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Occupational exposure during orthopaedic surgery of lower and upper extremities

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1. Background-Aim

- The use of fluoroscopy to guide fracture reduction and facilitate anatomic localization of implant placement has become essential for surgeons seeking to reach a radiographically ideal result.

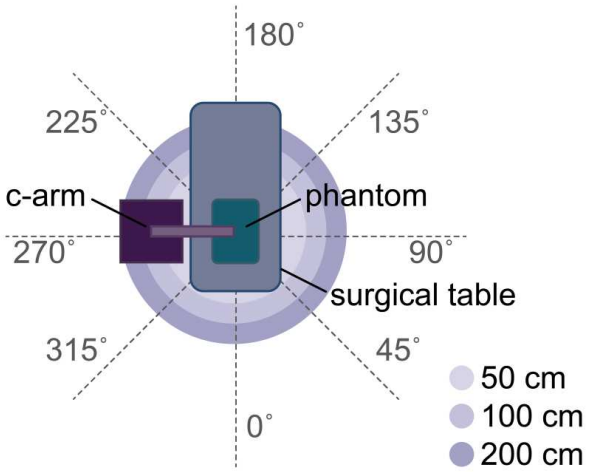
- Continued advances in digital imaging have allowed the performance of new and more complex surgeries.

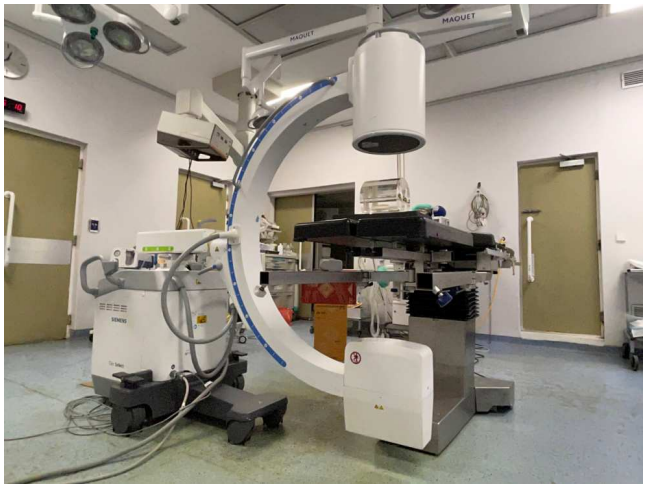
- Interventional procedures can require long fluoroscopy times, cine acquisitions, and high-dose fluoroscopy modes, which can end up to high doses to patients and staff.

- The current study aims to estimate occupational exposure during fluoroscopy-guided orthopaedic surgery of the lower and upper extremities.

2. Materials & Methods (1)

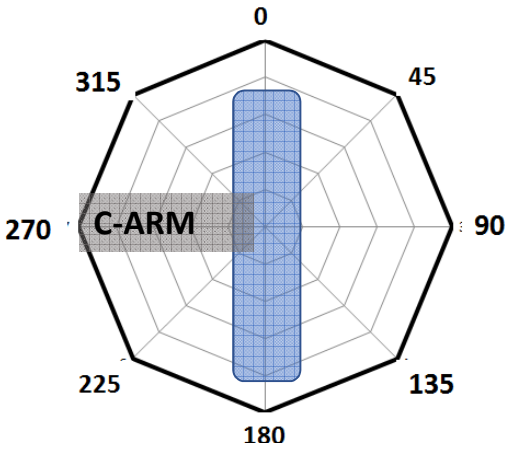
- A Siemens Cios Select c-arm unit with a 23 cm diameter image intensifier was used.
- A cylindrical PMMA phantom was irradiated → 150 mm thickness and 160 mm diameter.
- Inside the phantom, metal implants were embedded **(**titanium plates, titanium screws) → commonly used in orthopaedic surgery of lower and upper extremities.
- An RTI ion chamber (survey meter) was used for measuring scattered radiation (µSv/hr) at varying positions around the phantom.
- The angle range of measurements was 0° to 315°, with a step of 45°.

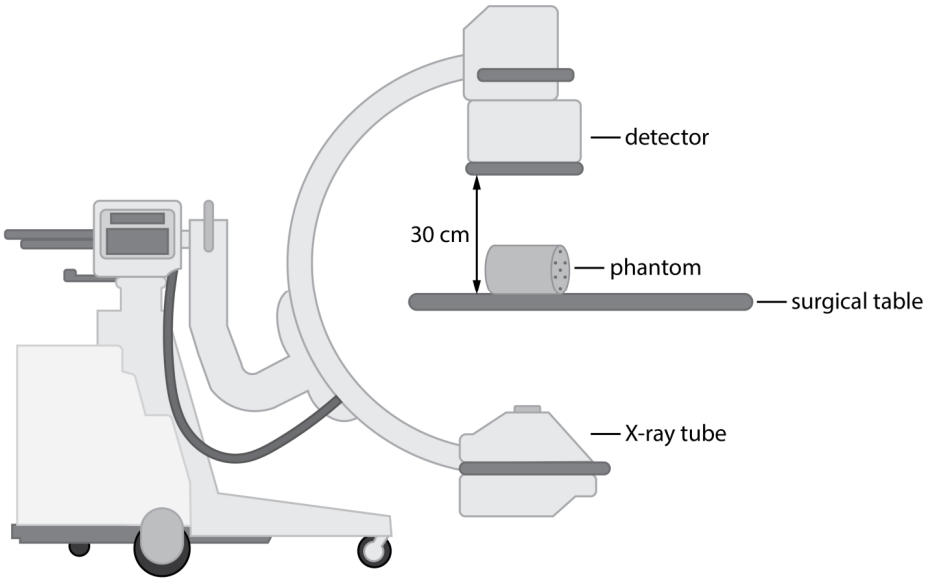




2. Materials & Methods (2)

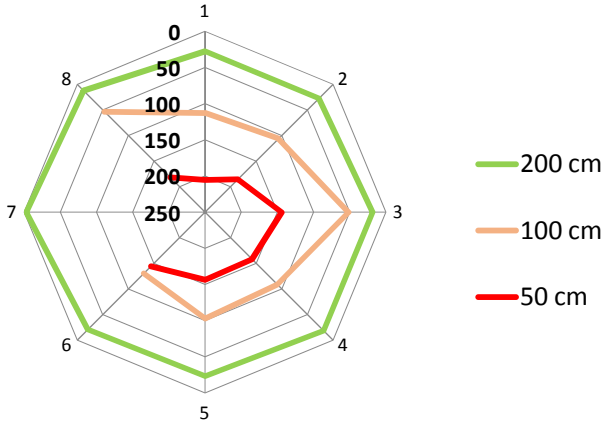
- Ion chamber-phantom distance → 50 cm, 100 cm and 200 cm
- Ion-chamber height → 80 cm (gonads) and 162 cm (lens of the eye) above the floor.
- Continuous fluoroscopy of 30 p/s was performed in an undercouch geometry.
- Fluoroscopy Dose Rate Modes used → Low, Normal, High
- Two field of views values used → 16 cm (zoom 1) and 32 cm (no zoom)
- Average fluoroscopy time per intervention → 30 s
- Organ equivalent dose (gonads, eyes) for personnel positioning (distance and angle) was estimated (workload: 200 interventions/year).



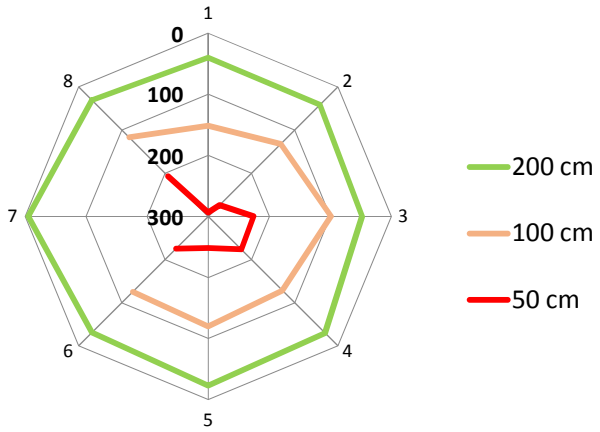


3. Results (1)

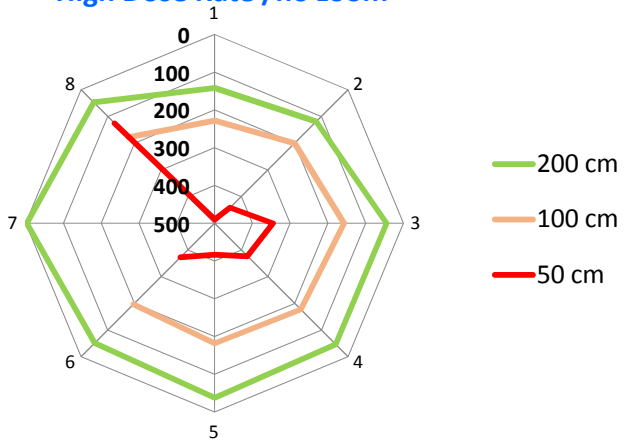
Dose rate (µSv/hr) @162 cm height
Low Dose Rate /no zoom



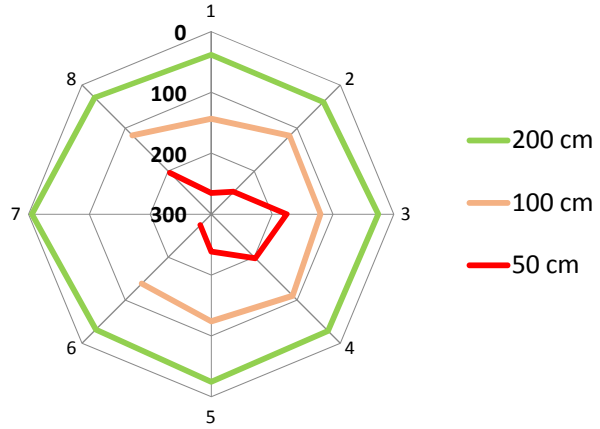
Dose rate (µSv/hr) @162 cm height
Normal Dose Rate /no zoom



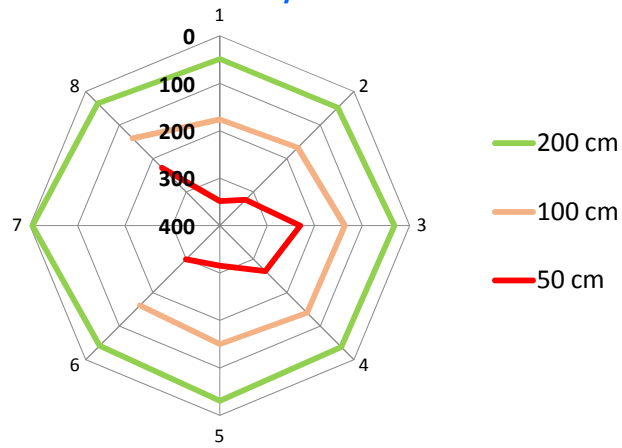
Dose rate (µSv/hr) @162 cm height
High Dose Rate /no zoom



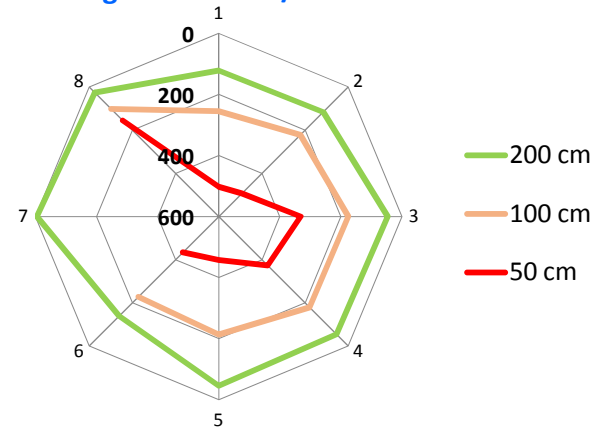
Dose rate (µSv/hr) @162 cm height
Low Dose Rate /zoom 1



Dose rate (µSv/hr) @162 cm height
Normal Dose Rate /zoom 1

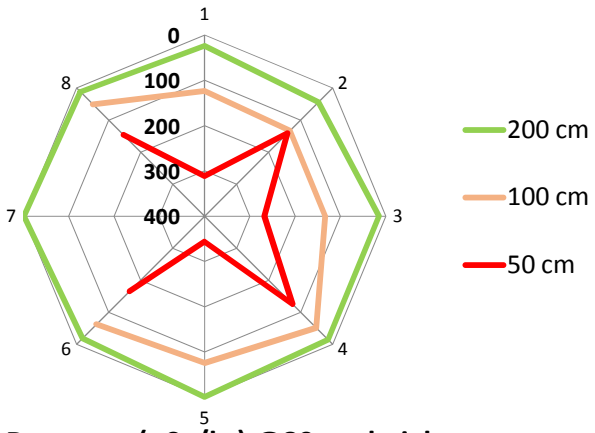


Dose rate (µSv/hr) @162 cm height
High Dose Rate / zoom 1

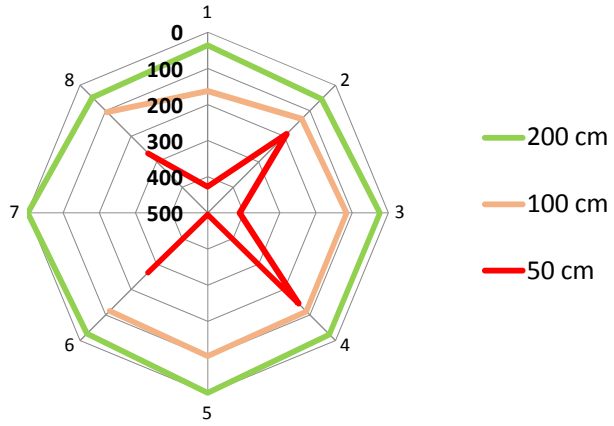


3. Results (2)

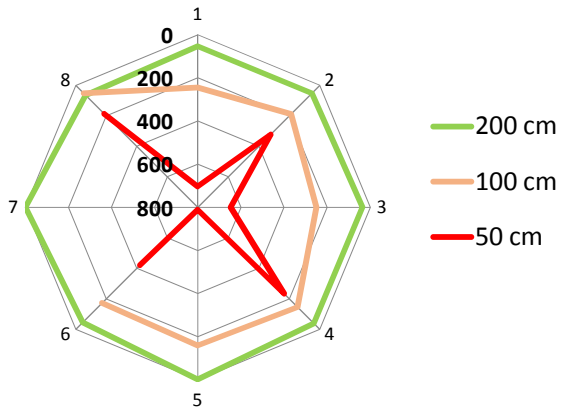
Dose rate (µSv/hr) @80 cm height
Low Dose Rate /no zoom



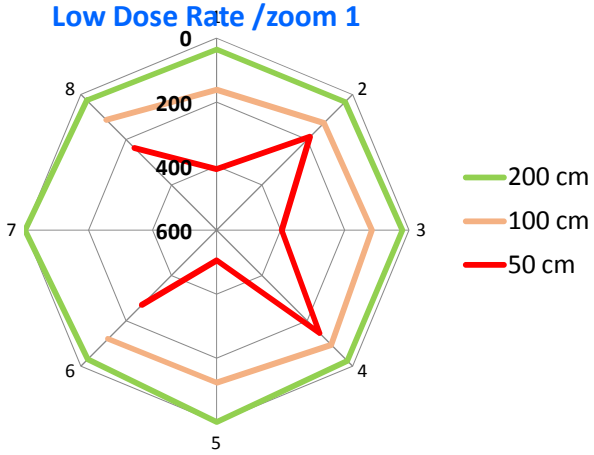
Dose rate (µSv/hr) @80 cm height
Normal Dose Rate /no zoom



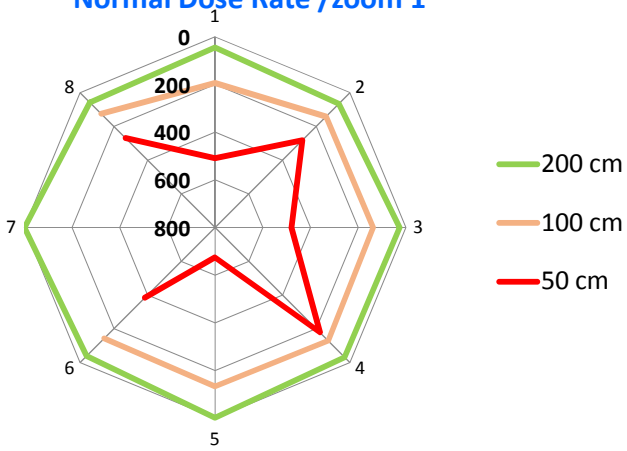
Dose rate (µSv/hr) @80 cm height
High Dose Rate /no zoom



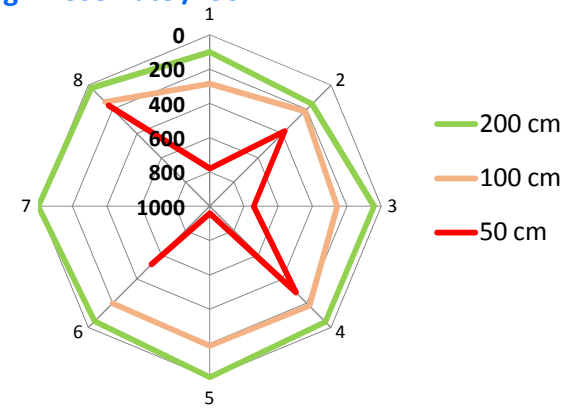
Dose rate (µSv/hr) @80 cm height
Low Dose Rate /zoom 1



Dose rate (µSv/hr) @80 cm height
Normal Dose Rate /zoom 1



Dose rate (µSv/hr) @80 cm height
High Dose Rate /zoom 1



Occupational exposure depends on exposure settings, as well as on distance and angle positioning relative to the phantom.

3. Results (3)

Personnel Positioning	Organ Equivalent Dose (µSv/year)		
	Gonads (with shielding)	Lens of the eye (without shielding)	Lens of the eye (with shielding)
Head Orthopaedic Surgeon (Distance: 50 cm, Angle: 0^0)	23,1	156,9	15,7
Assistant Orthopaedic Surgeon (Distance: 50 cm, Angle: 45^0)	11,4	145,0	14,5
Resident Orthopaedic Surgeon (Distance: 100 cm, Angle: 315^0)	4,5	57,4	5,7
Nurse 1 (Distance: 100 cm, Angle: 90^0)	7,1	53,1	5,3
Nurse 2 (Distance: 200 cm, Angle: 135^0)	1,3	15,7	1,6
C-arm Operator (Distance: 200 cm, Angle: 270^0)	0,1	2,4	0,2

Assumptions: Occupancy factor T=1, scattered radiation attenuation 90% with shielding (e.g. aprons, glasses)

4. Conclusions

Recording of the **spatial distribution of scattered radiation**, in case of fluoroscopy-guided orthopaedic surgery of lower and upper extremities, **may be used as an optimization tool** for occupational exposure, in addition to radiation protective means.

Annual equivalent doses to organs, such as gonads and lens of the eye, **are low** in fluoroscopy-guided orthopaedic surgery of lower and upper extremities , provided that appropriate protective means are utilized and good practices are adopted.

5. Future Work

- Exploit anthropomorphic phantom, as well as phantoms of varying thickness values, simulating varying BMIs (Body Mass Index).
- Use of active dosimeters (e.g. TLDs).
- Investigate the effect of metal implants of varying size and material.
- Consider additional c-arm orientations (e.g. horizontal).

6. References

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