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Accuracy, Radiation Time, and Radiation Exposure Using Computer-Assisted Instrument Navigation vs. Conventional C-Arm Fluoroscopy for Spine Surgery Instrumentation

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Introduction

Surgical instruments, especially during minimally invasive procedures, must be repositioned multiple times throughout an intervention and are often adjusted repeatedly until the physician is satisfied with placement. This increases radiation exposure to both surgeon and patient. Ultra-low radiation imaging coupled with image enhancement and optical instrument tracking (ULRI-IE/IT) allows a computer to show real-time movement of the instrument as it is adjusted, mimicking live fluoroscopy. This has the potential to drastically reduce intraoperative radiation reduction.

Methods

A cadaveric study was undertaken. Physicians from various specialties were asked to identify the ideal location for instrumentation for various spine, orthopedic, pain management, and physiatry procedures and then place an instrument to this location both with and without computer assistance, randomly assigned to reduce the impact of learning. Number of x-rays, radiation exposure and time to perform each procedure was recorded.

Figure 1

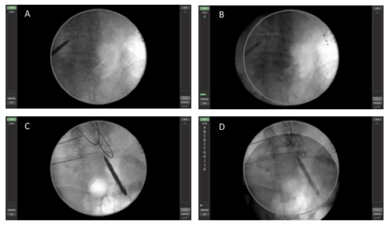

Figure 1. Comparison between ultra-low radiation imaging with and without image enhancement. A) ultra-low radiation anterior-posterior (AP) projection film of L2-3. There is very poor visualization of bony anatomy. B) image quality following enhancement of Figure 1A. Bony anatomy is now clarified and the instrument tip can be seen projecting over the left pedicle. C) ultra-low radiation AP project film of L4-5. Again, there is very poor visualization of bony anatomy. D) image quality following enhancement of Figure 1C. Bony anatomy is now clarified and the instrument tip can be seen projecting over the right L5 pedicle.

Results

Twenty-three trials of 9 procedures by 5 physicians were completed both with and without the assistance of ULRI-IE/IT, ranging from percutaneous pedicle screws to foramen ovale ablation. Total time to localize for all 23 cases was 31.2% longer without assistance. ULRI-IE/IT reduced the total number of x-rays by 74.8% and radiation exposure by 91.8%. Statistically significant radiation reduction was experienced for every procedure. With ULRI-IE/IT, physicians were able to successfully place the instrument in the correct location on the first attempt in 82.6% of trials and by the second attempt in 100% of trials. With standard fluoroscopy, physicians were never able on the first attempt and required an average of 4.65 images to achieve accurate placement.

Conclusions

Ultra-low radiation imaging with image enhancement and instrument tracking is able to dramatically reduce the number of unnecessary images taken when performing a fluoroscopic procedure. Overall, this resulted in 91.8% radiation reduction and a significant time savings.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) Describe the importance of reducing intraoperative radiation exposure, 2) Discuss the utility of ULRI-IE/IT, and 3) Identify ULRI-IE/IT as an effective method of reducing intraoperative radiation exposure

Figure 2

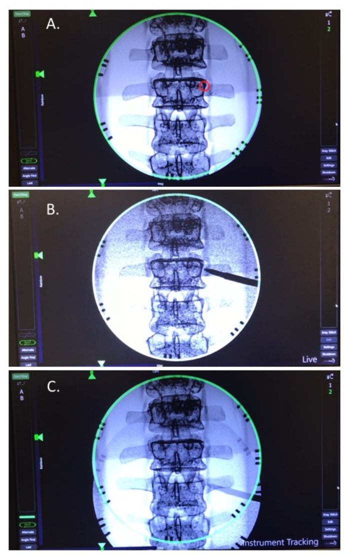

Figure 2. A) A full-dose image is taken and its position is registered within the instrument tracking system. A Jamshidi with an optical tracer is introduced to the field with goal to place the tip of the instrument on the right lumbar pedicle. The red circle estimates the position of the instrument tip based on the positioning of the instrument in relationship to the patient's anatomy. B) an ultra-low dose image is acquired, which shows the exact location of the instrument tip, which is then registered within the instrument tracking system. Because the Jamshidi's density, it is clearly delineated even at ultra-low radiation dosage. C) as the instrument is repositioned, the exact location of the instrument tip is shown on-screen, allowing the proceduralist to know the exact position of his or her instrument prior to taking an additional image.

Figure 3

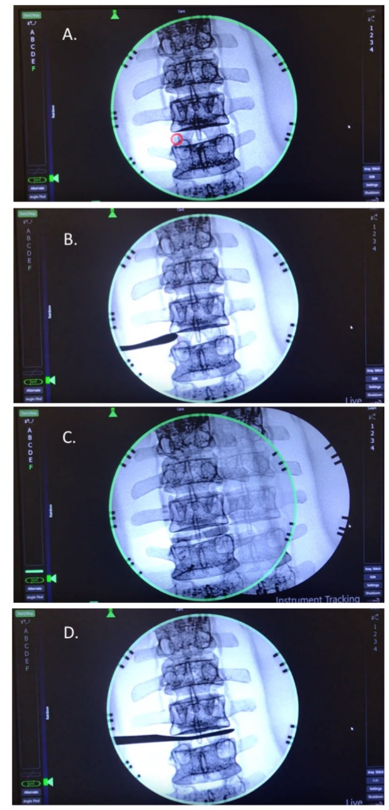

Figure 3. A) A full-dose image is taken and its position is registered within the instrument tracking system. An XLIF spacer with an optical tracer is introduced to the field with the goal to place the tip of the instrument at the lateral border of the disc space. The red circle estimates the position of the instrument tip based on the positioning of the instrument in relationship to the patient's anatomy. B) Ultra-low dose image is acquired, which shows the exact location of the instrument tip, which is then registered within the instrument tracking system. Because the spacer's density, it is clearly delineated even at ultra-low radiation dosage. C) as the instrument is advanced into the disc space, the exact location of the instrument is shown on-screen, allowing the proceduralist to know the exact position of his or her instrument prior to taking additional images. Here, the spacer is being advanced to the contralateral border of the disc space. D) Final low-dose image demonstrating placement of the spacer across the entirety of the disc space, matching the estimated position per image C.