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The magnitude of dose calculation errors as a component of the IROC lung and spine phantom failures

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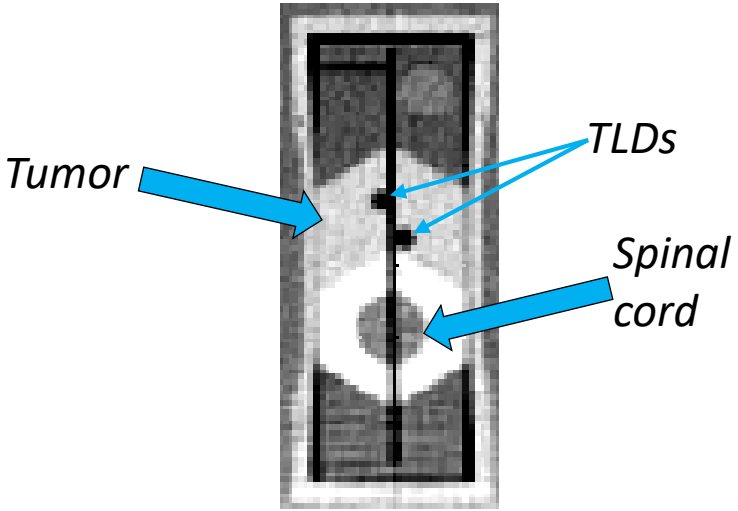
IROC Houston Phantom Credentialing

- Clinical trial participation (Followill et al. 2012)
  - Irradiate phantoms that represent human anatomy
  - Over 2000 institutions in U.S. and abroad

Fig. 1 Thoracic phantom



IROC Houston Phantom Credentialing

- Deliver 6 Gy to TLD and film

Moving lung phantom

Criteria:

- TLD ± 7 %, gamma 7 %, 5 mm

Failure rate:

$^{141}/_{1052} = 13$ % (2012-2018)

SBRT spine phantom

Criteria:

- TLD ± 7 %, gamma 5 %, 3 mm

Failure rate:

$^{46}/_{263} = 17$ % (2012-2018)

Questions to answer:

- Are there dose calculation errors in these treatment plans?
- What is the magnitude of this error?
- How much does this error influence phantom failure?

Method

- 188 phantom plans: 60 spine, 128 lung
- Recalculated plan dose on independent dose recalculation system (DRS)
  - ➢ previously commissioned with data from over 500 LINACs (Kerns et al 2016)
  - ➢ represents average-performing machine (generic model)

- Compared for each phantom:
  i. TPS/TLD
  ii. DRS/TLD

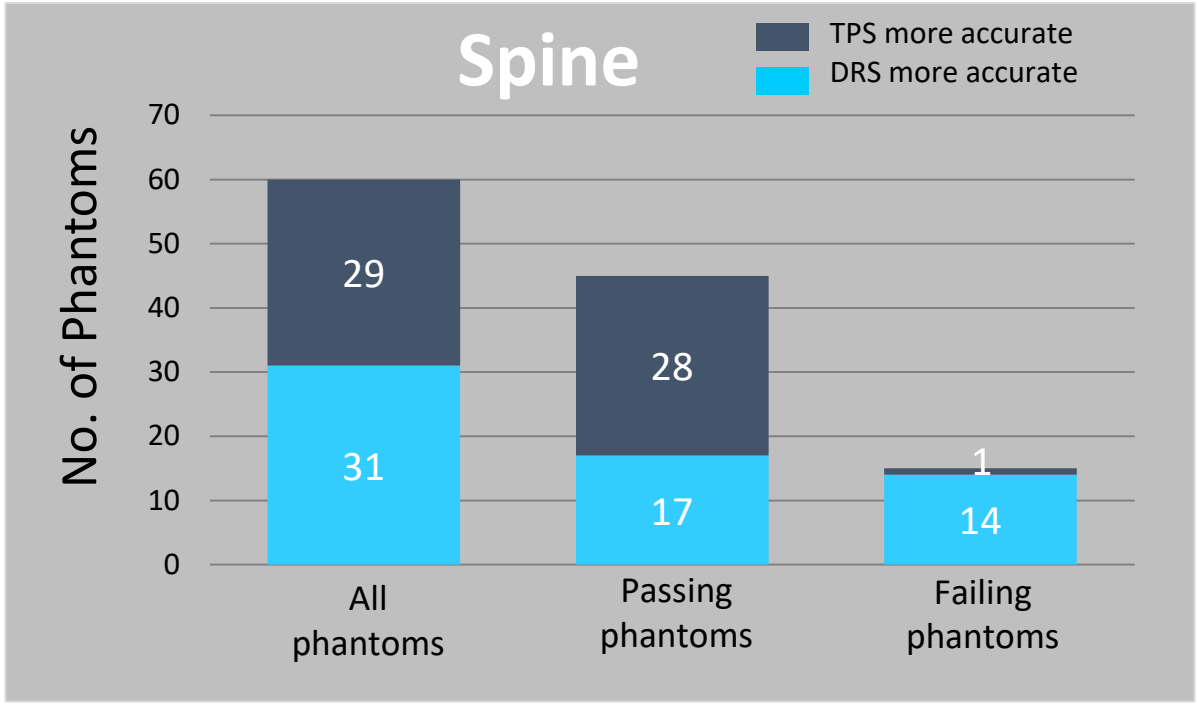
- Dose difference value (D)

$$D = \left(\left| 1 - \frac{TPS}{TLD} \right| - \left| 1 - \frac{DRS}{TLD} \right| \right) \times 100$$

- D value = TPS more accurate

+ D value = DRS more accurate

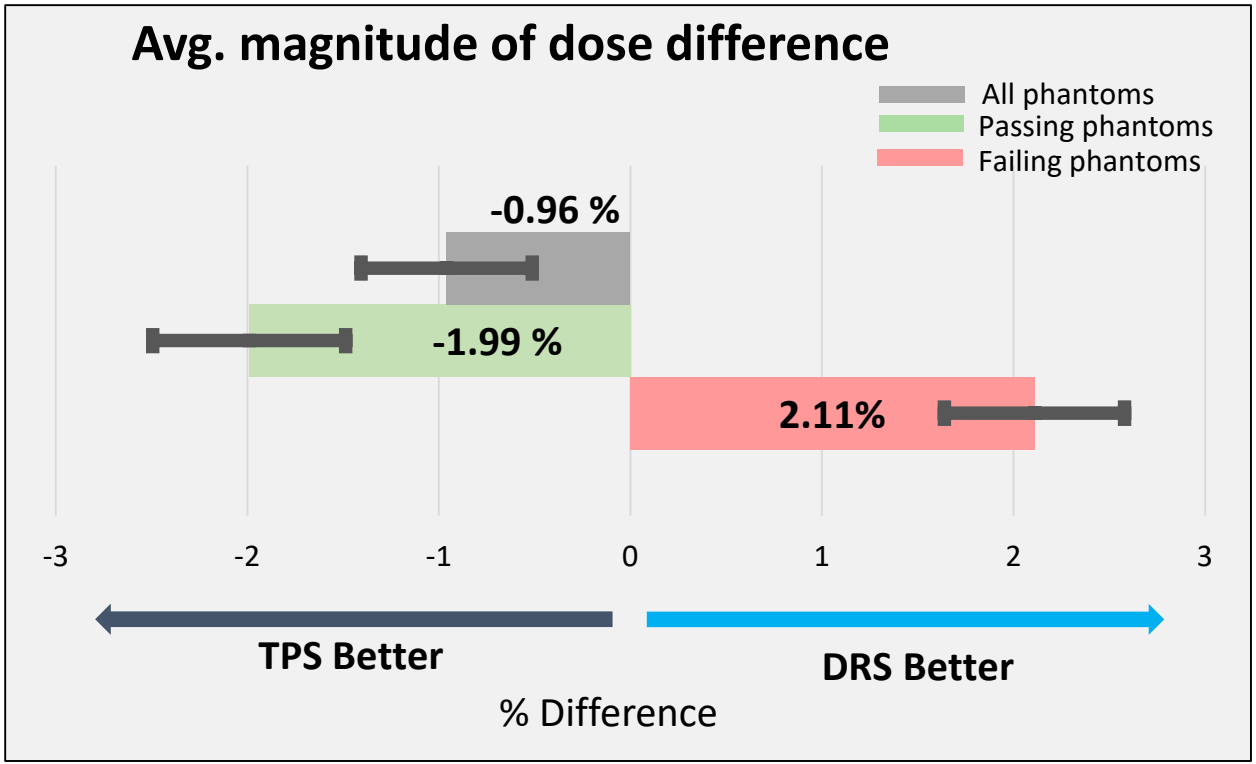
Spine results: Number of phantoms



DRS outperformed TPS in:

- 52% of total phantoms
- 38% of passing phantoms
- **93% of failing phantoms**

Spine results: Magnitude of Dose difference

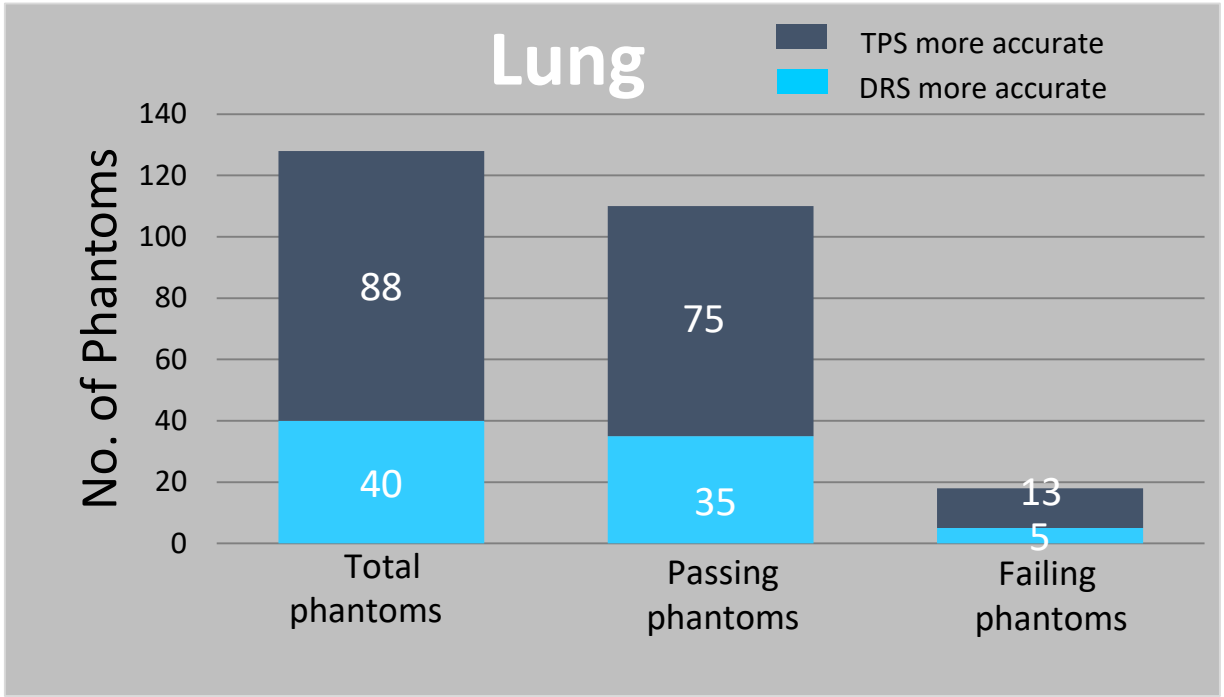


Average magnitude of D for failing spine phantoms = 2.11% (max = 5.25%)

D > 2% indicates DRS clinically considerably better than TPS calculation

(Kerns et al 2017)

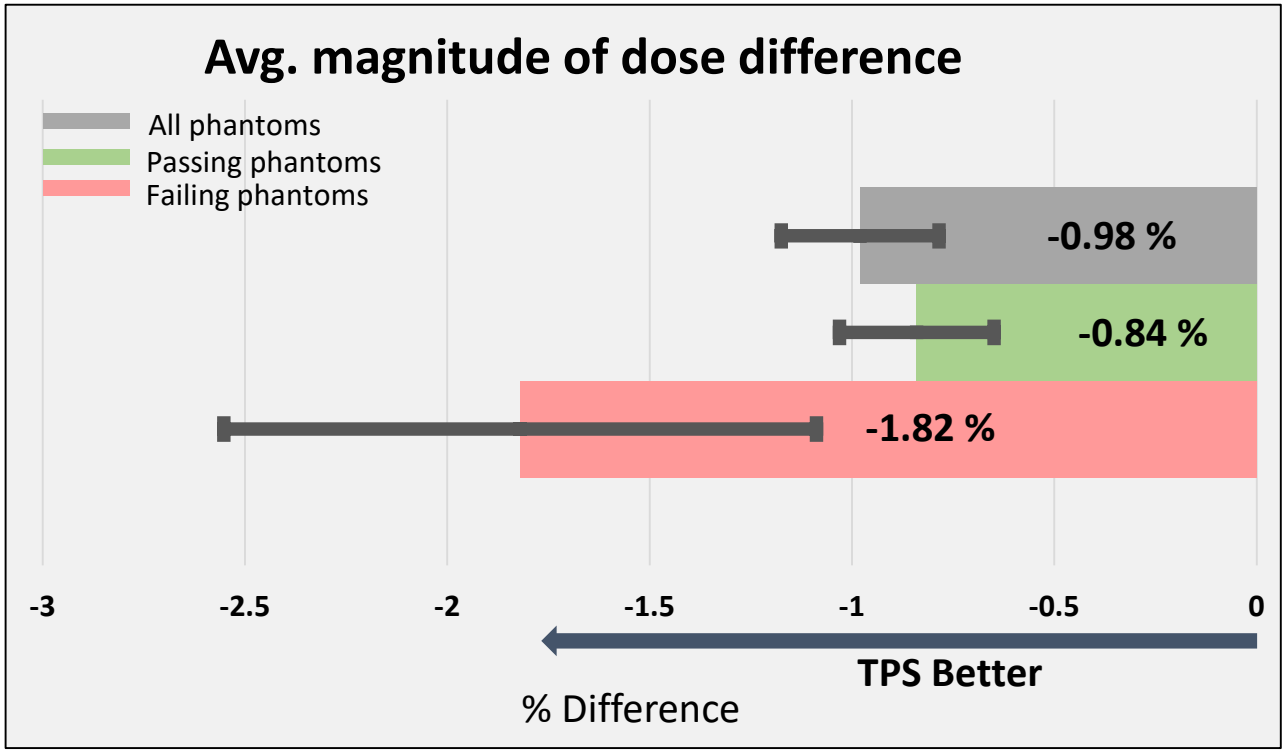
Lung results: Number of phantoms



DRS outperformed TPS in:

- 31% of total phantoms
- 32% of passing phantoms
- 28% of failing phantoms

Lung results: Magnitude of Dose difference



Negative D values in all categories indicating few dose calculation errors.

Lung vs Spine Performance

- Spine- highly modulated treatment plan
  - ➢ Tumor located on vertebral column near spinal cord

- Lung- low modulation treatment plan
  - ➢ Tumor located in air cavity

DRS vs TPS Performance

- DRS represents average-performing machines (average TrueBeam, average Versa etc.)

- DRS should not outperform TPS which is custom-tailored to an institution's machine and beam model

Conclusion

Spine:

- TPS and DRS performed fairly evenly overall (48% vs 52%)
- DRS remarkably better among failing phantoms (93%)

<u>Dose calculation errors do exist among failing spine phantoms</u>

Conclusion

Lung:

- TPS outperformed DRS in all phantom categories

<u>Few dose calculation errors exist among lung phantoms</u>

Future Work

- Investigate dose calculation errors in other phantom groups

- Evaluate other potential sources of error among phantoms

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