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Evaluating the use of eye dose reduction technologies on a Siemens Go CT scanner and their effect on measured eye dose and image quality

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Background

- Lens of the eye is a very radiosensitive organ
  - Deterministic effects: cataracts at 500 mGy
    International Commission on Radiological Protection (ICRP) (2012)
  - Stochastic effects: evidence for a much lower dose limit < 100 mGy (Little, et al. 2019)

- The two primary methods of eye dose reduction are orbitomeatal line (OML) angulation and organ tube current modulation (OTCM)

Our Scanners

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- Three CT scanners
  - Siemens SOMATOM Definition AS+ (2010 and 2019)
    - OML angulation only
  - Siemens SOMATOM Go All (2020)
    - OTCM (XCARE) and OML angulation

OML Angulation

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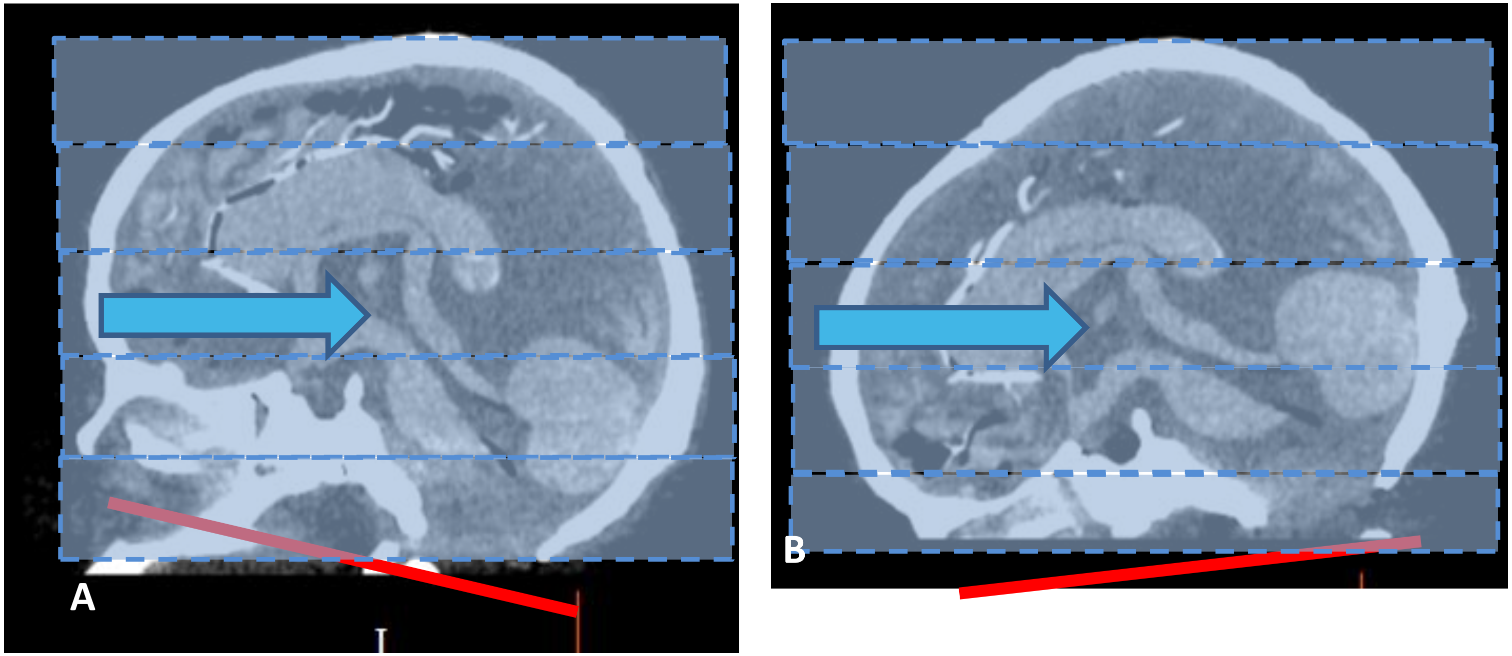

Sagittal view of phantom: red line represents the OML, blue arrow the direction of the x-ray beam, blue shaded area the x-ray field

A = non angled OML, B = angled OML

XCARE

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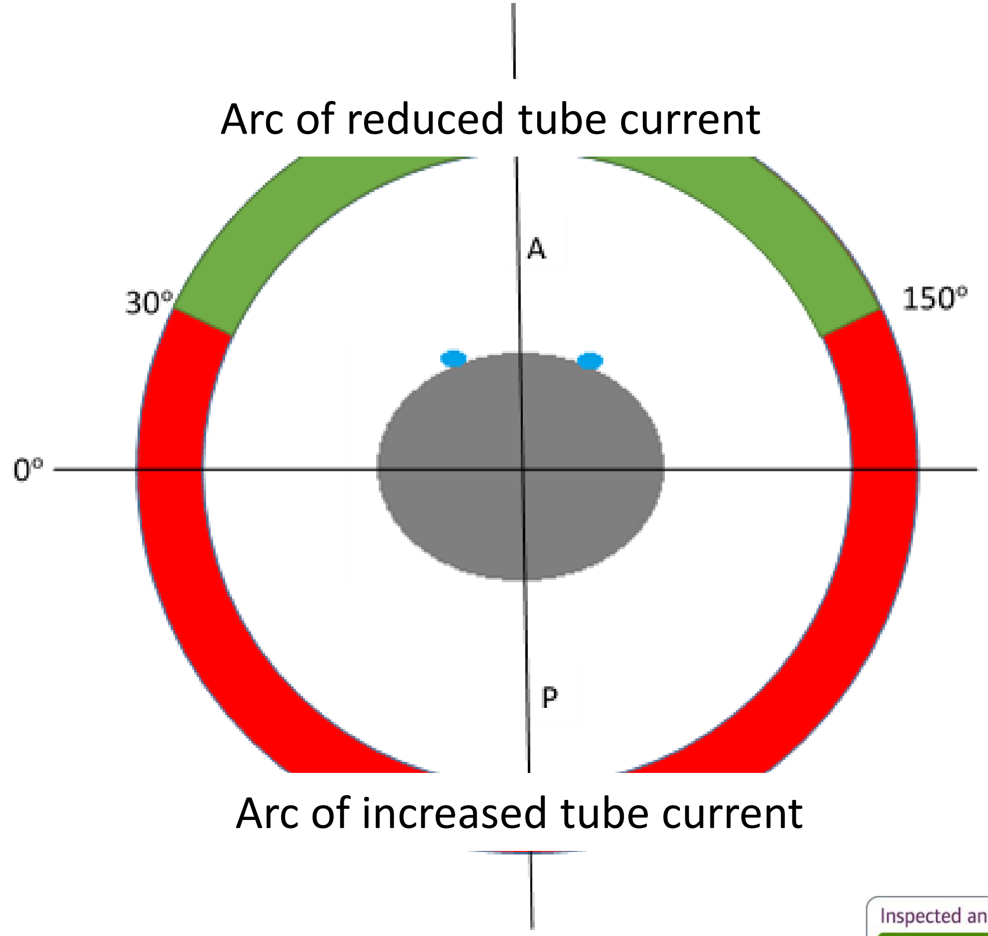
- 75 % reduction in tube current over a 120^0 arc (green)
- 25 % increase over remaining 240^0 (red)
- (Wang, J. et al. 2012)



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Initial Investigation

- Radiologists reported unfavourable image quality for head scans on the SOMATOM Go All compared to the Definition AS+ scanners.

- All three scanners have comparable image quality, based on QA results

- Siemens Go uses a different eye dose reduction technique
  - OML angulation and XCARE used in combination

Aims

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- Measure dose to the lens of the eye for CT head scans using different combinations of eye dose reduction methods

- Assess the change in image quality with different combinations of eye dose reduction methods.

Methods

- Anthropomorphic phantom
- Scanned on GO scanner using following dose reduction combinations:
  - No dose reduction (baseline)
  - XCARE
  - OML angulation
  - OML angulation and XCARE

Kyoto Kagaku ACS anthropomorphic angiographic head phantom (Kyoto Kagaku, 2021)

Eye Dose Measurement

- TLD-100 dosemeters placed over the eyes of an ACS head phantom
- TLDs calibrated locally

Kyoto Kagaku ACS anthropomorphic angiographic head phantom (Kyoto Kagaku, 2021)

Eye Dose Analysis

- Do the eye dose reduction methods result in a statistically different dose to the lens of the eye?
  - Difference in mean eye dose
- Analysis of variance (ANOVA) identified any statistically significant difference within eye dose data
- Two sample T-test compared each possible combination of mean eye dose

Image Quality Assessment

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- Locations in the brain discussed with Radiologist

1= cerebellum

2= basal ganglia

3 = centrum semiovale.

Image Quality Assessment

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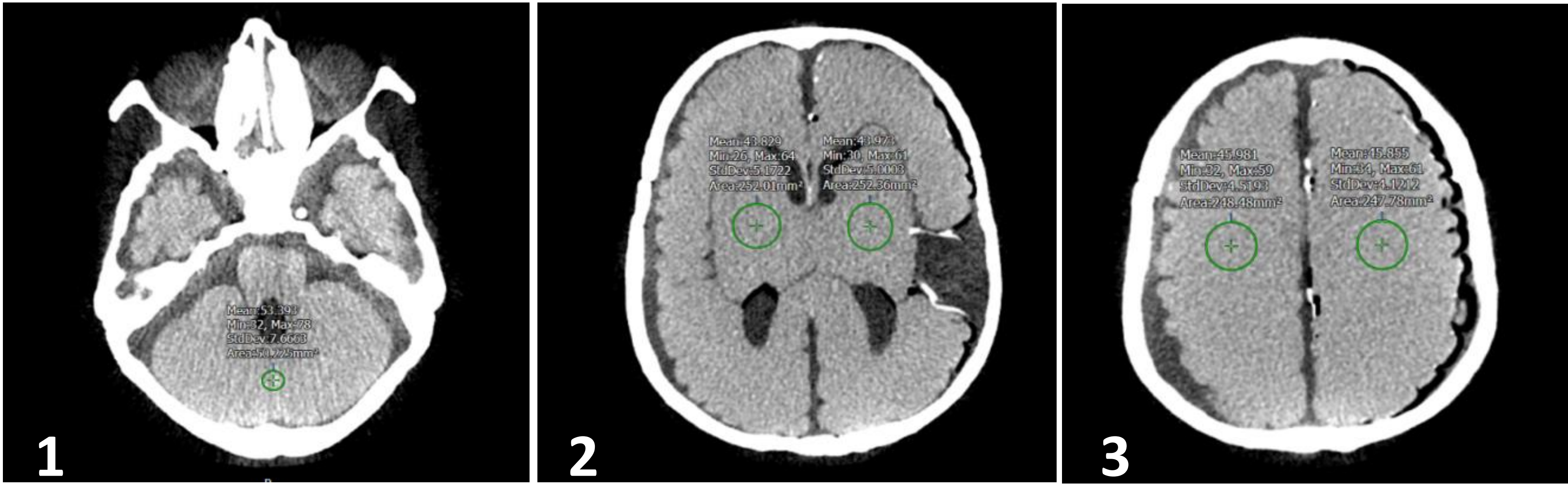

- Mean CT number and standard deviation (SD) measured within regions of interest (ROIs) in 3 locations in the brain:
  - 1: cerebellum
  - 2: basal ganglia
  - 3: centrum semoivale

Image Quality Analysis

- Using image noise as metric for image quality (CoV%)
  - Suitable measure of image quality?

- 5 images for each dose reduction strategy at each of the 3 locations

- For each set, error was estimated using the SD of the CoVs from the 5 images
  - Insufficient sample size for parametric statistical tests (n<30)

Eye Dose Results

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- Difference in mean dose between each dose reduction method was statistically significant
  - Two sample T test (P<0.0083)
- XCARE displayed comparable eye dose reduction (30 %) to Wang, J. et al. (2012)

	No eye dose reduction (Baseline)	OML angulation	XCARE	OML angulation + XCARE
Mean eye dose (mGy)	43	32	31	26
Change from baseline %	Baseline	-24	-29	-40

Eye Dose Results

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- Error bars show combined error
  - Calibration uncertainty
  - CoV% in TLD measurements

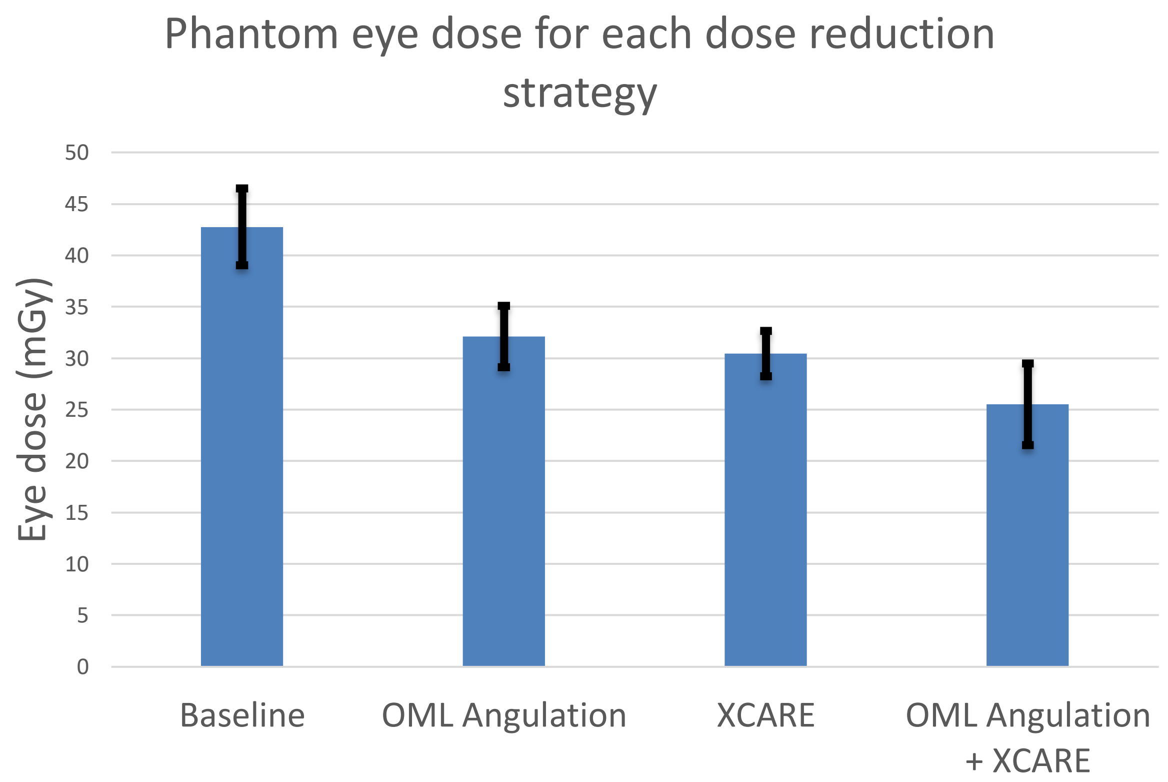

Image Quality Results

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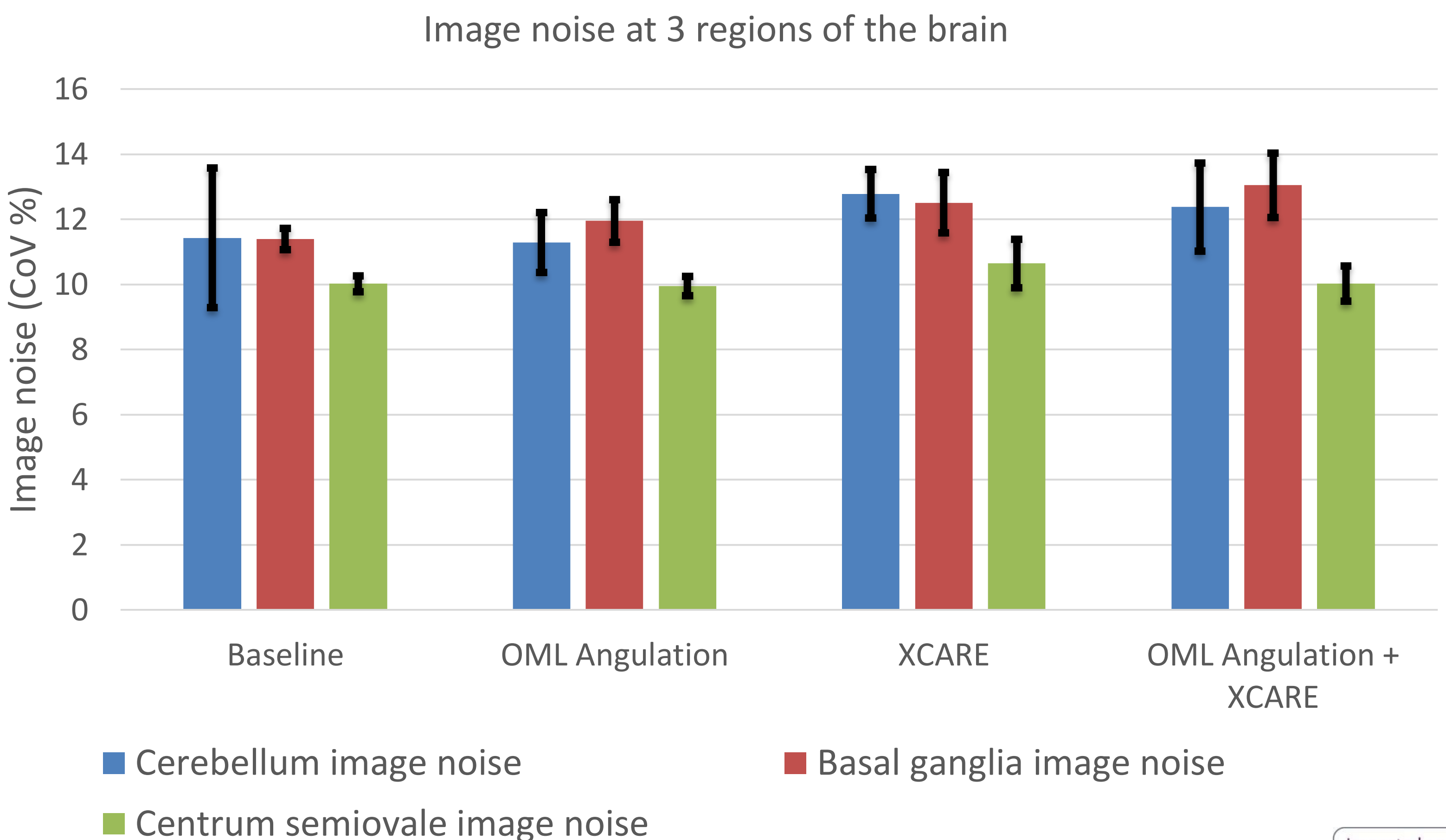

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Image Quality Results

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- The only statistically significant increase in image noise was observed at the Basal Ganglia when OML Angulation and XCARE were *both* applied
- XCARE resulted in a slight increase in image noise in all regions, but not statistically significant
  - Wang, J. et al. (2012) observed a comparable increase (10%) in image noise using XCARE (at the centre of the brain)
- OML angulation generally resulted in the lowest change in noise relative to baseline

Project Conclusions

- Current clinical protocol (XCARE and OML Angulation) gave
  - Significant increase in noise in the basal ganglia
  - Slightly lower eye dose

- XCARE is comparable to OML angulation for eye dose reduction, but slightly higher noise
  - Ideal OML angulation not always possible!

References

International Commission on Radiological Protection (2012) *Annals of the ICRP: ICRP Publication 118, ICRP on Tissue Reactions and Early and Late Effects of Radiation in Normal Tissues and Organs - Threshold Doses for Tissue Reactions in a Radiation Protection Context,* s.l.: ELSEVIER.

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