

Estimation of peak skin dose (PSD) from $CTDI_{vol}$ for head CT

Teresa Lo
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- Neuro interventional procedures
 - High dose – requiring skin dose estimates
 - Come with multiple and different types of head CT
- Head CT
 - Not monitored for skin dose
 - Wide range of head CT protocols
 - 10 – 180 mGy (from local scanner)
 - Doses accumulate

Background

- Skin dose estimates
 - Established method for interventional procedures
 - Currently no method for CT
- Skin dose for head CT maybe doable
 - Little variation in head sizes
 - Existing QA data:
 - $CTDI_{vol}$ measurements on CTDI head phantom

Hypothesis

- $CTDI_{vol}$ for single slice on a local scanner
 - IPEM91 recommended QA measurements
 - 120kV, 260 mAs, 40 mm collimation, CTDI head phantom
 - Max peripheral $CTDI_{100} / CTDI_{vol} \sim 1$

$CTDI_{vol}$ (mGy)	
calc	scanner
40.3	42.05

Position	$CTDI_{100}$ (mGy)
Centre	40.13
N	42.93
E	40.80
S	38.33
W	39.28

- De las Heras et al., 2013
 - PSD and $CTDI_{vol}$ measurements on CTDI phantom
 - 4 scanners
 - $CTDI_{vol}$ measurements following AAPM protocol
 - Single slice
 - Gafchromic film for PSD measurements
 - 2 film strips at the top and bottom surfaces of phantom

- Nawfel and Young, 2017
 - Patient and skull phantom measurements
 - 2 scanners
 - Clinical protocols for head CT and CTA
 - nanoDot OSL dosimeter for PSD measurements
 - 4 nanoDots on the forehead, back of the head, left and right temporal bone
 - Scanner stated $CTDI_{vol}$

Literature review

- De las Heras et al., 2013
 - PSD/CTDI_{vol} = 0.75 – 0.94
 - Scanner specific
- Nawfel and Young, 2017
 - PSD/CTDI_{vol} = 0.53 – 0.7

(de las Heras et al., 2013)		(Nawfel and Young, 2017)			
Scanner	PSD/CTDI _{vol}	Scanner	Patient/Phantom	PSD/CTDI _{vol}	
				Head CT	CTA
GE	0.84 ± 0.04	Siemens	Patient	0.57 ± 0.07	0.53 ± 0.07
Philips	0.94 ± 0.05		Phantom	0.58	0.63
Siemens	0.75 ± 0.04	Toshiba	Patient	0.66 ± 0.16	0.70 ± 0.07
Toshiba	0.87 ± 0.04		Phantom	0.60	0.68

Objectives

- Evaluate the relationship between PSD and $CTDI_{vol}$ for head CT for a local scanner
- Explore effects of different measurement set up on PSD/ $CTDI_{vol}$
 - CTDI head vs RANDO head
 - Helical vs axial
 - 120 kV vs 80 kV
 - PSD vs north peripheral dose (NPD)

METHODS

Phantom Measurements

- GE Discovery CT750 HD
- PSD
 - TLDs along mid line of phantom
- Scanner stated $CTDI_{vol}$

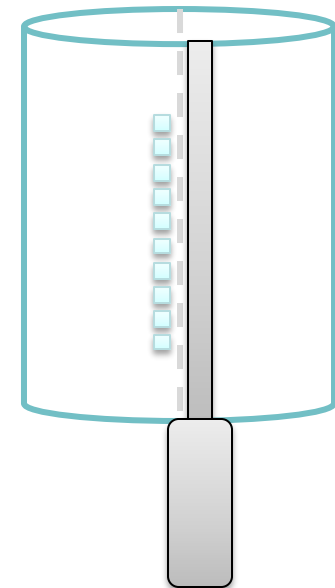
Exposure parameters

kV	120 & 80
mA	260 (CTDI head) 80-280 (Rando head)
Collimation (mm)	20
Scan length (mm)	157.5
Scan type	Axial & Helical (CTDI head) Axial (Rando head)
Pitch	0.531



Calibration

- Direct calibration
 - Same beam quality
- TLDs over active region of chamber
- Over scan to ensure uniform dose to TLDs
- Calibration factor = Chamber dose / mean TLD reading
- Axial and scout scan

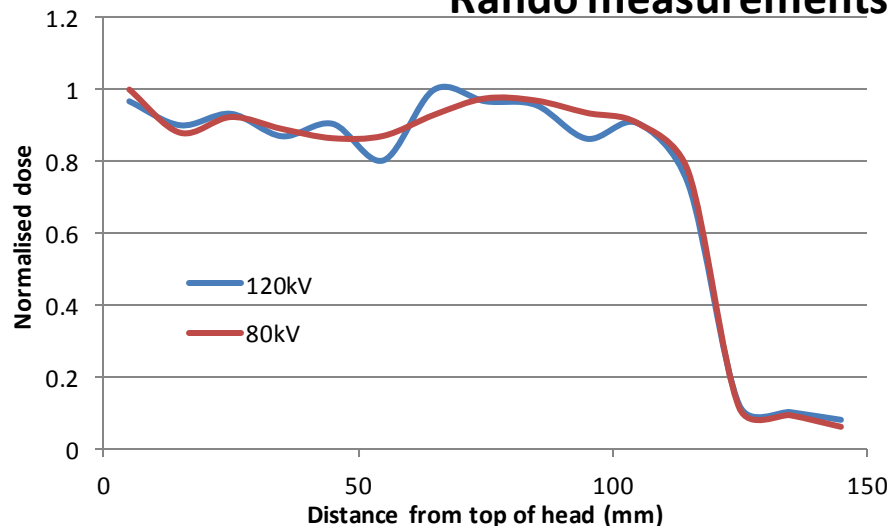


RESULTS & ANALYSIS

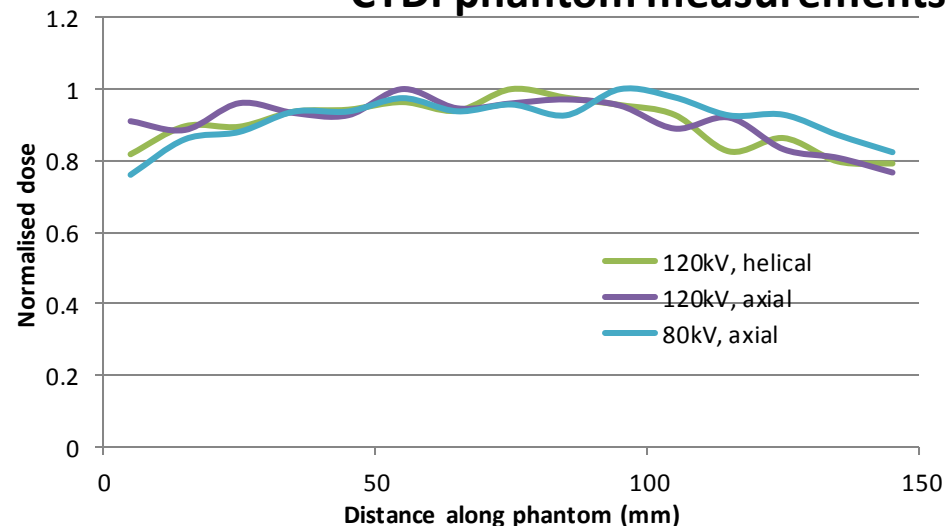
Skin dose profile

- Drop in Rando measurements
 - Patient alignment
- Bow shaped profile along CTDI phantom
 - Variation in scatter

Rando measurements



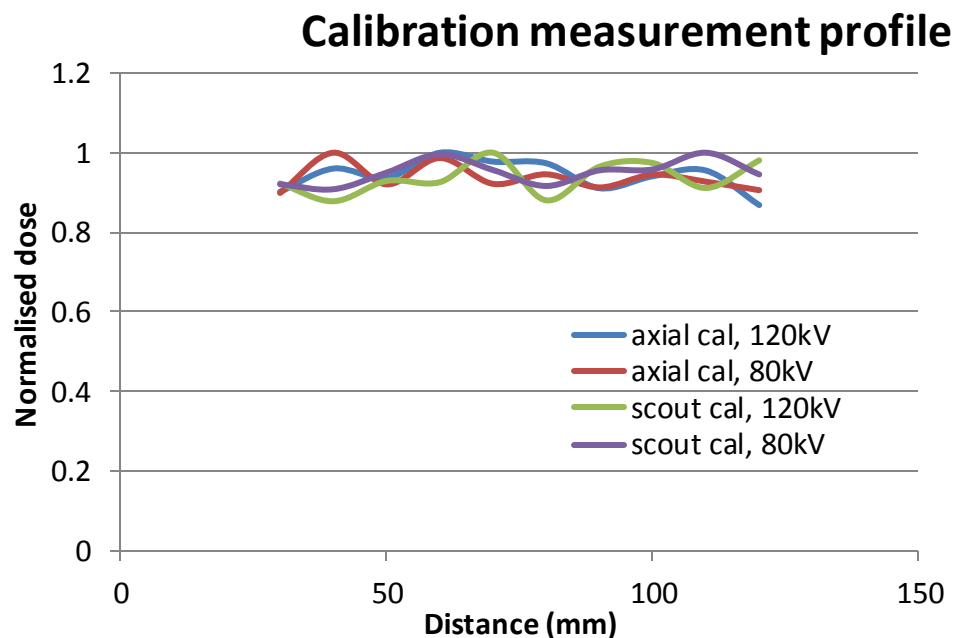
CTDI phantom measurements



Calibration factors

- Similar for different scan types and kVs
- Flat dose profile
 - Over scan

Scan type	kV	Calibration factor (mGy/nC)
Axial	120	0.16 ± 0.02
	80	0.17 ± 0.02
Scout	120	0.15 ± 0.01
	80	0.16 ± 0.02



PSD/CTDI_{vol}

- Mostly close to 1
 - Support hypothesis
- Larger than literature results
 - Different calibration method?

Phantom	Scan type	kV	PSD/CTDI _{vol}	
			Axial cal	Scout cal
Rando head	Axial	120	0.89 ± 0.10	0.87 ± 0.10
	Axial	80	0.89 ± 0.13	0.85 ± 0.12
CTDI head	Helical	120	1.01 ± 0.12	0.99 ± 0.11
	Axial	120	1.04 ± 0.12	1.01 ± 0.12
	Axial	80	1.07 ± 0.16	1.02 ± 0.15

PSD/CTDI_{vol}

- Rando head < CTDI head
 - CTDI head overestimates patient skin dose
 - Reflects literature
- Minimal effect from scan type and kV

Phantom	Scan type	kV	PSD/CTDI _{vol}	
			Axial cal	Scout cal
Rando head	Axial	120	0.89 ± 0.08	0.87 ± 0.08
	Axial	80	0.89 ± 0.08	0.85 ± 0.07
CTDI head	Helical	120	1.01 ± 0.09	0.99 ± 0.09
	Axial	120	1.04 ± 0.10	1.01 ± 0.10
	Axial	80	1.07 ± 0.09	1.02 ± 0.09

Skin vs peripheral

- $\text{PSD}/\text{CTDI}_{\text{vol}} \sim \text{NPD}/\text{CTDI}_{\text{vol}}$
 - On CTDI head phantom
 - Insignificant effect from scan length and measurement position

kV	NPD/CTDI _{vol}	PSD/CTDI _{vol}	
		Axial cal	Scout cal
120	1.02 ± 0.09	1.04 ± 0.11	1.01 ± 0.11
80	0.98 ± 0.09	1.07 ± 0.11	1.02 ± 0.10

Uncertainty

- TLD measurement uncertainty
 - CoV for calibration measurements
 - 3.3 – 4.5 %
- CT chamber uncertainty
 - 8.7% combined spec and calibration uncertainty
 - 7.1% considering only measurement uncertainty and energy dependence
- Variation between scanner & measured $CTDI_{vol}$
 - 4.3% at 120 kV
 - 10.5% at 80 kV

CONCLUSIONS

Conclusions

- Estimated ratios of PSD to $CTDI_{vol}$ for head CT on a local scanner
 - $PSD/CTDI_{vol} \sim NPD/CTDI_{vol} \sim 1$
 - Minimal effect from kV and scan type
 - CTDI phantom measurements may overestimate patient skin dose by $\sim 10\%$
 - Variation in skin sensitivity
- PSD from head CT can be estimated using existing $NPD/CTDI_{vol}$ data
 - Scanner specific
 - Body maybe more complex

Thank you for listening!

**And thank you to Anne Hill and Mary
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experiment and interpreting results**