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Optimising CT Head protocols using Kyoto-PBU Phantom

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Content

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- Dose audit findings
- Possible factors affecting patient dose
- GE CT scanner protocol review and acquisition parameters
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Dose audit findings at both CUH and Wembley

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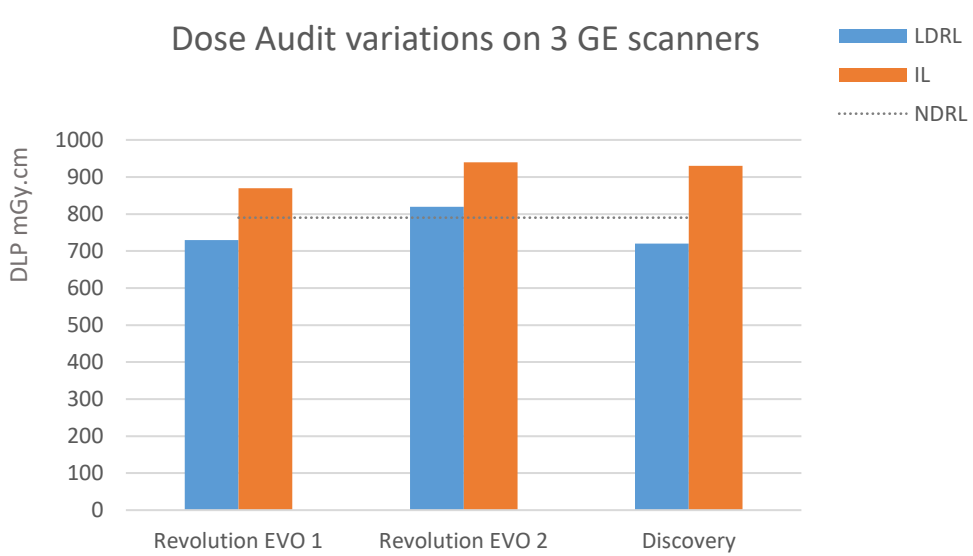
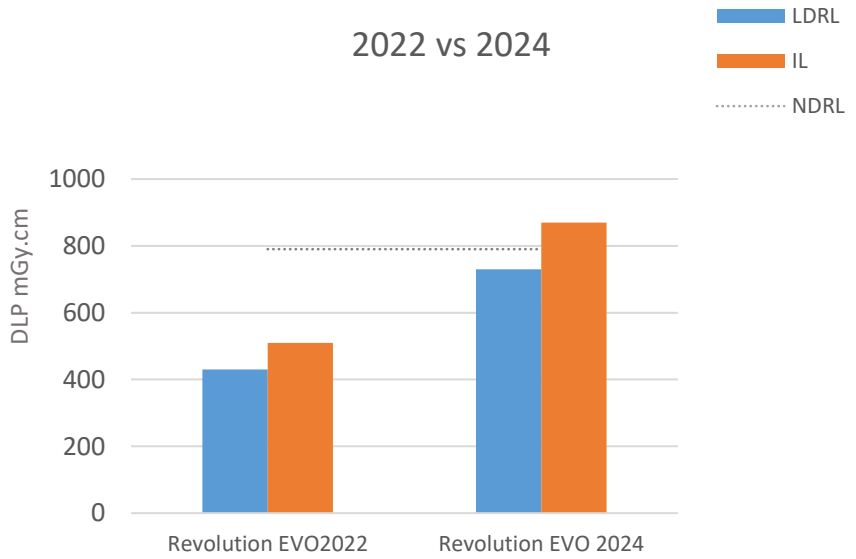
- Three scanners: Revolution Evo1 at Wembley CDC ; Revolution Evo2 at CUH & Discovery at Purley.
- Neurology consultant shows IQ concerns over head images on Revolution Evo1.
- Dose audit shows lower DRL on an older scanner(Discovery) compared to newer Revolution EVOs.
- Same scanner at different location showing significant 58.9% increase (430 ⟹ 730 mGycm) in median values in two years.





Possible factors affecting patient dose

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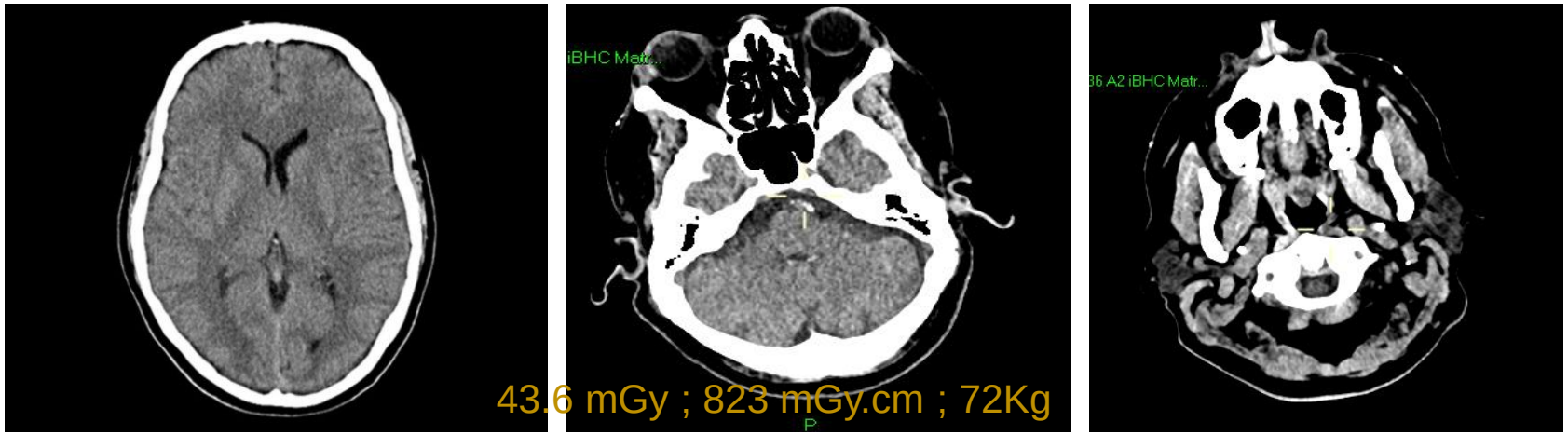
- Extreme DLPs showed over-scanning by radiographers
- Adaptation to other scanner type e.g. canon
- Scanning mode – axial or helical
- Training



CTDI vs Scan Length and DLP

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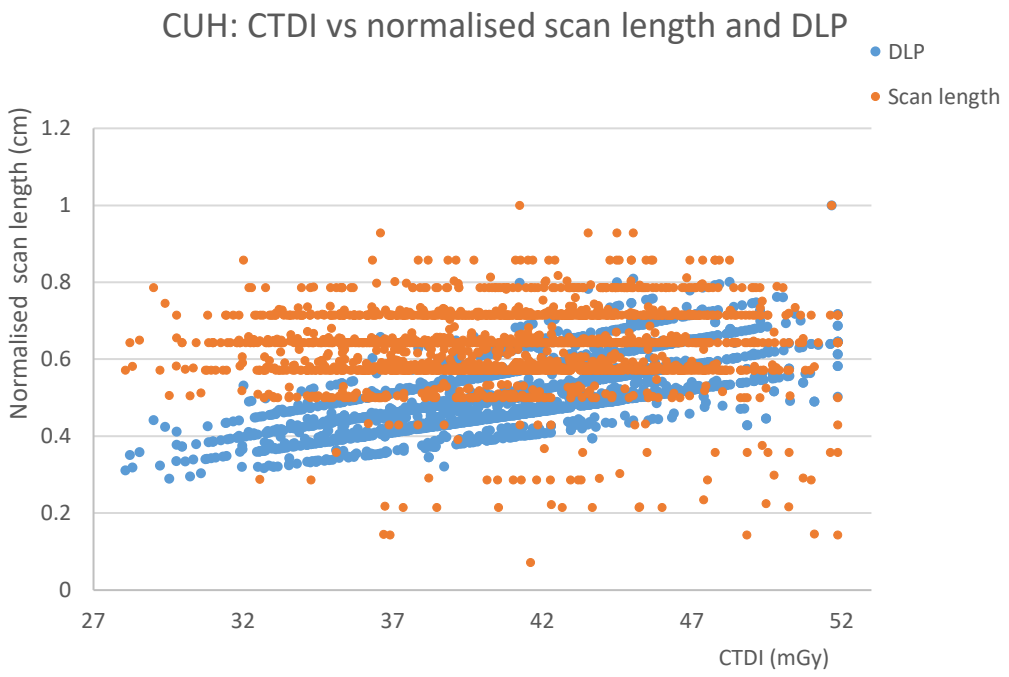

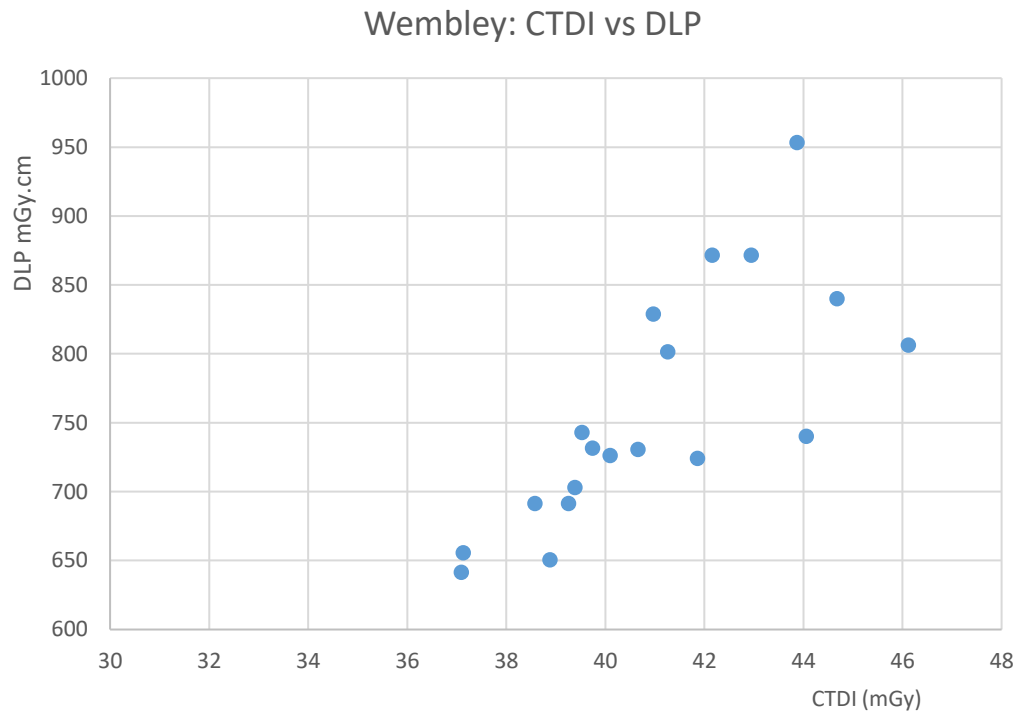

DLP, DLP Total and CTDI

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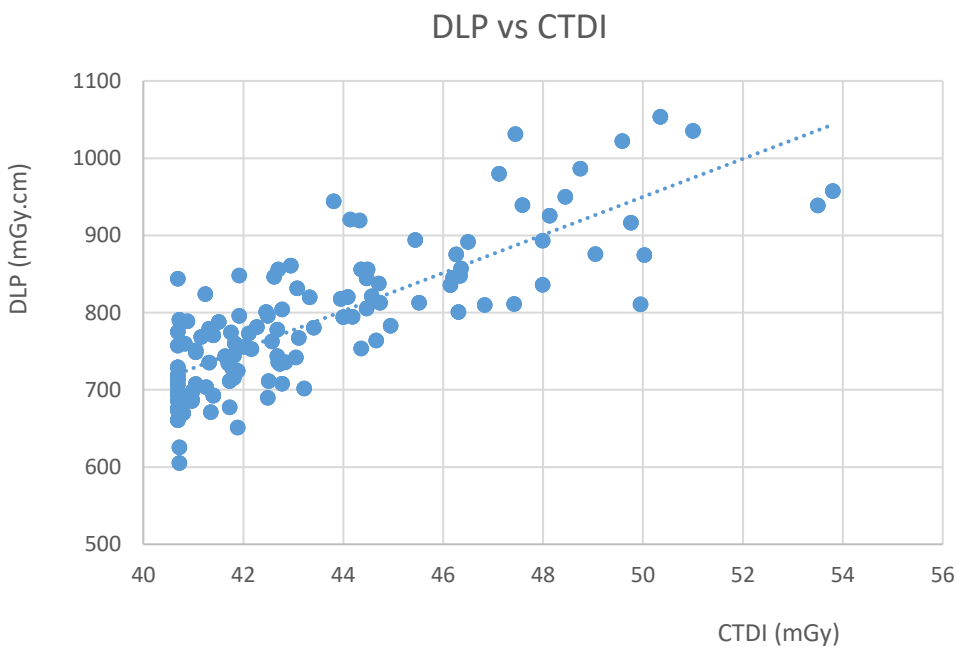

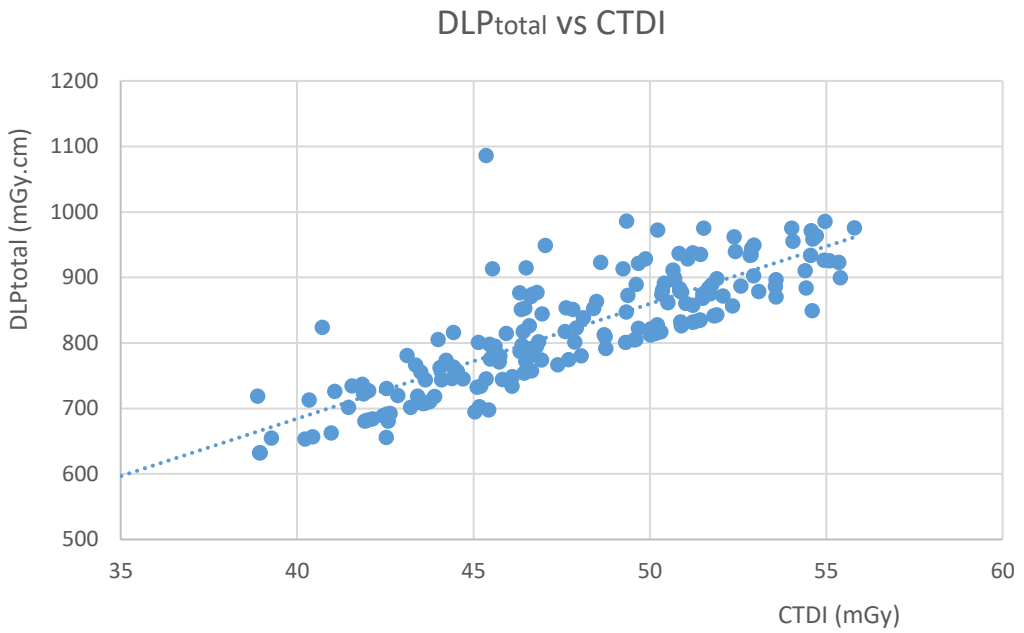

Reviewing the protocols

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- Table showing current head protocol and recons on all scanners
- GE Discovery uses Axial scanning, a different detector width (16x1.25) and iterative reconstruction (ASIR 60%)
- Reconstruction algorithms are overall similar

Category	Details	Imperial CX (GE Evo)	Purley GE Evo	GE Discovery
Exam details	Examination name	ADULT HEAD 1.1 STANDARD HEAD	ADULT HEAD 1.1 STANDARD HEAD	ADULT HEAD 1.1 STANDARD HEAD
	Type - Volumetric/axial	Helical	Helical	Axial
Acquisition	Detectors (n x width)	32 x 0.625	32 x 0.625	16 x 1.25
	Thickness (mm)	0.625	0.625	1.25
	Rotation T (s)	0.8	0.8	0.8
Parameters	Pitch	0.53125	0.53125	
	kV	120	120	120
	mAS	smartmA	smartmA	smartmA
	Iterative recon (Type/Strngth)	ASIR 40%	ASIR 40%	ASIR 60%
Ref kV - noise ind	Reference kV - noise ind	AR40	AR40	AR60
	Ref mAs - noise ind	NI: 8	NI: 9	NI: 8

Category	Details	Imperial CX (GE Evo)	Purley GE Evo	GE Discovery
Recon 1	Planes (A/S/C) e.g. AC if axial and coronal	A	A	A
	Thickness (mm)	1	1	1
	Increment (mm)	1	1	1
	Kernel	Stnd#	Soft#	Soft#
	Filter			
Recon 2	Kernel	Soft#	Bone	Soft#
	Window		AR 20	
	Planes (A/S/C) e.g. A, C if axial and coronal	A	A	A
	Thickness (mm)	3	3	3
	Increment (mm)	3	3	3
	Filter			
Recon 3	Kernel	soft fine	soft fine	soft fine
	Window			
	Planes (A/S/C) e.g. AC if axial and coronal	A	A	A
	Thickness (mm)	3	3	3
	Increment (mm)	3	3	3
	Kernel			

Visit with head phantom

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- The Kyoto phantom is a life-size human phantom with a life-size synthetic skeleton made of resin.
- The phantom was acquired through a scheme called Innovate; to improve service across the trust.
- Phantom availability has greatly aided optimisation of different protocols across imperial.
- Purpose is to adjust scan parameter to optimise dose and image quality.

Overview of acquisition parameters

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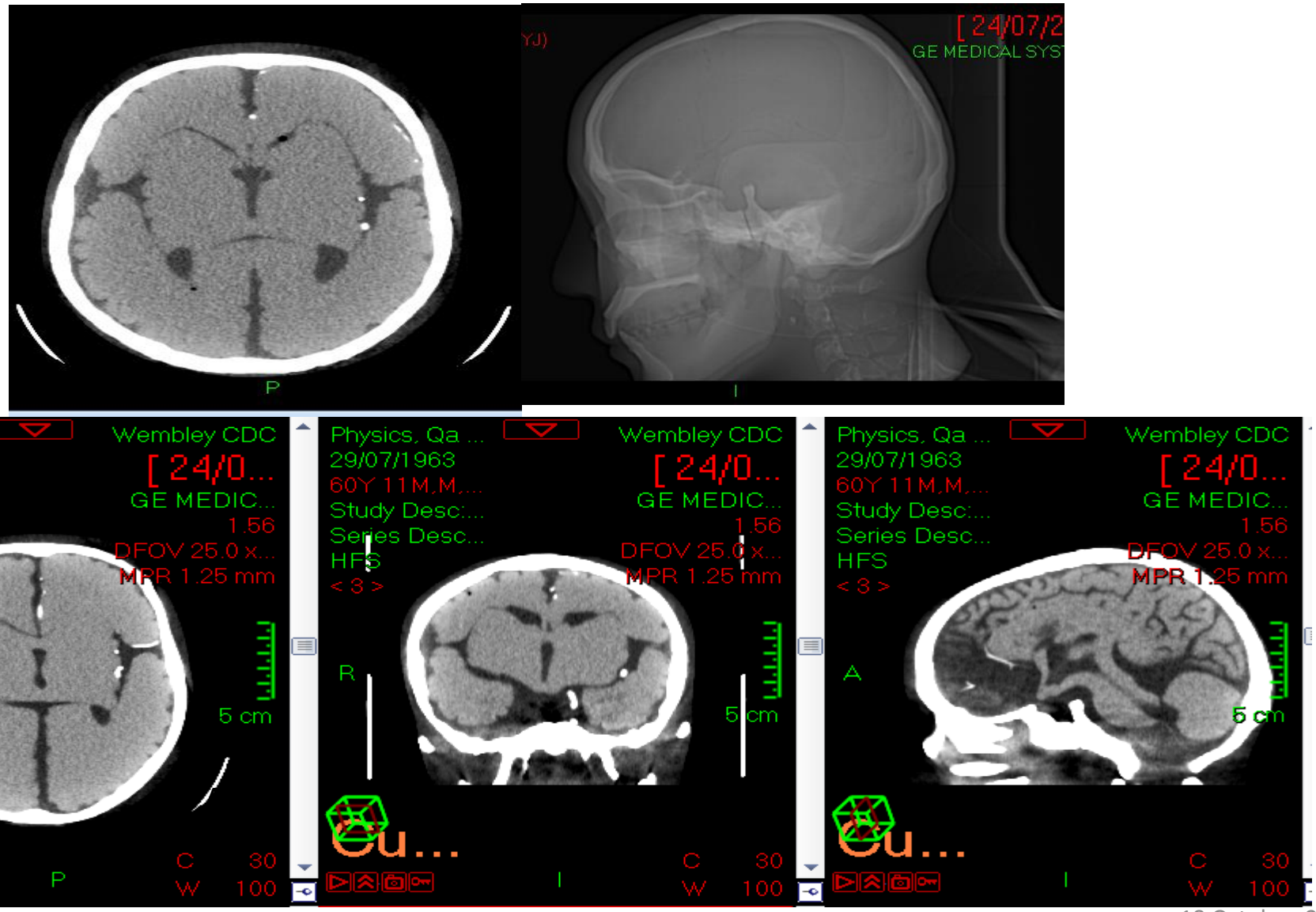
Acquisition	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical	Helical
	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.62	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.62	32 x 0.625	32 x 0.625	32 x 0.625
	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625
Rotation Time	0.8	0.8	0.8	0.8	0.4	0.5	0.6	0.7	0.8	0.4	0.8	0.4	0.4	0.4	0.5	0.6	0.7
Pitch	0.53125	0.53125	0.53125	0.53125	0.53125	0.53125	0.53125	0.53125	0.53215	0.969	0.969	0.53125	0.53125	0.53125	0.53125	0.53125	0.53125
Parameters	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA	smartmA
	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%	ASIR 40%
	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40	AR40
Noise Index	7	8	8.5	9	8	8	8	8	8	8	8	7	7.55	9	7	7	7
Ref CTDI and DLP	806.28	642.66	587.14	545.87	532.07	602.93	616.56	628.11	642.66	339.48	626.38	572.62	681.24	478.74	675.72	754.77	797.07
	44.52	35.49	32.42	30.14	29.37	33.28	34.04	34.68	35.49	18.59	34.32	31.61	37.60	26.42	37.30	41.67	44.01

Which patient is this?



Head scoring criteria

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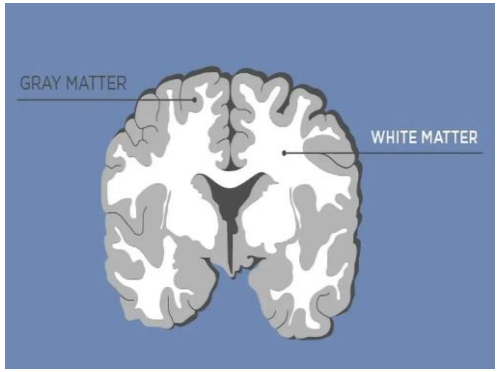
- 0 = Desired features not seen
- 1 = Anatomy not included in the images
- 2 = Unacceptable image quality (images do not allow diagnostic interpretation
- 3 = Limited quality (images are adequate only for limited clinical interpretation due to high noise)
- 4 = Adequate quality (images are just adequate for diagnostic interpretation)
- 5 = Excellent quality (images are much better than needed for interpretation with little or no noise)

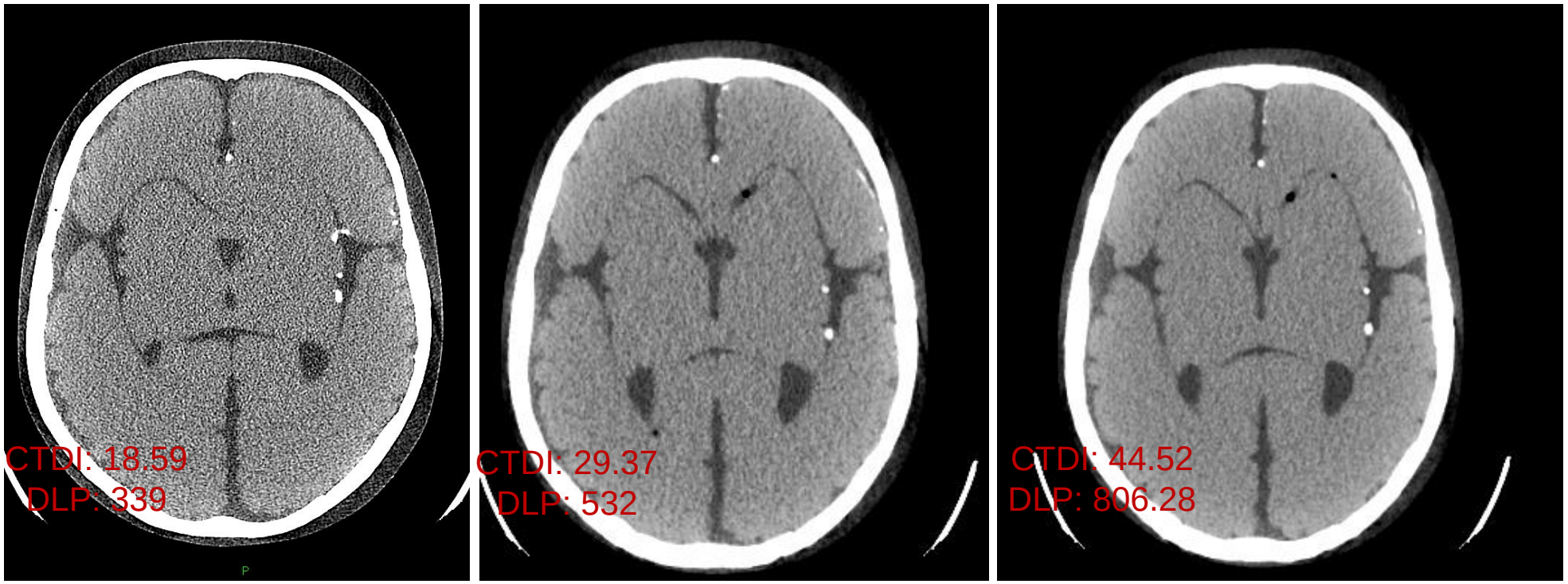
Scoring Criteria –

- Visualization of the whole cerebrum and cerebellum
- Visualization of the skull base
- Adequate reproduction of the border between white and grey matter
- Adequate reproduction of the basal ganglia
- Adequate reproduction of the ventricular system
- Adequate reproduction of the great vessels and the choroid plexuses after intravenous

Final criteria

- Gray & white matter contrast not visualized in any of the images even when imaging the phantom on a new Siemens scanner of acceptable image quality
- Terrible Noise
- Moderate Noise
- Low Noise





Radiologist scoring results

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Series Description	Radiologist 1	Radiologist 2	CTDI vol/DLP	DLP
2	2	1	44.52	806.28
3	2	2	44.52	806.28
4	0	0	44.52	806.28
5	1	1	35.49	642.66
6	1	1	35.49	642.66
7	0	0	35.49	642.66
8	1	1	30.14	545.87
9	1	2	30.14	545.87
10	0	0	30.14	545.87
11	1	1	32.42	587.14
12	2	2	32.42	587.14
13	0	0	32.42	587.14
14	1	1	29.37	532.07
15	1	1	29.37	532.07
16	0	0	29.37	532.07
17	1	1	34.32	626.38
18	1	1	34.32	626.38
19	0	0	34.32	626.38
20	0	0	18.59	339.48
21	0	0	18.59	339.48
22	0	0	18.59	339.48
23	1	1	35.49	642.66
24	2	1	35.49	642.66
25	2	2	35.49	642.66
26	1	1	33.28	602.93
27	2	2	33.28	602.93
28	2	2	33.28	602.93
29	1	1	34.68	628.11
30	1	2	34.68	628.11
31	0	0	34.68	628.11
32	1	1	34.04	616.56
33	1	2	34.04	616.56
34	0	0	34.04	616.56
35	1	1	33.28	602.93
36	2	2	33.28	602.93
37	0	0	33.28	602.93
38	1	1	26.44	478.98
39	1	1	26.44	478.98
40	0	0	26.44	478.98
41	1	1	26.42	478.74
42	0	0	26.42	478.74
43	1	1	26.42	478.74
44	2	1	44.52	806.28
45	0	0	44.52	806.28
46	2	2	44.52	806.28
47	2	2	31.61	572.62
48	0	0	31.61	572.62
49	1	1	31.61	572.62
50	2	2	37.3	675.72
51	0	0	37.3	675.72
52	1	1	37.3	675.72
53	2	2	41.67	754.77
54	0	0	41.67	754.77
55	1	1	41.67	754.77
56	2	2	44.01	797.07
57	0	0	44.01	797.07
58	1	1	44.01	797.07
59	2	2	37.6	681.24
60	0	0	37.6	681.24
61	1	1	37.6	681.24

Helical

32 x 0.625

0.625

0.6

0.53125

120

smartmA

ASIR 40%

AR40

7

754.77

41.67

Optimisation process/Future work

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- Harmonize all head protocols to helical scanning across the three scanners
  - This was impossible on the GE Discovery, all helical scans are grainy even at high doses.
- Discuss with neurology consultants as per the protocol to be used and why
- Implement the new protocol and ask for feedback
- If necessary, incrementally increase/decrease noise index based on feedback
- Repeat dose audit after three months

Conclusion

- The Kyoto phantom provides excellent visualisation of the bony structures and arteries in the head but does not have sufficient white and gray matter contrast as seen in standard head images. Might be more suitable for optimising CT Angiography in the head.
- Optimising head protocols on very old GE scanners can be challenging.
- It is important to check similar CT scanners of the same/similar type to notice variations in patient dose/image quality.
- Clinicians/radiographers input is very important in the optimisation process.
- Training and appropriate scan setup is important.
- Optimisation plan is in place.

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Thank You