Ultra Low Dose CT Scanning: A Reliable and Effective Modality with an Improved Patient Safety Profile

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Background

- Computerized tomography (CT) was invented in the early 1970s.
- 71.7 million CT scans were performed in 2007.[1]
- 600,000 head and abdominal CT scans are performed annually for children <15 years old.[2]
- It is projected that 500 of these individuals will die from cancer attributable to this irradiation.[2]

Objective

To determine whether or not a novel CT imaging protocol could produce similar diagnostic capability as compared to conventional CT scanning while minimizing radiation exposure for a given body part.

Methods

Previously an ultra low dose CT (ULD-CT) protocol was developed to identify articular penetration of the knee joint.[3–5] A novel low dose CT protocol was developed by altering multiple parameters and used to prospectively assess fracture patients. Ten orthopaedic fracture surgeons evaluated de-identified images for diagnosis, management, and image quality. The total radiation dose for each imaging type was determined and recorded.

Results

- Ultra low dose CT scanning resulted in an estimated effective dose (ED) 14x lower than that of conventional CT (C-CT) scanning.
- Mean ED for ULD-CT vs. C-CT was 0.03 milliSieverts (mSv) vs. 0.43 mSv ($p<.005$).
- Sensitivity (Sn), Specificity (Sp), Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of ULD-CT scan to detect fractures was 0.98, 0.89, 0.98, and 0.89 with 2 occult fractures excluded.
- Reliability statistics between ULD-CT and C-CT assessments were comparable reflecting that the diagnostic value of CT technology does not decay with an ULD protocol.

References

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2. Brenner DJ, Elliston CD, Hall EJ, Walter EB. Estimated Risks of Radiation-Induced Fatal Cancer from Pediatric CT. AJR Am J Roentgenol. 2001. Feb;176(2):289-96.
3. Brenner DJ, Hall EJ. Computed tomography--an increasing source of radiation exposure. *N Engl J Med*. 2007.
4. Konda S, Davidovitch R, Egol K. Open knee joint injuries: an evidence-based approach to management. *Bull Hosp Joint Dis*. 2014.
5. Konda SR, Howard D, Davidovitch RI, Egol KA. The Role of Computed Tomography in the Assessment of Open Periarticular Fractures Associated with Deep Knee Wounds. *J Orthop Trauma*. 2013;27:509-514.

Results

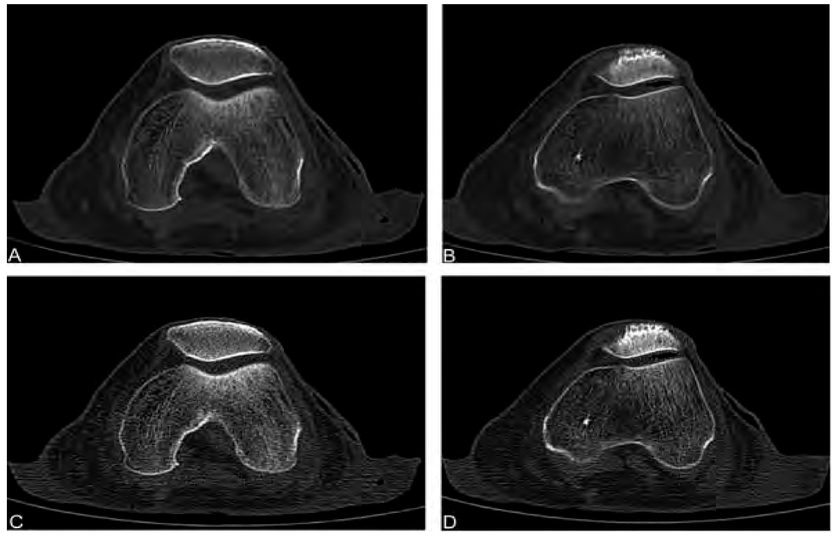

Figure 1. CT scan slices through the intra-articular space. Scan: **A**, Without air introduced; **B,** With 0.1 cc of air introduced into the lateral retropatellar space. **C,** Reduced dose (0.74 mGy) without air introduced; **D**, Reduced dose (0.74 mGy) with 0.1 cc of air introduced into the lateral retropatellar space.

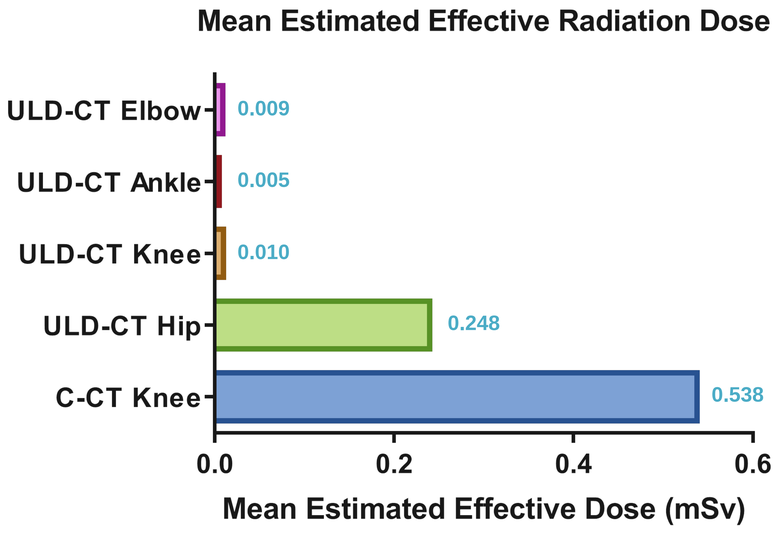

Figure 3. Estimated effective radiation dosages for various extremity locations. C-CT= conventional CT scan; ULD-CT= ultra low dose CT scan.

Scan Parameters	Center 1	Center 2
Scanner Type	Siemans Definition Edge	GE Lightspeed VCT
Standard CTDI	6.43	9.1
New CTDI	0.75	0.75
Mode	Helical	Helical
KV	100	80
eff mAs	19	15
Detector collimation	0.6	0.625
DFOV	200	200
Slice thickness (display)	3	3
Recon Interval	3	3
Table feed	n/a	n/a
Scan delay	n/a	n/a
Gantry Angle	n/a	n/a
Pitch	0.8	.516 - 1
Gantry rotation time	0.5	0.5
Reconstruction algorithms	Bone and Soft	Bone and Soft
Window	Bone and Soft	Bone and Soft
Phase of Respiration	n/a	n/a

Figure 2. Ultra low dose CT protocol displaying various adjusted parameters as listed.

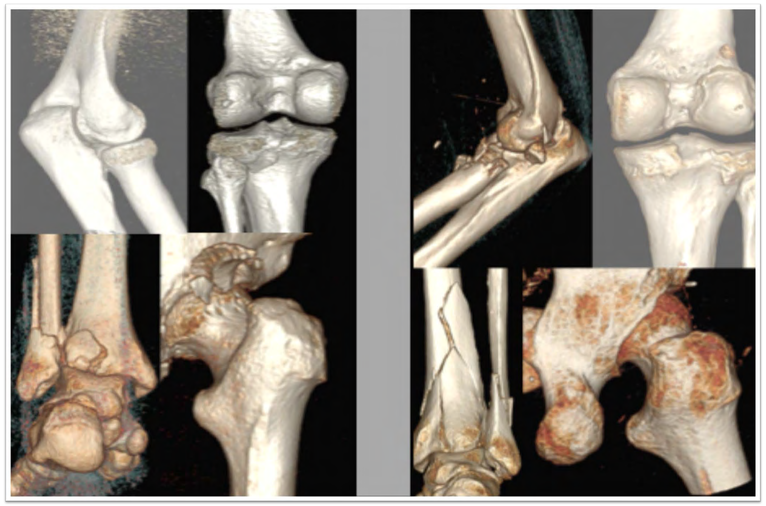

Figure 4. Four ULD-CT images (left of gray bar as follows: top left- elbow, top right- knee, bottom left- ankle, bottom right- acetabulum) vs. corresponding C-CT images (right of gray bar). Nearly indistinguishable resolution with ULD-CT and with a 10x decrease in effective radiation dose.

Conclusions

1. Our ULD-CT protocol appears to represent a significant advancement in the refinement of an ubiquitous diagnostic tool.
2. This ultra low dose protocol appears to provide for high fidelity images in appropriately selected patients, with an improved safety profile over conventional CT.
3. By employing dose reduction strategies as demonstrated here, orthopaedic surgeons can address public concerns over radiation exposure in their medical care.