Dosimetric Characterization of a Cone Beam O-arm Imaging System

Results: The results show that under identical technical conditions and with the same scan length, the O-arm 3D mode delivers radiation dose to patients and scatter dose to personnel that is comparable to that of the 64 slice CT scanner. The O-arm 2D mode produces similar scatter radiation as a conventional GE OEC fluoroscopic C-arm system.

Conclusion: Our study demonstrated that the O-arm had comparable radiation dose to patients and radiologists as CT and Carm systems.

Twice a fluoro case!!

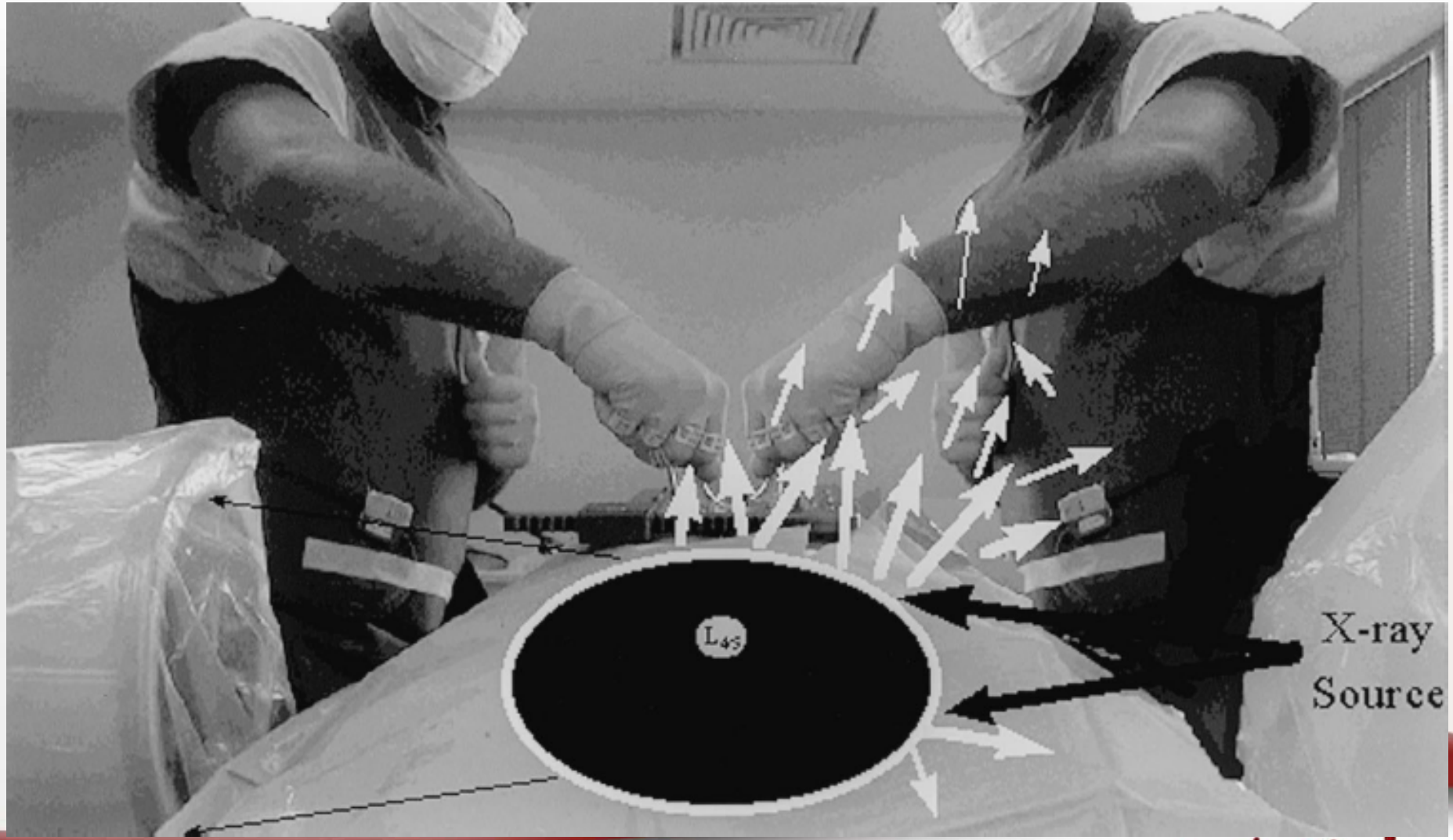
O-Arm == a CT!!!

Dosimetric characterization of a cone-beam O-arm imaging system.
Zhang J, Weir V, Fajardo L, Lin J, Hsiung H, Ritenour ER: **J XRay Sci Technol 17:**305–317, 2009

Texas Back Institute®

But, Remember, The Patient Is In The Beam And Is Getting The Whole Enchilada, But The OR Team Is Getting *Scatter Radiation*

Compton Scatter



Texas Back Institute®

Deterministic risks (e.g., cataract, osteonecrosis)

Radiation Induced Cataract

Threshold < 700 mGy

Long-term stochastic risks (e.g., cancer)

Spinal surgeons

- **Spinal surgeons can sustain a 10- to 12-fold increase in radiation exposure as compared with surgeons using fluoroscopy for nonspinal procedures.**

Radiation exposure to the spine surgeon during fluoroscopically assisted pedicle screw insertion. Rampersaud YR, Foley KT, Shen AC, Williams S, Solomito M: **Spine 25:**2637–2645, 2000

The Patient

- What is the problem for the patient?
  - Entrance skin dose rates with fluoro
    - Typically 30mGy/min
- Skin erythema occurs due to local skin exposure dose >2000mGy$_t$

Wagner et al. Partners in Radiation Management, 2000

Texas Back Institute®

Fluoroscopic Exposure

- **Percutaneous surgery is associated with greater radiation exposure**
  - **For example, radiation dose/pedicle screw was 3.2 times higher than with an open approach**

Fransen, Acta Orthop Belg, 2011

Texas Back Institute®

MIS TLIF

- **In a prospective study measuring surgeon radiation exposure in MIS TLIF, mean fluoroscopy time of 1.69 minutes per case, with a mean radiation exposure to the surgeon's torso (under a lead apron) of 27 mrem per case.**
- **The recommended maximum allowed annual radiation exposure of 5 rem to the torso might be exceeded if a surgeon performed more than 194 of these procedures annually.**

Surgeon and patient radiation exposure in minimally invasive transforaminal lumbar interbody fusion. Bindal RK, Glaze S, Ognoskie M, Tunner V, Malone R, Ghosh S: **J Neurosurg Spine 9:**570–573, 2008

Radiation Exposure to the Surgeon and the Patient During Kyphoplasty

Thomas E. Mroz, MD, Takayuki Yamashita, MD, William J. Davros, PhD, and Isador H. Lieberman, MD, MBA, FRCS(C)

- **27 pts, 52 vertebra (T4-L5)**

TABLE 2. Exposure Dose to the Surgeon

	Dose/Vertebra (mSv/Vertebra)	Dose/Exposure Time (mSv/min)
Badge dosimeter (Left chest, outside the lead apron)		
Deep	0.248 ± 0.170	0.058 ± 0.024
Eye	0.271 ± 0.200	0.063 ± 0.027
Shallow	0.273 ± 0.200	0.064 ± 0.027
Other dosimeters	< minimum reportable dose	
Ring dosimeter	1.744 ± 1.173	0.413 ± 0.257

- **Without eye or hand protection, surgeon would exceed OEL after 300 cases/yr**
- **Wear lead glasses and keep hands out of beam**

J Spinal Disord Tech 2007

Even In OPEN AIS Surgery!!!!

The index surgeon is projected to receive 13.49 mSv of whole body ionizing radiation and 4.31 mSv of thyroid gland irradiation annually.

The National Council on Radiation Protection's current recommendations set lifetime dose equivalent limits for classified workers (radiologists) at 10 mSv per year of life and at 3 mSv for nonclassified workers (spinal surgeons). At the levels estimated, a surgeon beginning his/her career at age 30 years would exceed the lifetime limit for nonclassified workers in less than 10 years.

"Radiation exposure during pedicle screw placement in adolescent idiopathic scoliosis: is fluoroscopy safe?" Ul Haque M, Shufflebarger HL, O'Brien M, Macagno A. Spine. 2006 Oct 1;31(21):2516-20.

Texas Back Institute®

Conclusions

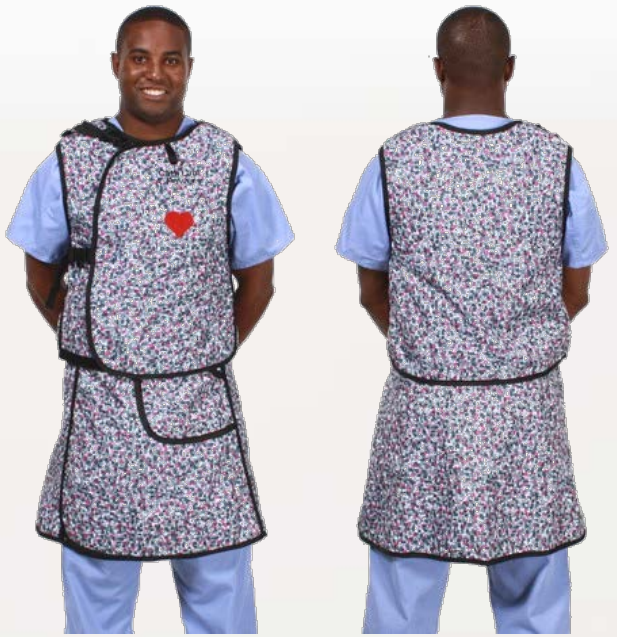
- **Radiation is Bad – for surgeons, for their patients, for the staff…whether it's a Sv, a Gy, or a rad**
- **An AVERAGE spine case can give the patient enough radiation to increase their risk of CANCER 1%**
- **New Techniques and MIS have a tendency to increase exposure**
- **Doctors will exceed their Lifetime Limits within 10yrs**
- **If you can cut radiation exposure by 90%, it would take 1000 cases per year instead of 100, 100yrs instead of 10yrs,…**

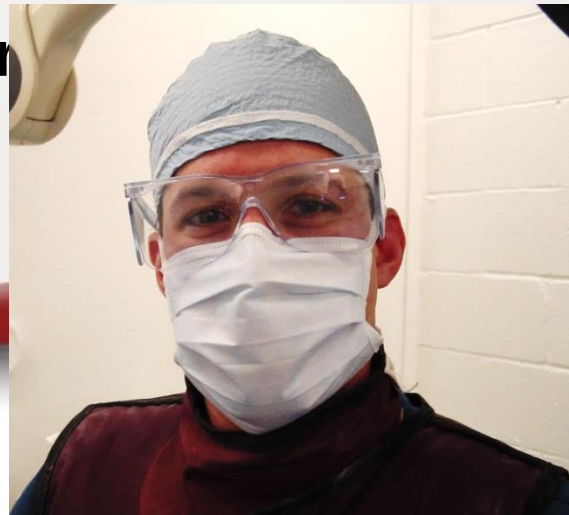
How to Minimize?

- Personal protection devices
- Technique changes
- Open Procedures
- Slot Imaging
- Navigation
- Robotics
- Computed Radiography
- All end up requiring a change in workflow

Protective Measures

- Wrap-around lead shield
- Thyroid shield
- Radioprotective glasses
- Safer gloves
- Staying away from beam
- Technique adjustments to avoid or minimize live fluoro





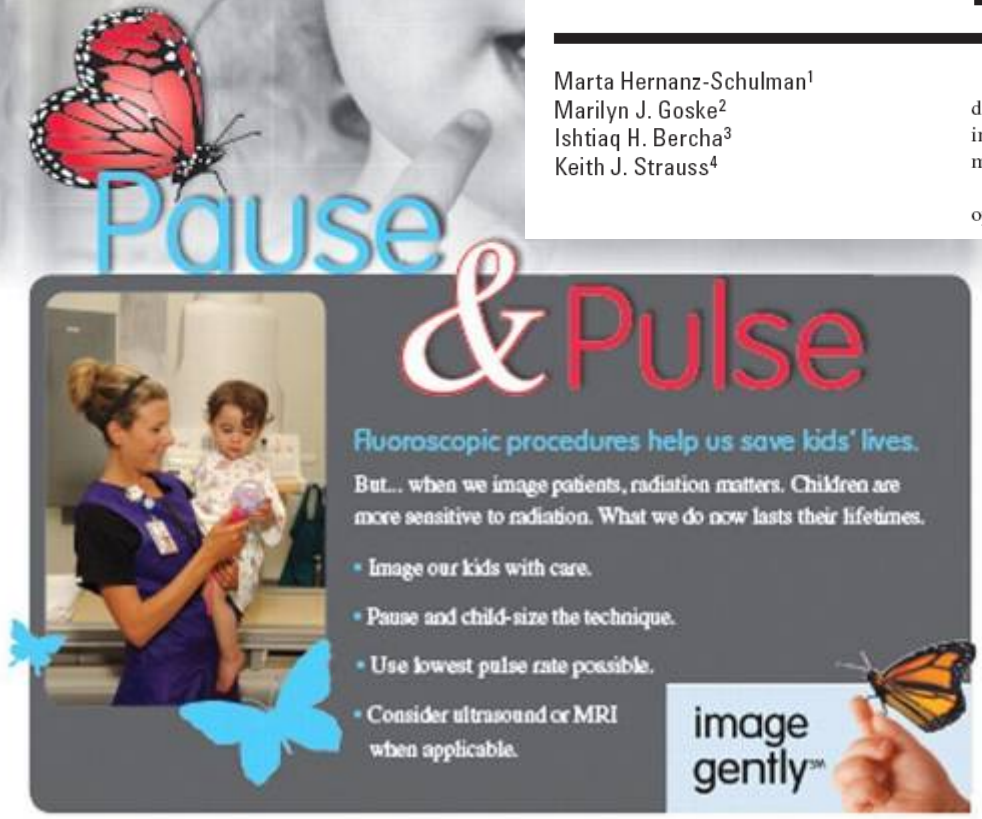
The American College of Radiology
The Society for Pediatric Radiology

Pause and Pulse: Ten Steps That Help Manage Radiation Dose During Pediatric Fluoroscopy

Marta Hernanz-Schulman[1]
Marilyn J. Goske[2]
Ishtiaq H. Bercha[3]
Keith J. Strauss[4]

OBJECTIVE. The Image Gently Campaign of The Alliance for Radiation Safety in Pediatric Imaging seeks to increase awareness of opportunities to lower radiation dose in the imaging of children. Pause and Pulse is the most recent phase of the campaign, addressing methods of dose optimization in pediatric fluoroscopy.

CONCLUSION. This article discusses 10 steps that can be taken for fluoroscopic dose optimization in pediatric diagnostic fluoroscopy.



ALARA –
radiation dosing “As Low As Reasonably Achievable”

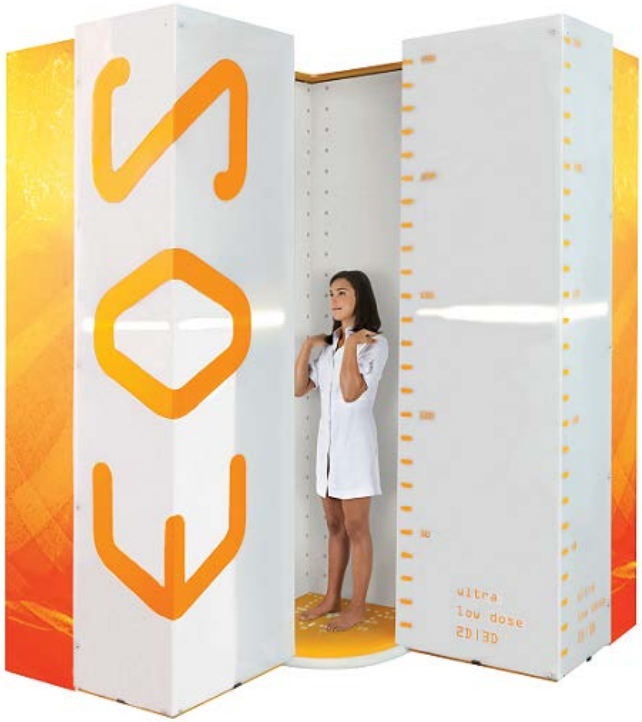
Texas Back Institute®

Revert to More Open Procedures

- **Direct Visualization of Landmark**
  - **Is that even possible?**
  - **Lessons from Mission Trips**
- **Increased Blood Loss, Procedure Times**
- **A Step Backwards?**

Slot Imaging

- Prototype is EOS
- Definite (radiation) advantage to patients
  - Decrease 50% vs DR, 85% vs CR
  - Less benefit to surgeons
- Reimbursement issues
- Cost
- Imaging can be excellent
- Full Length, Standing
- Simultaneous AP & Lat Images
- May need to send the patient out



Texas Back Institute®

Navigation

- Less live fluoro when directing implants
- Trade pre-procedure Imaging (CT) and pre-procedure registration for decrease in live fluoro
- Big advantage to surgeon
  - O Arm workflow has the surgeon away from the scanner when spinning
- Less advantage to the patient
- ? Improved accuracy
- Workflow changes required

Spine

SURGERY

SPINE Volume 38, Number 22, pp 1953-1958

Intraoperative Cone Beam–Computed Tomography With Navigation (O-ARM) *Versus* Conventional Fluoroscopy (C-ARM)

A Cadaveric Study Comparing Accuracy, Efficiency, and Safety for Spinal Instrumentation

Ehsan Tabaraee, MD,* Anthony G. Gibson, MBBS,* Dean G. Karahalios, MD,† Eric A. Potts, MD,‡ Jean-Pierre Mobasser, MD,‡ and Shane Burch, MD, MSc, FRCSC*

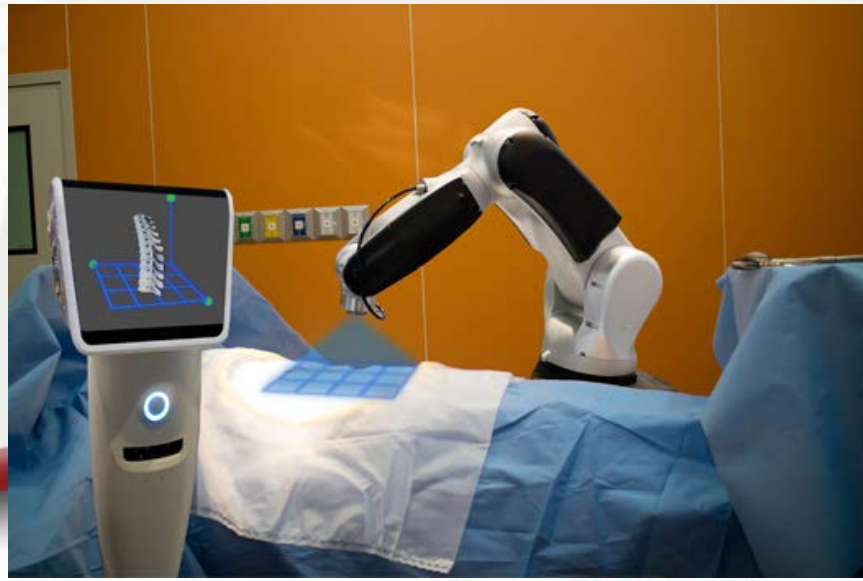
- **160 pedicle screws placed in 8 cadavers without deformity**
- **O-Arm related to significantly less radiation exposure to surgeon**
  - **But significantly greater radiation exposure to specimens**

Gibson et al., AANS, 2010

Texas Back Institute®

Robotics

- Similar advantages to navigation
- Less live fluoro when directing implants
- Trade pre-procedure Imaging (CT) and pre-procedure registration for decrease in live fluoro
- Big advantage to surgeon
- Less advantage to the patient
- ? Improved accuracy
- Workflow changes required for sure



J Spinal Disord Tech, in press

ORIGINAL ARTICLE

Assessment of Pedicle Screw Placement Accuracy, Procedure Time, and Radiation Exposure Using a Miniature Robotic Guidance System

Isador H. Lieberman, MD, Mitchell A. Hardenbrook, MD,† Jeffrey C. Wang, MD,‡ and Richard D. Guyer, MD**

- **Compared with free hand placement of pedicle screws, robotic guidance associated with:**
  - **Lower surgeon radiation exposure (136 vs. 4.2 mrem)**
  - **Less fluoroscopy time per screw (33.0 vs. 0.9 sec)**

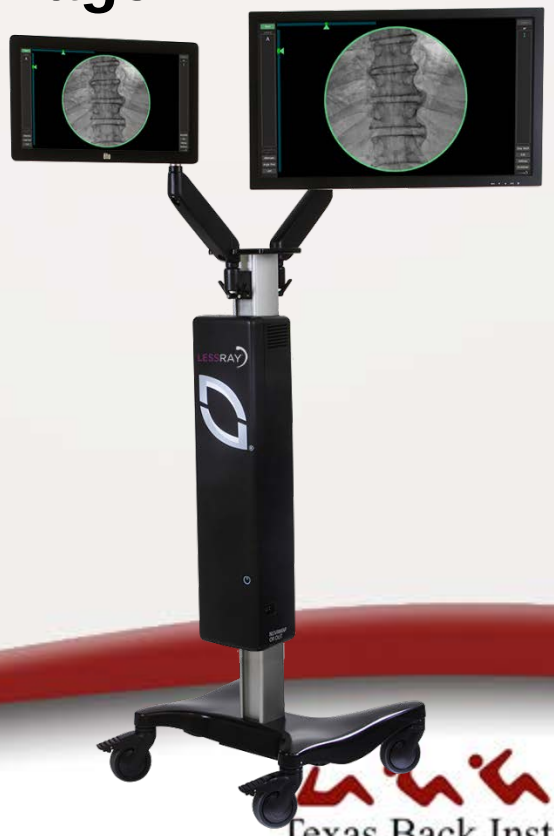
Texas Back Institute®

Patient's Exposure Associated with Robotic-Guided System

- **Robotic guidance is generally associated with reduced fluoro time during surgery compared with traditional screw placement techniques**
- **However, the patient may also have significant added exposure if thin slice CT is needed for use with the robotic system**
  - **Particularly in pts with spinal deformity requiring thoracic and lumbar thin slice CT**

Computed Radiography

- Prototype is Less Ray
- Get scout films then low dose incremental images and calculate a higher resolution image
- Less radiation per click
- Fewer localization images
- May even improve workflow
- Not Inexpensive



Texas Back Institute®