Power and Scatter: A Study Comparing RetractOrtho and Stainless-Steel Retractors

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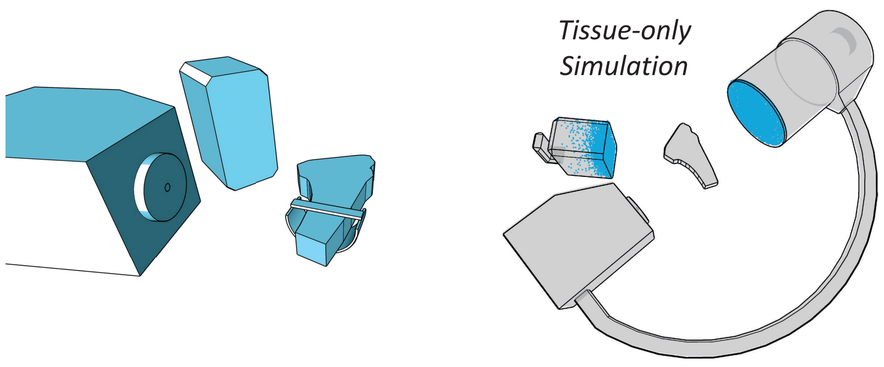
Purpose

The study was performed to evaluate the differences in x-ray power required for imaging and radiation scatter dose when utilizing RetractOrtho retractors versus stainless-steel retractors.

Simulation

In preparation for the testing, a Monte Carlo simulation was performed to validate the model and sensitivity of the equipment. All simulations were run using mono-energetic x-rays at 59kV for tissue and plastic retractor samples and 66kV for metal retractors. A minimum energy threshold of 25keV was used based on the sensitivity of the Geiger counter.

Simulated geometry included realistic models of a C-arm, lamb shank, and retractors made of either stainless steel or nylon. Additionally, a Geiger counter was simulated at an angle of 45 degrees to the C-arm's beam.

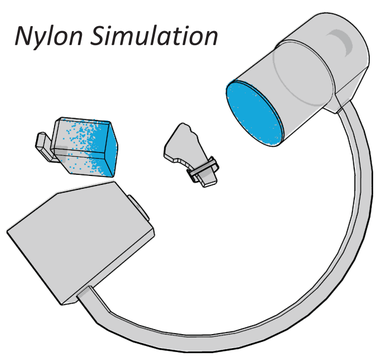


Tissue-only Simulation

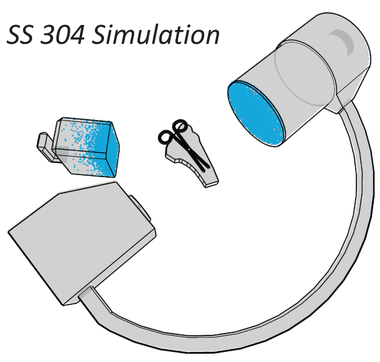
Simulation Setup

Simulation results were exported and analyzed in order to calculate differences in scattered radiation based on retractor design. In the visualized simulation output, each blue dot represents the location that an x-ray was absorbed by the C-arm detector or Geiger counter.

To account for the auto-focus feature of the C-arm, simulation results for both retractor designs were normalized based on the number of x-rays absorbed by the C-arm's detector. After normalization, absorbed energy was calculated for the Geiger counter to represent radiation dose to surgical staff.



Nylon Simulation



SS 304 Simulation

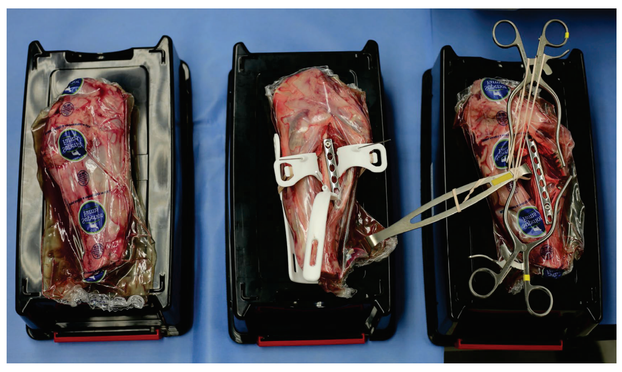
The following table details the results of the simulations.

Test Load	Power (kV)	Recorded Events		Versus 'Tissue Only'		Relative Dose	
		C-Arm Detector	Geiger Counter	C-Arm Detector	Geiger Counter	C-Arm Detector	Geiger Counter
Tissue Only	59	133,038	4,150	-	-	-	-
Nylon Retractor	59	131,683	4,308	100.0%	105.2%	100.0%	99.8%
SS304 Retractor	66	82,804	3,907	71.7%	63.0%	111.7%	109.6%

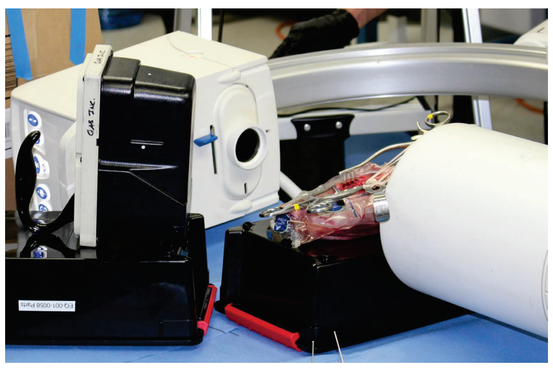
Methods

Three test systems were created using similarly sized tissue samples: a lamb shank, a light load (RetractOrtho retractors in a lamb shank), and a heavy load (stainless-steel retractors in a lamb shank). Both retractor setups contained the same metal compression clamp and bone screw. The RetractOrtho lamb shank had 2 plastic metaphyseal retractors, a plastic drill guide, and 3 metal k-wires. The stainless-steel retractor lamb shank had 2 Weitlaner retractors and an Army Navy retractor. Imaging was also completed with nothing in the C-arm view as a control.

A Geiger counter (Victoreen 450P) was used to record the radiation scatter dose at the location of the physician's hand during a distal/radial fracture procedure. Using the auto focus setting on a Hologic InSight 2 mini C-arm, each of the 3 test setups were imaged and the X-ray power setting was recorded from the C-arm and radiation scatter dose was recorded from the Geiger counter.



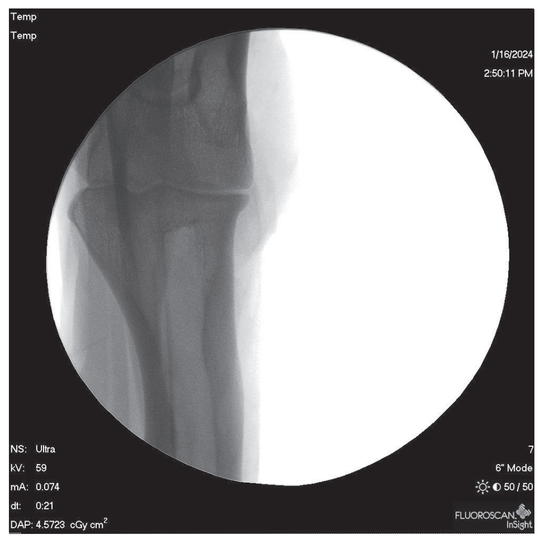
Test Setup: (left to right) lamb shank, light load, heavy load

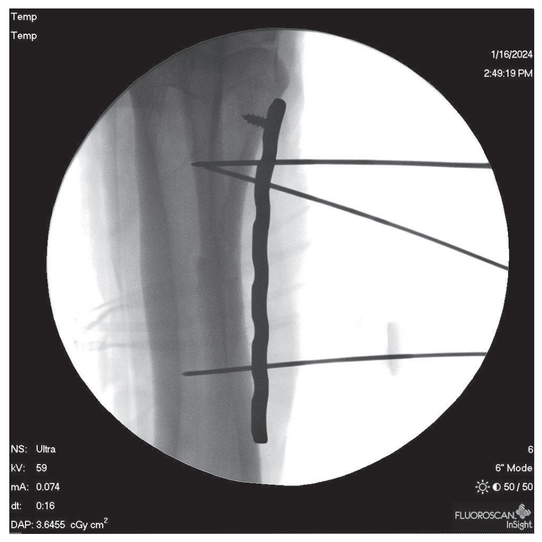


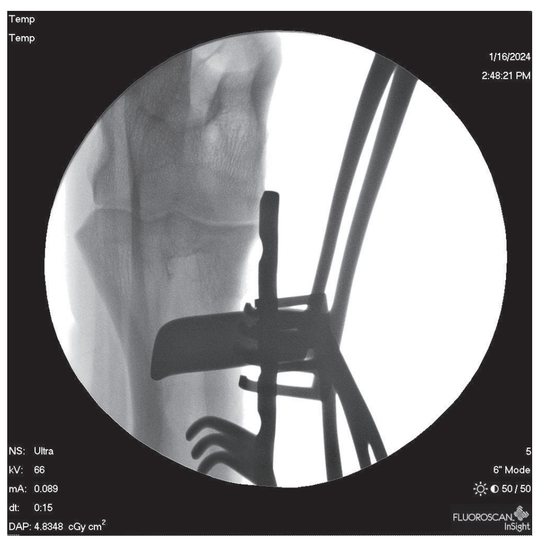
Geiger Counter Setup

Results

During autofocus imaging, the simulated tissue sample and the RetractOrtho retractors had identical power settings of 59kV, while the stainless-steel retractors had a power setting of 66kV. As a negative control, an autofocus image was taken with nothing in the C-arm field of view (picture not shown). The negative control power setting was 50kV.







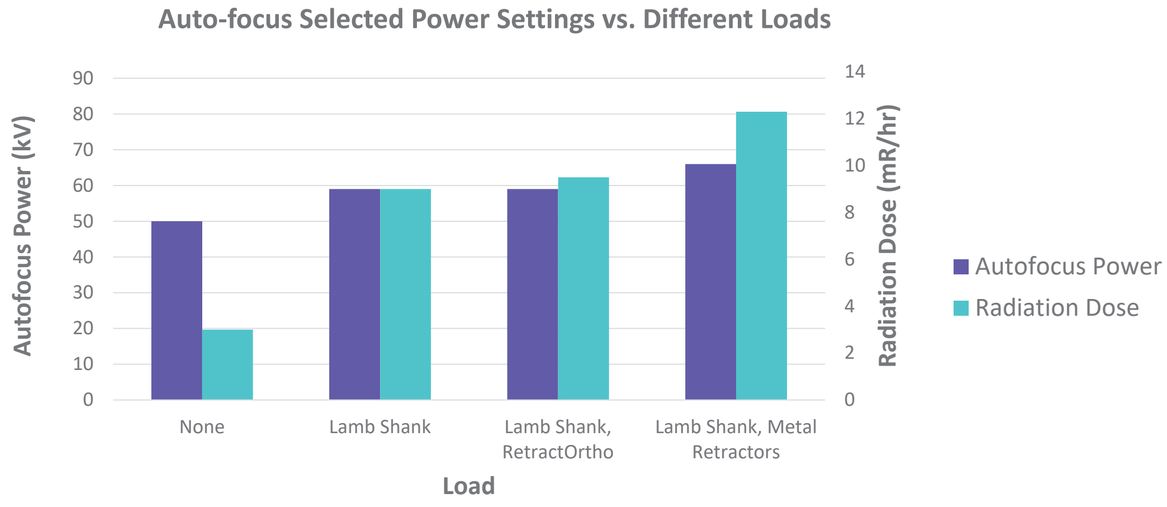
(Upper Left) Autofocus Image of Simulated Tissue Sample (59kV)

(Upper Right) Autofocus Image of RetractOrtho Retractor Test Sample (59kV)

(Lower Left) Autofocus Image of Stainless-Steel Retractor Test Sample (66kV)

The stainless-steel retractors required a 12% increase in power to acquire similar image resolution to the non-metal imaging.

Radiation dosage measurements during each of these imaging sessions of the different loads demonstrated a positive correlation between power setting and radiation dosage. When using autofocus, a physician's hand may be exposed to 30% (12.3 vs. 9.5 mR/hr) greater radiation scatter dosage when imaging with stainless-steel retractors in place instead of RetractOrtho retractors.



Discussion

Overall, the Monte Carlo simulation produced results consistent with the physical testing described with the RetractOrtho and stainless-steel retractors. The repeatability of these results and trends validates the testing setup and equipment sensitivity for dosage measurements.

For both auto-selected power settings and radiation dose, the simulated tissue sample and the RetractOrtho test sample were almost identical, while the stainless-steel retractor test sample had a higher auto-selected power setting and subsequently a higher radiation dose. Using the current clinical workflow, physicians may remove stainless-steel retractors before imaging to acquire a cleaner image of the fracture site. Based on this study and the radiolucent nature of the RetractOrtho retractors, imaging could be performed with the RetractOtho retractors in place without requiring an increase in power or associated radiation dose.

References

1. Sandborg, PhD, Michael. "Measurement of Entrance Air Kerma Rate on Anthropomorphic Phantoms in Relation to DoxpalTM Double and DoxpalTM Hip/Spine and Their Metallic Counterparts i.e. the Weitlander and Adson Self-Retaining Retractor", 26 May 2010.
2. Groover, Michael T., et al. "The effect of metal instrumentation on patient and surgical team scatter radiation exposure using mini C-arm in a simulated forearm fracture fixation model." JAAOS: Global Research and Reviews, vol. 3, no. 6, June 2019, https://doi.org/10.5435/jaaosglobal-d-18-00089.

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