Applications of Digital Tomosynthesis in the Musculoskeletal System

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Background - DTS

- Digital tomosynthesis (DTS) is a well-established radiographic technology.
- DTS has become the gold standard for breast mammography.
- There is a rapid increase in its utilization in musculoskeletal (MSK) imaging in recent years due to:
  - Acknowledgement of its benefits
  -Growing availability of systems at lower costs
- Reading DTS is different than radiography but requires just a short learning curve.

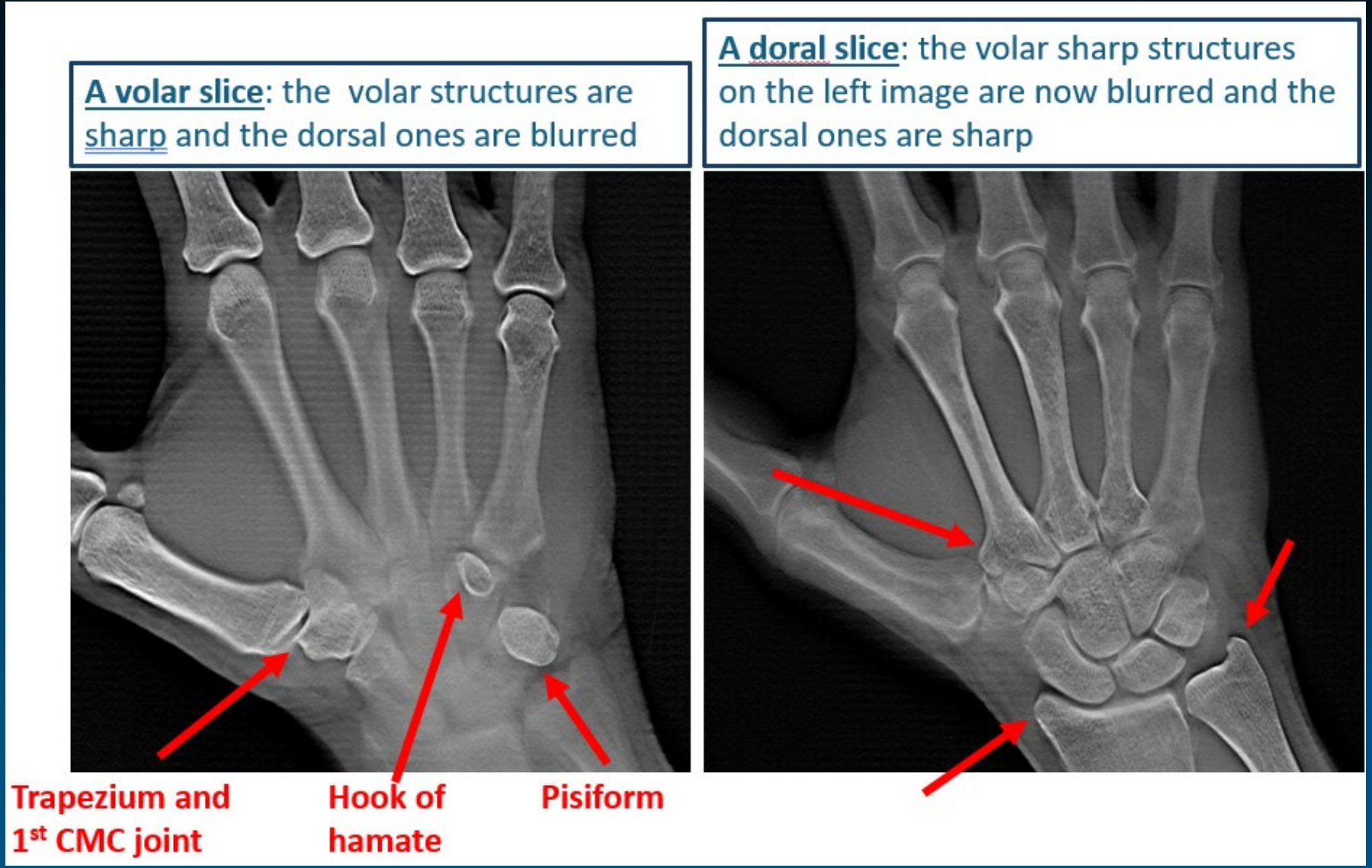
Background - DTS

- DTS basically splits the radiographs into layers resulting in anatomical structures and abnormalities not obscured by other structures

- This leads to
  - -Improved visualization of bones joints (especially wrist and hand, foot)
  - -Increased sensitivity of occult fracture diagnosis
  - -Improved visualization of different types of lesions
  - -Improved imaging in patients with metal, casts, splint and bracing
  - -Better localization of lesions
  - -Less dependency on position
  - -Elimination of pseudo-fractures created by superimposition of structures

How to read a DTS scan?

- The DTS splits the radiographs into layers.
- On each layer some of the structures are in the plane of focus and therefore are sharp.
- Other structures are out of the plane of focus and are blurred.
- When reading a DTS study focus on the sharp structures only (arrows).



Imaging modalities comparison

X-Ray

Overlapping Body Structures
Bi dimensional

Chest Dose: ~ 0.1 mSv
Power Supply: 70 kW
Weight: 600 kg
Size: 8’ x 3’

DTS (Nanox.ARC)

Partially overlapping anatomy
Pseudo tri dimensional

Chest Dose: ~0.2 mSv
Power Supply: 1.8 kW
Weight: 350 kg
Size: 8.5’ x 2.5’

CT

Body structures separated
True tri dimensional

LDCT: 1-1.5 mSv
CT: > 2 mSv
Power Supply: 100 kW
Weight: 2,000 kg
Size: 10’ x 6’

Case studies and examples

Images were taken under the ethical committee (Helsinki) permit to conduct a clinical study, using the multisource Nanox.ARC system.

Images courtesy of Shamir and Rabin Medical Centers, Israel.

A sacral fracture not seen on a radiograph

- Higher sensitivity than the radiograph in DTS
- Similar information to CT

X-Ray

No visible fracture

DTS

No obscuration of sacrum by bowel contents and complex anatomy

CT

Fracture confirmed on CT

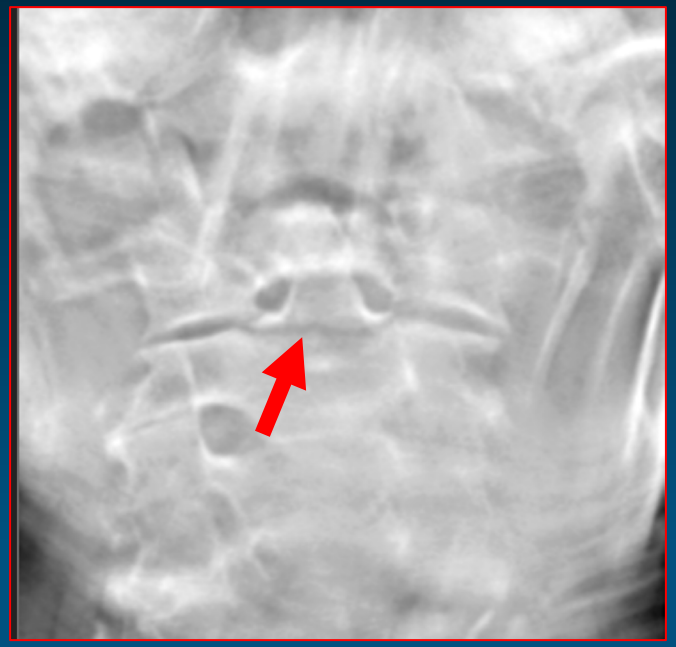
Base of odontoid process fracture not seen on open mouth view radiograph

- Higher sensitivity than the radiograph
- No dependency on radiographer positioning and patient cooperation on open mouth view

X-Ray

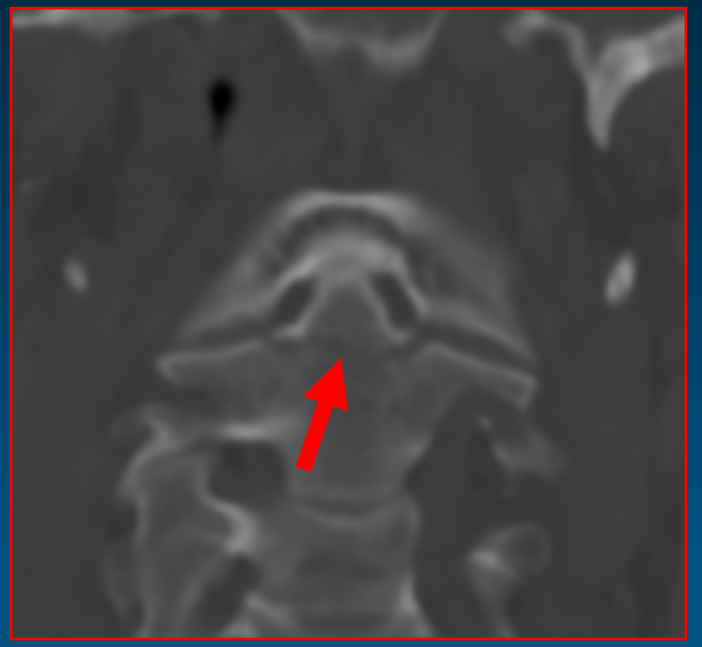
Fracture not seen on an open mouth view

DTS



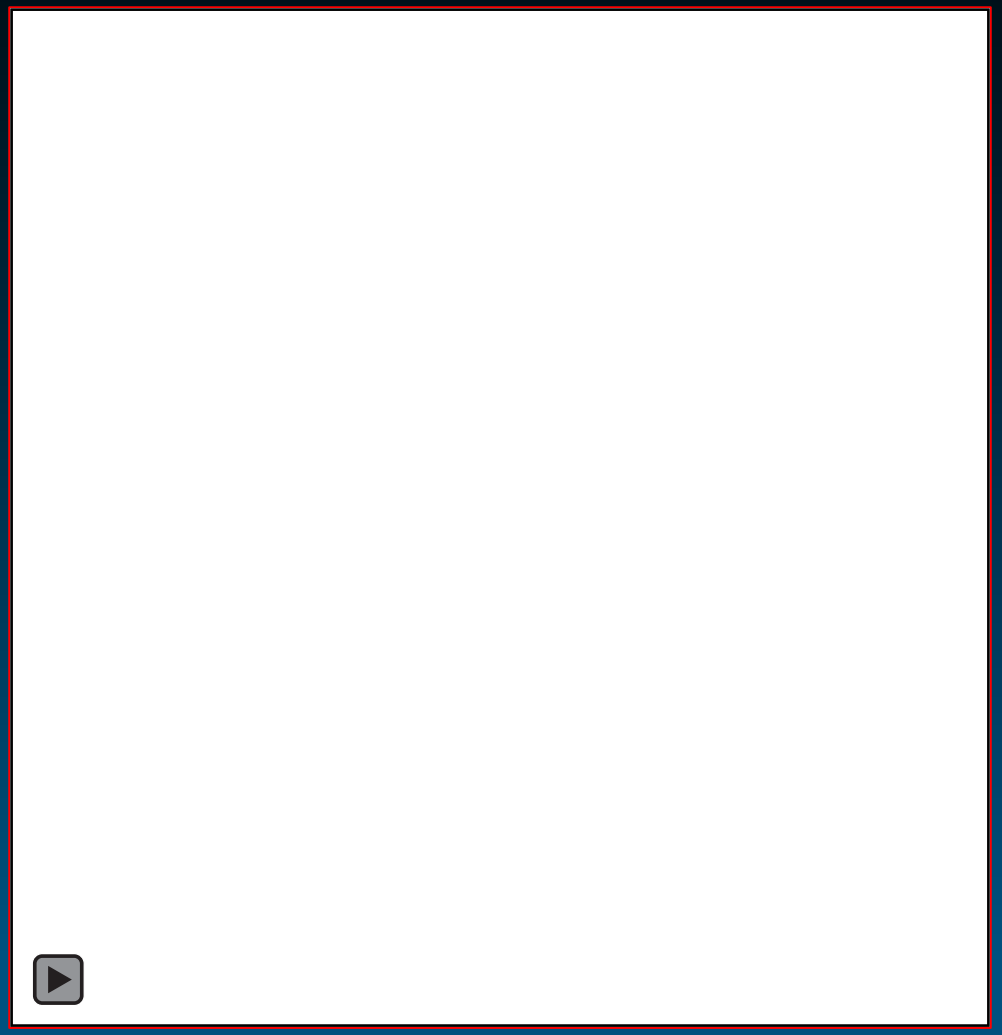
Fracture clearly seen on an AP DTS

CT



Fracture confirmed on CT

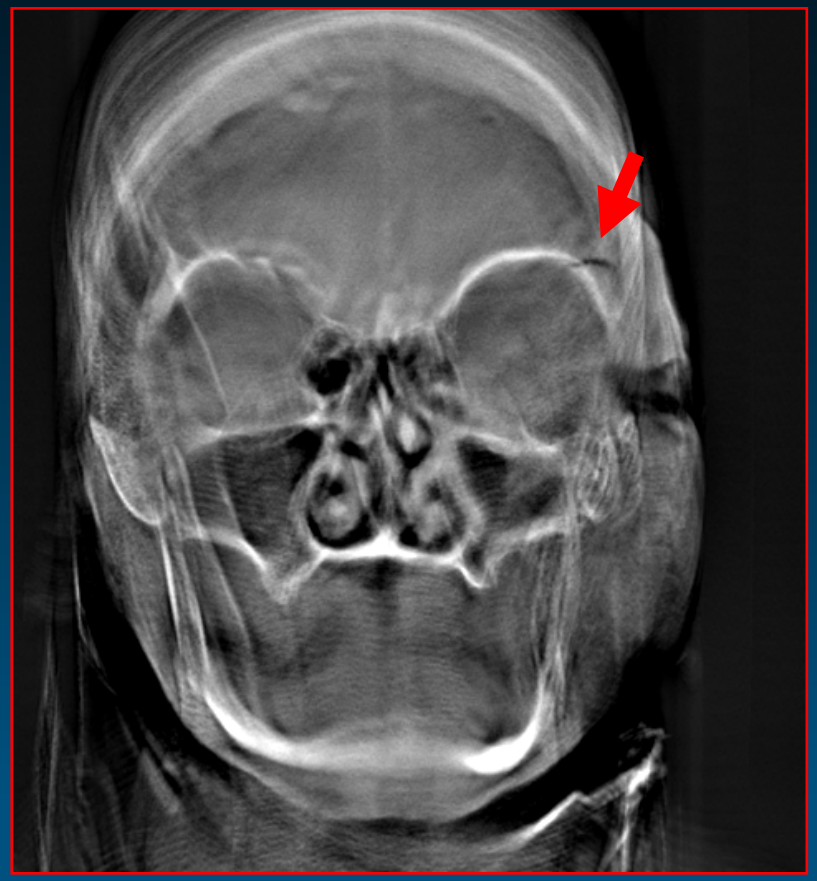
DTS Clip



Images were acquired with Nanox.ARC

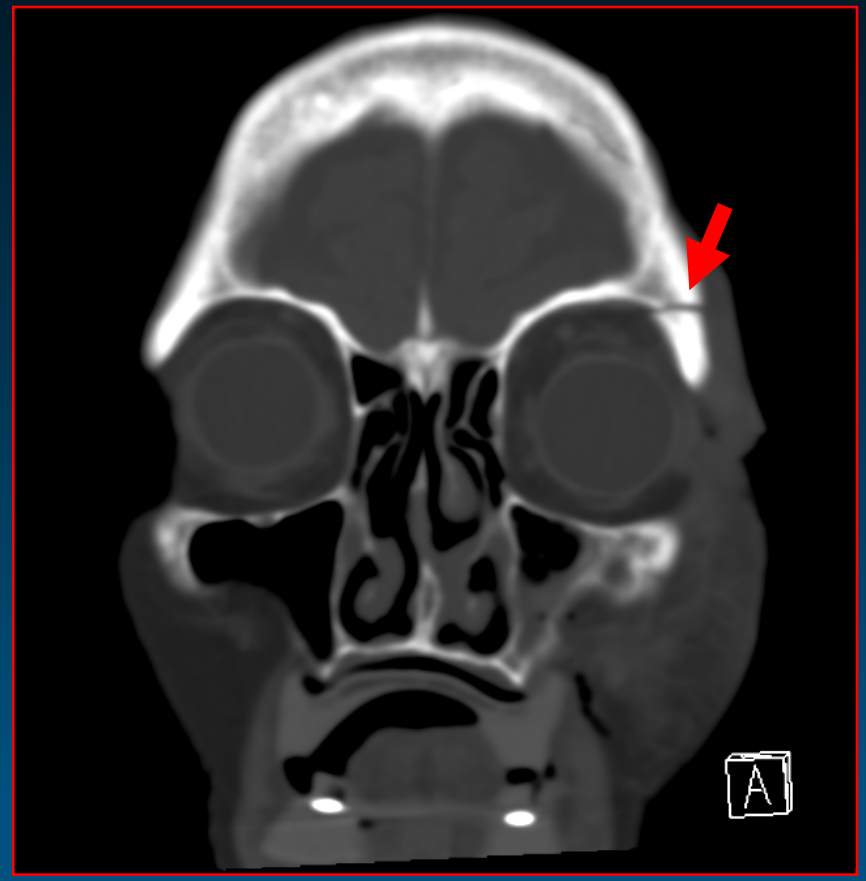
Assessment of an orbital fracture in the same case

DTS



Clearly defines a fracture of the left orbit (**red arrow**)

CT



Fracture confirmed on CT (**red arrow**)

An elderly patient after a fall

- The hip is rotated. The greater trochanter is superimposed on the lateral aspect of the femoral neck
- There is a femoral neck fracture that can be easily missed.
- Frog leg view can be painful for the patient and requires much effort from the radiographer

Visualization of the fracture in DTS despite the superimposition of the greater trochanter

X-Ray

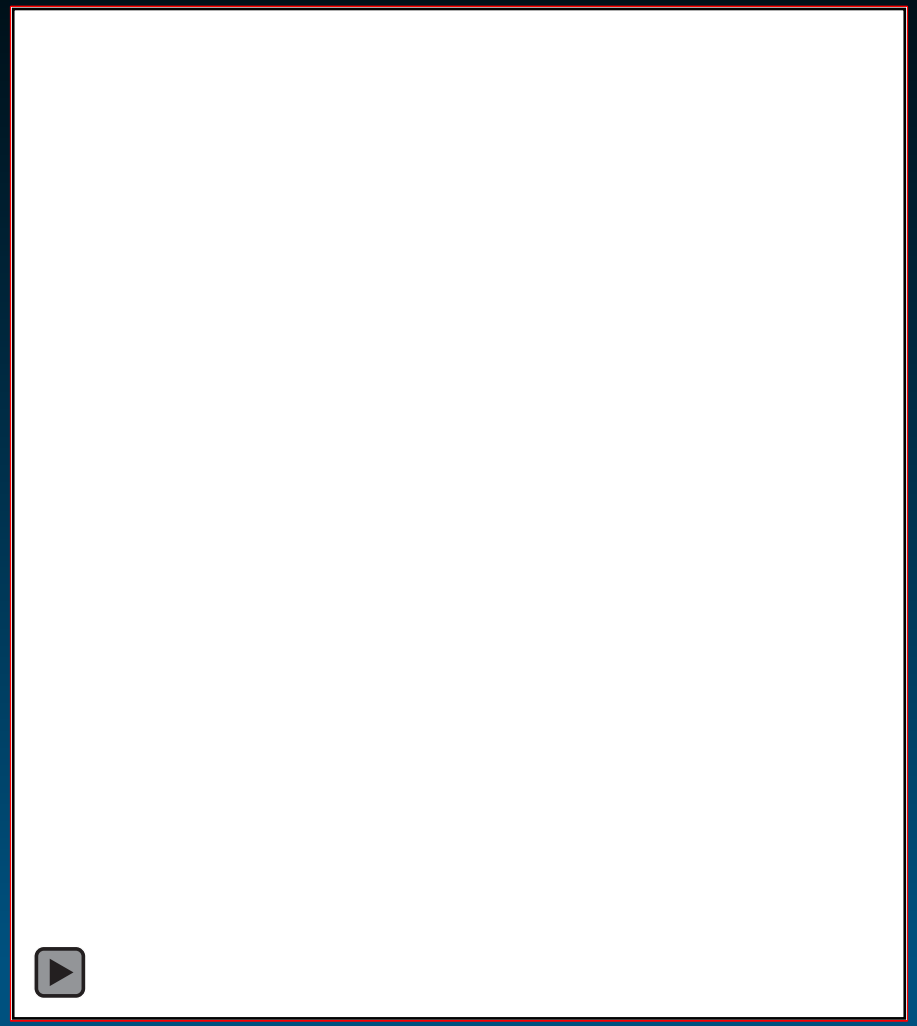
DTS

Greater trochanter obscures the fracture

Cortical step-off

Fracture lines

DTS Clip



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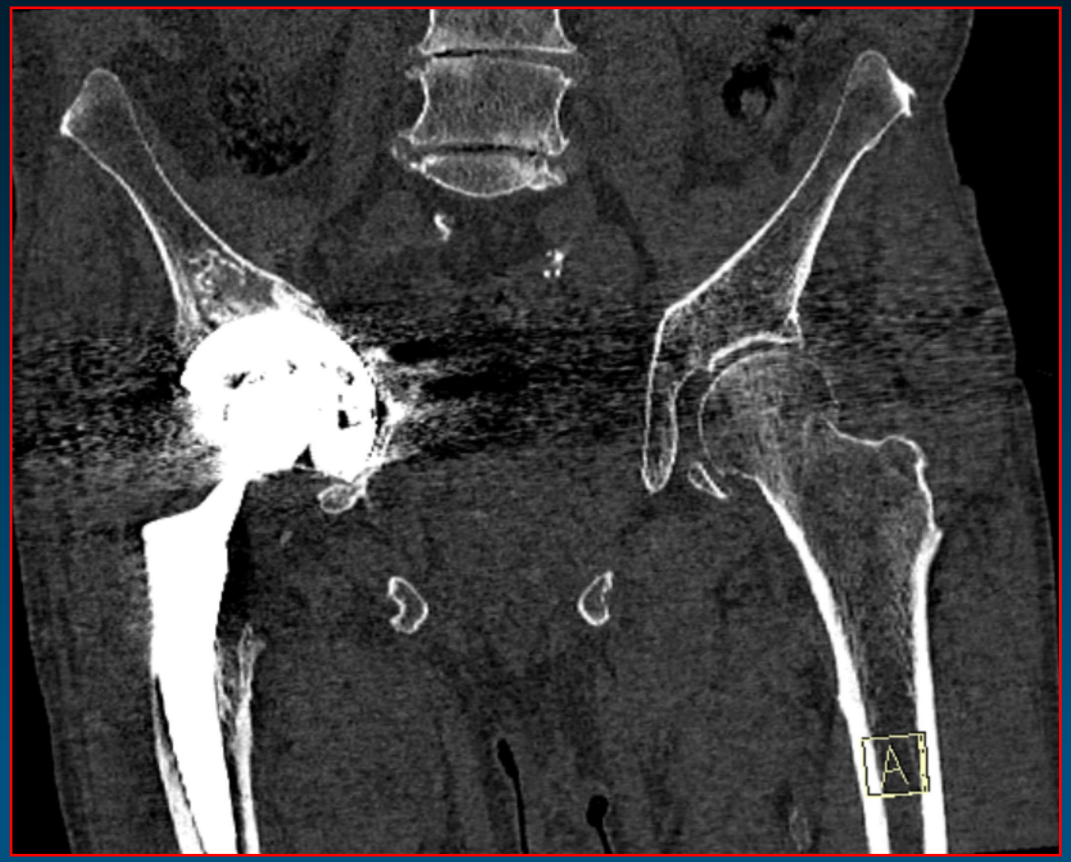
Metal artifacts in CT

- DTS is less influenced by metal artifacts
- No dependency on hip rotation
- AP DTS was sufficient without the need to rotate the patient's painful hip



The fracture is hard to visualize due to metal artifacts from the contralateral hip

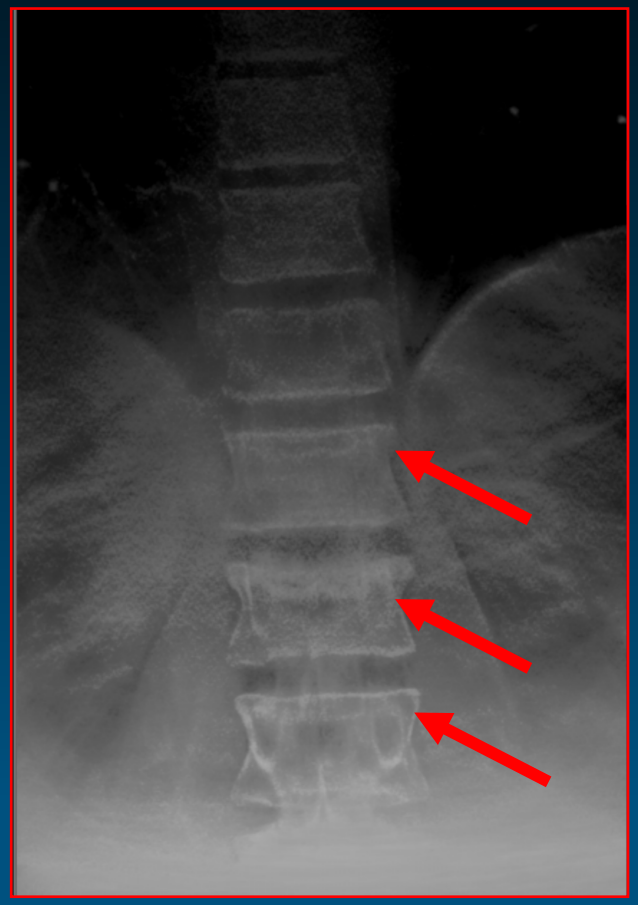
The fracture is seen on axial images

L1-3 fractures not seen on AP radiographs

X-Ray

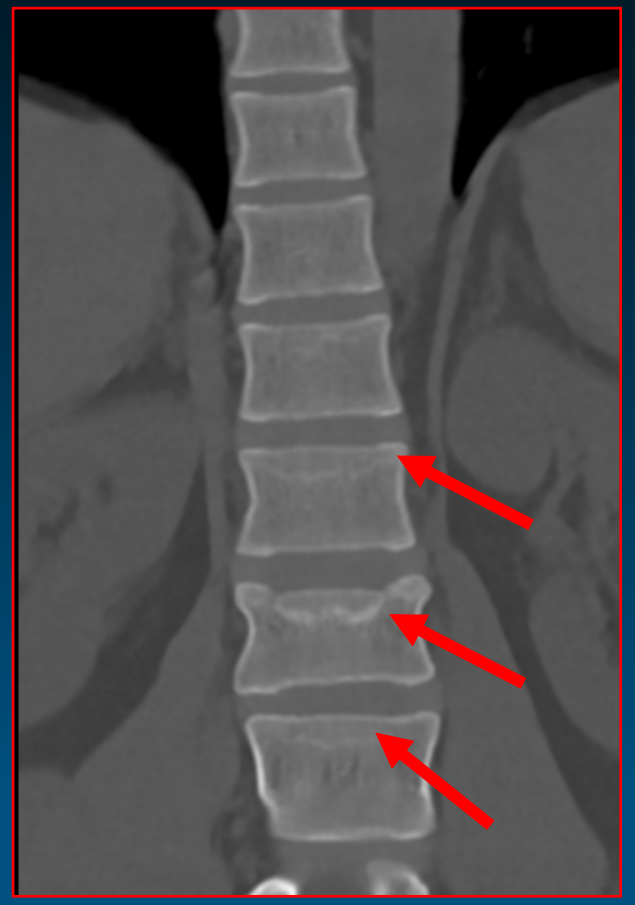
No visible fracture

DTS



Dense thin fracture lines

CT



Fracture lines seen on CT

Foot imaging through cast

X-Ray

The cast obscures fine bony details. There is a suspected subluxation of the 2nd MTP

DTS

Avulsion fracture of the Lisfranc ligament (red)

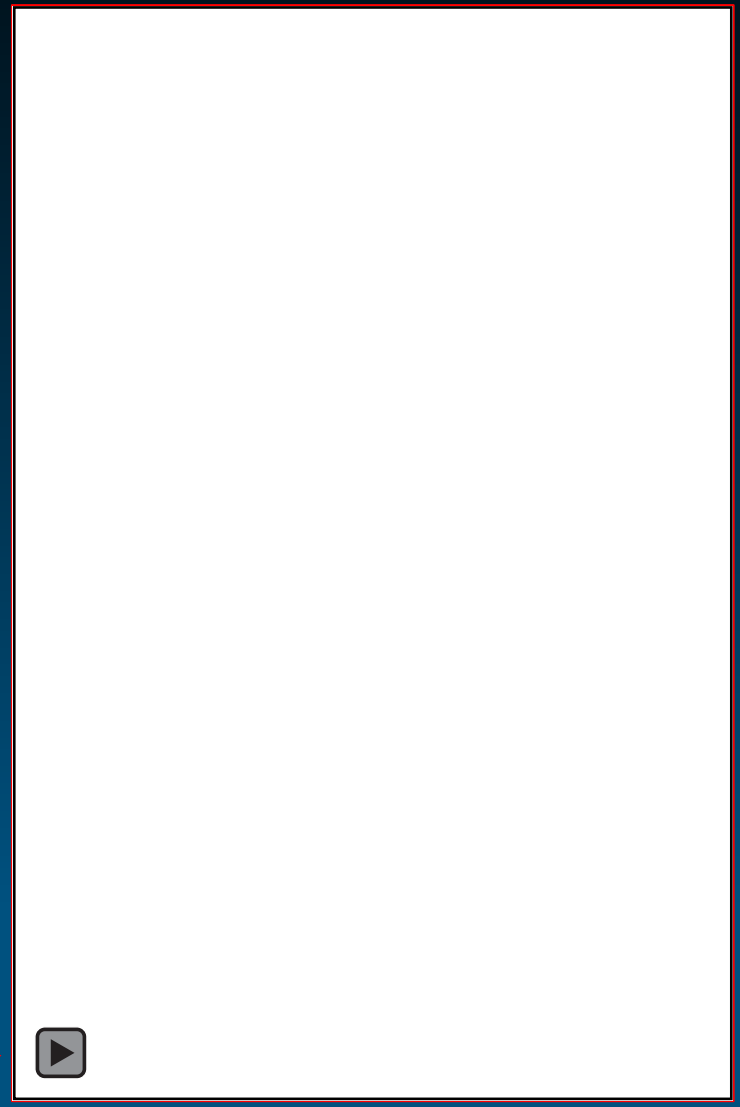
Intraarticular fracture of the 2nd MTT (yellow)

A displaced bony fragment (orange) and a 4th MTT fraxture (tin)

Foot imaging through cast (DTS Clip)

The arrow points at the following:

1. Starting at the plantar aspect, where the sesamoid bones are sharp because they are in the plain of focus.
2. An avulsion fracture of the Lisfranc ligament
3. An intraarticular fracture at the base of the 2nd metatarsal
4. A fracture at the 4th proximal metatarsal
5. Despite the cast and the complex anatomy of the foot, the bony trabecula, the fractures and a detailed evaluation of the joints is seen



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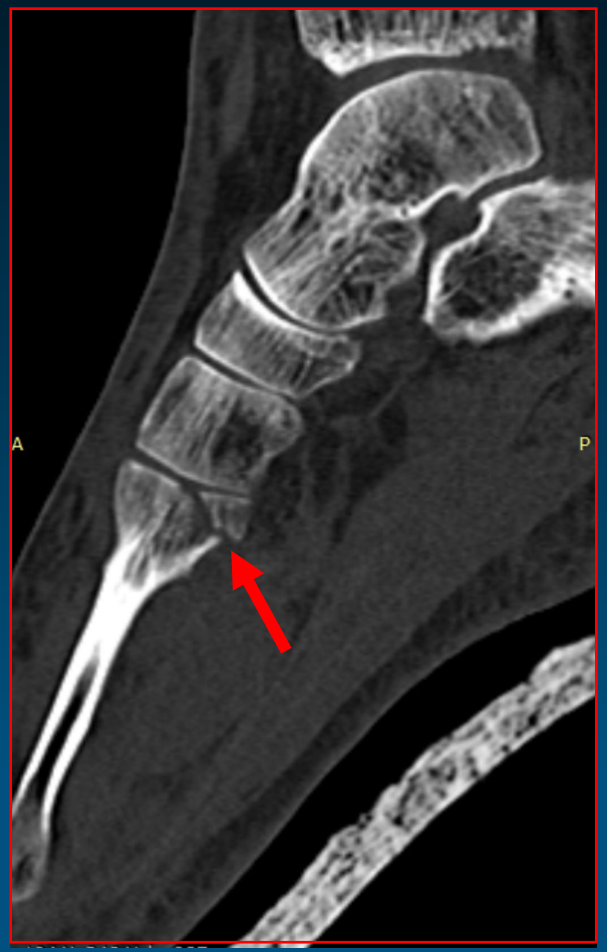
CT demonstrates the same findings

- DTS is not influenced by the cast
- No dependency on MPR accurate axis selection
- DTS provided the information sufficient for treatment decision making



Take home messages

- DTS is an old imaging modality that has revived as a digital technology in recent years
- DTS can reduce missed lesions on radiographs
- Can improve localization of lesions
- In those cases, in which DTS provides sufficient information, it can alleviate the need for CT, at lower radiation exposure to the patient
- Can reduce burden on radiologists
- The learning curve for the radiologist is short