thoracic, and lumbar spine surgery and integration with novel navigation subsystems critical to high-precision surgical guidance, including: tracking, video augmentation, deformable registration, and multi-modality visualization.

Method and Materials: Image quality, patient dose, and in-room dose were assessed in phantom and cadaver studies approximating spine surgery. An open-source software architecture was employed for integration of navigation systems based upon the CISST libraries linked to 3D Slicer. For spine surgery, a novel video-based tracking and augmentation system was developed to facilitate high-precision minimally invasive techniques. Target registration error (TRE) and accuracy of overlay were assessed. Deformable registration of preoperative and intraoperative images was based upon a fast implementation of the Demons algorithm.

Results: Image quality demonstrated sub-mm spatial resolution and soft-tissue visibility; protocols were identified for "standard" and "high-quality" imaging of the spine – respectively for bone visualization (100 kVp, 2.4 mA, 200 projections, 1.6 mGy) and for soft-tissue (100 kVp, 5.0 mA, 400 projections, 7.1 mGy). The TRE for video-based and infrared tracking systems was 0.67 and 0.54 mm, respectively, and the accuracy of video overlay was 1.0 mm for the integrated video-based tracker, compared to 1.3 mm for separate video and infrared trackers. Deformable registration demonstrated accuracy on the order of the voxel size on timescales consistent with surgical application.

Conclusion: The first evaluation of an integrated mobile CBCT and guidance systems for spine surgery was demonstrated and characterized, emphasizing a flexible architecture of application-specific navigation technologies. Drawing upon a decade of research in C-arm CBCT, a new clinical prototype C-arm is realized and undergoing evaluation and translation to spine surgery trials.

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