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New Ziehm Vision RFD 3D[1]: An Evaluation of Mobile C-Arm Three-Dimensional Workflow, Features and Image Quality

Introduction

Dr. Roger Härtl, Professor of Neurological Surgery and Director of Spinal Surgery at Weill Cornell Medical College, and Dr. José Alfredo Corredor, Clinical Spine Research Fellow at Weill Cornell Medical College, evaluated workflow features and quality of three-dimensional images of spinal hardware placement acquired from a Ziehm Vision RFD 3D mobile C-arm, a Siemens ARCADIS® Orbic 3D mobile C-arm and a Siemens Biograph™ TruePoint™ PET•CT system at New York Presbyterian Hospital.

Methods

An 84-year-old male cadaver specimen was the subject of the evaluation held at the Microneurosurgery Skull Base Laboratory at New York Presbyterian Hospital over a two-day period. 3D scans were taken following screw placement in the lumbar, thoracic and cervical spine using the Ziehm Vision RFD 3D [Typical results including volume rendering in Fig. 1], the Siemens ARCADIS® Orbic 3D mobile C-arm [Typical results in Fig. 2] and the Siemens Biograph™ TruePoint™ PET•CT system. 2D and 3D intraoperative images from the Ziehm Imaging and Siemens C-arms were used intraoperatively for pre-planning of hardware placement and then for assessment of actual placement. The Ziehm Vision RFD 3D used SmartScan technology for 3D reconstruction and took approximately 45 seconds for a scan and 45 seconds for 3D reconstruction. (Note: All Ziehm Vision RFD 3D reconstructions shown have a resolution of 320^3 voxels.) Drs. Härtl and Corredor analyzed footprint, features, workflow, and image quality in the cross system comparison.

Results

Workflow and Features

The Ziehm Vision RFD 3D has a smaller footprint (63”H 32”W 75”L) in comparison to the Siemens ARCADIS® Orbic 3D (71”H 32”W 85”L). The Ziehm Vision RFD 3D utilizes a 30x30 flat-panel detector for image acquisition and the Siemens ARCADIS® Orbic 3D utilizes a 9” image intensifier (I.I). The use of flat-panel technology on the Ziehm Vision RFD 3D provides a larger C-arm opening size of 33” versus the 31” C-arm opening size on the Siemens ARCADIS® Orbic 3D. Dr. Corredor had more working space and better access to the specimen when performing the hardware placement on the Ziehm Vision RFD 3D. Using the full motorization capabilities of the Ziehm Vision RFD 3D, Dr. Corredor was able to precisely position the C-arm directly from the Remote Vision Center (touchscreen) mounted on the C-arm or the Position Control Center (joystick) mounted to the side of the OR table.

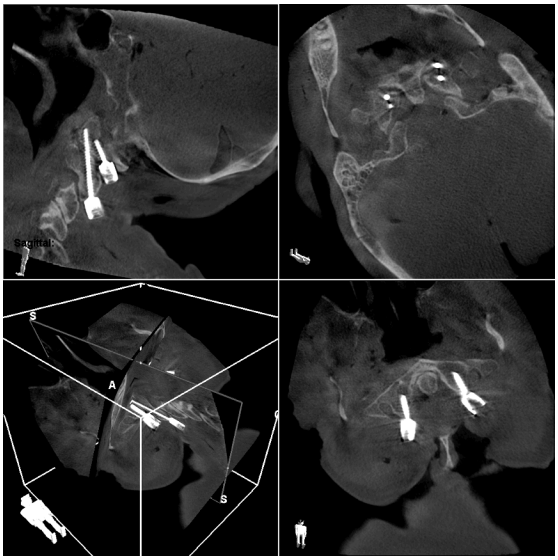

Fig. 1 Ziehm Vision RFD 3D[2]

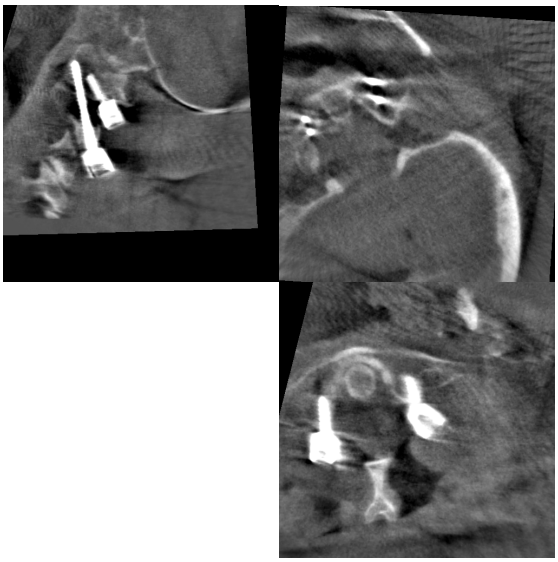

Fig. 2 Siemens ARCADIS® Orbic 3D[2]

Image Quality

The Ziehm Vision RFD 3D captured a full 3D dataset on the specimen using Ziehm Imaging's SmartScan technology. SmartScan is a technology that uses a combination of vertical and horizontal travel to provide the equivalent of 180 degree of rotation in the Ziehm Vision RFD 3D's compact dimensions. The 3D images captured from the 25kW generator Ziehm Vision RFD 3D provided a larger field of view with less noise and artifacts [Fig. 3] when compared to the images captured from the I.I. based, 2.3kW generator Siemens ARCADIS® Orbic 3D [Fig. 4].

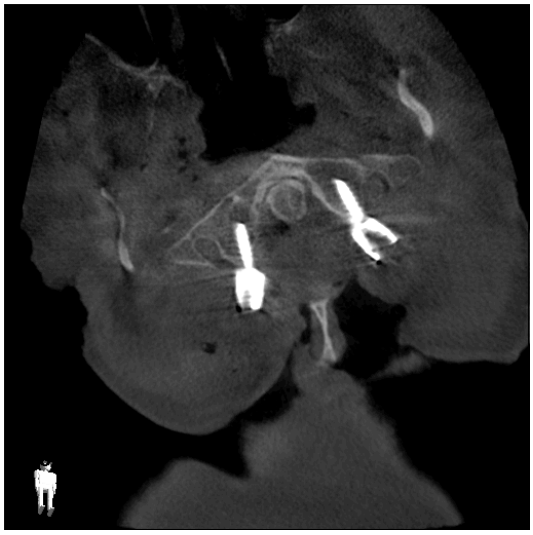

Fig. 3 Ziehm Vision RFD 3D[2]

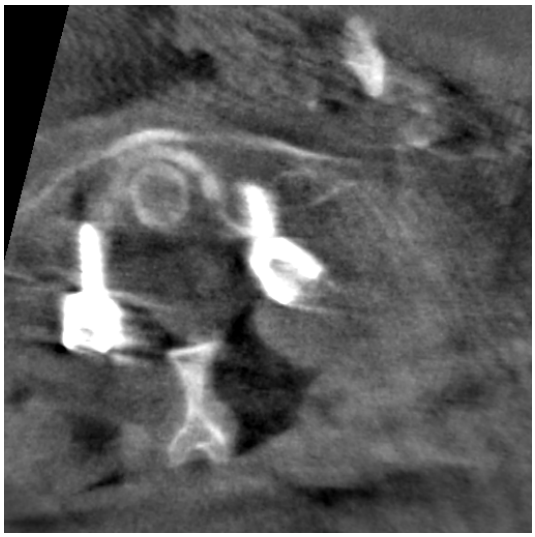

Fig. 4 Siemens ARCADIS® Orbic 3D[2]

Image quality of the Ziehm Vision RFD 3D [Fig. 5] was compared to the Siemens Biograph™ TruePoint™ PET•CT [Fig. 6]. The Ziehm Vision RFD 3D provided 3D intraoperative images with comparable CT quality while offering a surgeon the capability to make hardware adjustments directly in the OR.

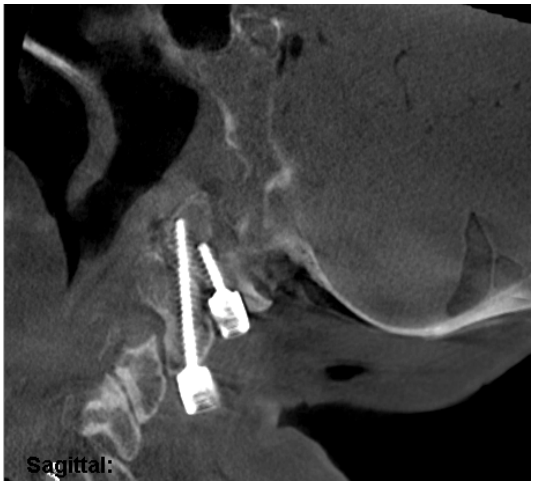

Fig. 5 Ziehm Vision RFD 3D[2]

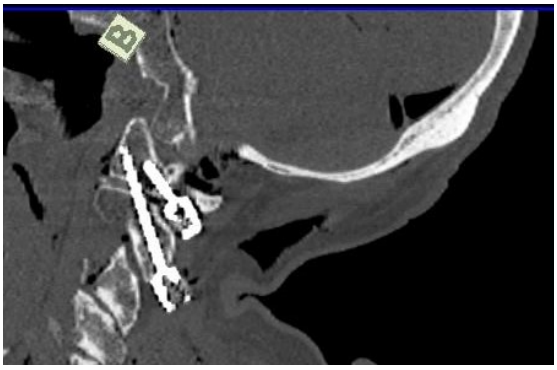

Fig. 6 Siemens Biograph™ TruePoint™ PET•CT[2]

Discussion

Deficiencies in existing 3D fluoroscopic and CT based imaging systems currently offered in the market prohibit an industry wide imaging solution for spinal imaging. Although there have been great advances in the capabilities of these imaging systems, including improvements in mobile imaging platforms which offer 3D capabilities, spinal anatomy continues to prove challenging for surgeons. Surgeons need to weigh what features a solution offers against the limitations it may present. For example, an imaging modality may offer 3D imaging but not 2D.

For many surgeons, crowded operating rooms remain problematic with limited space for large single modality imaging equipment. A surgeon can find it difficult to position a C-arm, especially those lacking motorization, in a congested area. For the mobile C-arms that do offer 3D imaging, they often have compromised ability to image difficult spinal anatomy due to the lack of sufficient generator power or limited rotation for capture of 3D images. C-arms offering full 180 degree scanning capabilities may be so large in size it may limit additional equipment that can also be in the OR. Anatomy commonly seen by neurosurgeons and orthopedic surgeons, could encounter imaging limitations if the 3D C-arm technology being used is limited to only the centered anatomy.

Surgeons using C-arms with image intensifiers (I.I.), who capture intraoperative images for surgical tool positioning, can find it hard to acquire the image with limited free-space available between the patient and I.I. on the C-arm system.

Traditional CT based imaging modalities have limited functionality intraoperatively. This may require patients to endure pre and post operative scans as part of their treatment. The ability to detect and adjust hardware intraoperatively may reduce the need for postoperative scans and additional radiation improving patient outcomes. Learning curves across multiple modalities and imaging equipment can be challenging, time consuming and may require a hospital additional staff to manage them.

Poor image quality has plagued the conventional fluoroscopy 3D imaging market. Solutions for mobile 3D spinal imaging predominately include the use of C-arms with image intensifiers, whose images can suffer imperfections from distortion and effects of metal artifacts. When sufficient quality images are not captured intraoperatively, a patient may need to leave the OR to undergo additional imaging scans. Post operative studies may indicate that revision surgery is needed to correct hardware/implant positioning. Complications associated with misplacement could also cause undesirable neurological or vascular injuries for a patient. The field of view (FOV) for extremities is challenging for surgeons using I.I. based C-arm systems, as they may not be able to capture adequate images at sub-optimal angles or can be further limited by the FOV of a round detector for image capture.

Summary by Dr. José Alfredo Corredor

Most spinal surgeries, regardless of the complexity of the operation, anatomical region of interest, and level of comfort and training of the individual surgeon, require imaging to guide the procedure. 3D imaging techniques have gained acceptance in many surgical disciplines. This system offers an advantageous view of the surgical field and increases the accuracy of instrument placement. The use of 3D imaging has become prominent in minimally invasive surgery procedures and reconstructive surgeries such as deformity. Additionally, it can be used in tandem with a navigation system to improve surgical outcome. The Ziehm Vision RFD 3D imaging device, distinguished by its compact footprint and versatile application, provides better intraoperative comfort and image quality than currently available devices in the market. In fact, its intraoperative image quality is comparable to that of stationary CT scans. In the clinical practice, such imaging technologies will significantly enhance the overall surgical workflow and accuracy of procedures performed, particularly those in patients with complex spine anatomies.

Acknowledgments:

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Image Appendix

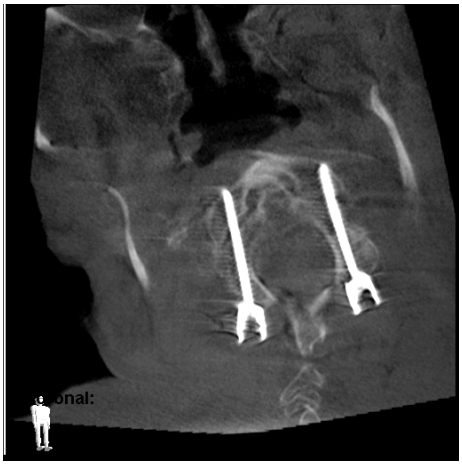

Fig. 7 A Ziehm Vision RFD 3D[2]

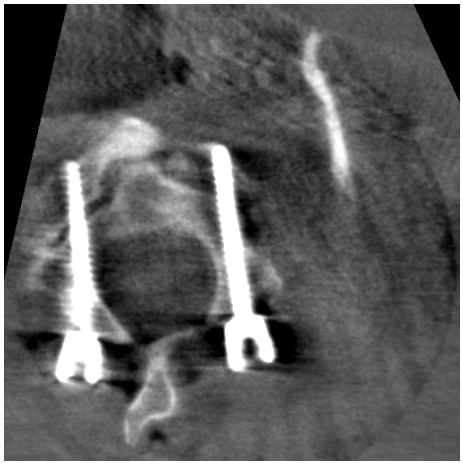

Fig. 7 B Siemens ARCADIS® Orbic 3D[2]

Fig. 7 C Siemens Biograph™ TruePoint™ PET•CT[2]

Fig. 7. A-C
A cross modality comparison of image quality.

[1] The Ziehm Vision RFD 3D is not cleared for sale in the US.
[2] When original medical images are reproduced they will always lose a certain amount of detail.