Indications and limits of digital tomosynthesis in trauma imaging.

Poster No.: C-1788
Congress: ECR 2015
Type: Educational Exhibit
Authors: P. Gollini, G. Battezzati, G. Cortese; torino/IT
Keywords: Digital radiography, Musculoskeletal system, Trauma, Musculoskeletal bone, CT, Diagnostic procedure
DOI: 10.1594/ecr2015/C-1788

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org


**Learning objectives**

The purpose is to illustrate advantages and limitations of digital tomosynthesis (DT) as a secondary imaging modality in trauma imaging.

We have evaluated clinical utility of DT in emergency department patients with traumatic injuries. The goal was to reduce the number of patients recalled for further examinations, reduce adjunctive radiographic projections and better selection of patients eligible for CT.

**Background**

DT is a direct digital tomographic technique based on the acquisition of multiple low-dose radiographic projections acquired from different angles during a single linear sweep of the X-ray tube across a stationary detector. The sweep can be performed horizontally over a table or vertically in front of a wall stand. Patients can be placed in various positions (standing, supine, prone) allowing to investigate selected body part in each position.

The acquired projection imaging data are reconstructed using a "shift and add" algorithm to form tomographic sections through the selected object separating in-plane from out-of-plane structures (reference 1).

**Findings and procedure details**

We retrospectively evaluated 400 patients (as shown in table 1) with clinical suspected traumatic lesions who underwent DT at our institution between March 2011 and December 2014. All DT examinations were done for evaluating equivocal or incomplete standard radiographic findings.

DT was performed with GE Discovery XR650 equipment using defined preset protocols for different body parts.

**IMAGING FINDINGS**

**WRIST-HAND**

Indications of the 96 wrist/hand examinations were:
- equivocal standard radiographic findings (59 patients, fig 1)
- negative standard X-ray but positive clinical history (19 patients, fig 2)
- distinction between old and recent fracture (11 patients, fig 3)
- control with plaster cast (2 patients)
- outpatient RM examinations (5) which had abnormal MR signal but no standard X-ray available (fig 4)

DT has aided in identifying fractures, especially scaphoid fractures, often subtle (references 2,3) and in evaluating fracture consolidation (fig 5-6).

Even though it is not part of our experience, DT has been described in literature as useful for evaluating small bone erosion in rheumatoid arthritis (references 4,5).

ELBOW

Indications of the 46 elbow examinations were:

- equivocal standard radiographic findings (20 patients, fig 7)
- negative standard X-ray but positive clinical history (18 patients, fig 8)
- distinction between old and recent fracture (2 patients)
- better depiction of complex fractures (3 patients, fig 9)
- bone healing evaluation (3 patients)

In this anatomic region DT was useful not only for identifying fractures but also for detecting foreign bodies and in distinguishing avulsion from fractures.

DT was not sufficient to evaluate preoperative planning of complex fractures.

SPINE

Indications of the 59 spine examinations were:

- equivocal standard radiographic findings (7 patients, fig 10)
- negative standard X-ray but positive clinical history (16 patients)
- distinction between recent fracture and old somatic deformity (13 patients, fig 11)
- better depiction of fracture already demonstrated at X-ray examination (3 patients, fig 12-13)
- adjunctive investigation after equivocal chest X-ray finding (1 patient)
- rheumatoid arthritis (1 patient)

DT has proven not to be sufficient in evaluating unstable vertebral fractures.

**KNEE**

Indications of the 76 knee examinations were:

- equivocal standard radiographic findings (8 patients)
- negative standard X-ray but positive clinical history (37 patients, fig 14)
- better evaluation of tibial plateau fracture already demonstrated at X-ray examination (18 patients, fig 15)
- patellar evaluation (3 patients). DT was very useful in patellar evaluation and particularly for a rapid differential diagnosis between bi-tripartite patella and fracture (fig 16-17).
- evaluation of fixators, screw and plates positioning and of bone healing evolution (fig 18).

As in other anatomic regions, DT was not sufficient for preoperative evaluation of complex fractures (fig 19).

**FOOT/ANKLE**

Indications of the 43 foot/ankle examinations were:

- equivocal standard radiographic findings (17 patients) (fig 20)
- negative standard X-ray but positive clinical history (17 patients)
- distinction between old and recent fracture (4 patients)
- osteochondritis evaluation (2 patients, fig 22)
- evaluation of bone healing with external fixator (2 patients)
- better depiction of arthrodhesis (1 patient)

DT was particularly useful for distinguishing avulsion and fractures at the malleolar apex from accessory bones (fig 21).

**SHOULDER**

Indications of the 26 shoulder examinations were:
- equivocal standard radiographic findings (8 patients, fig 23)
- negative standard X-ray but positive clinical history (7 patients, fig 24)
- better evaluation of a fracture demonstrated at X-ray examination (8 patients)
- osteomyelitis (1 patient)
- evaluation of bone healing with external fixator (1 patient)
- periarthritis calcifications evaluation (1 patient)

**HIP/FEMUR**

Indications of the 52 hip/femur examinations were:

- equivocal standard radiographic findings (38 patients, fig 25),
- negative standard X-ray but positive clinical history (4 patients) and in 1 patient in hip prothesis placement (fig 26, fig 27)
- distinction between old and recent fracture (2 patients)
- better evaluation of a fracture demonstrated at X-ray examination (5 patients)
- bone healing evaluation (2 patients, fig 28)

DT was particularly useful for correctly identifying fractures and for evaluating periprosthetic fractures (fig 29).

**STERNUM**

Two patients with thoracic trauma underwent DT in the first case to solve an equivocal finding and in the second case to better depict a known fracture.

In all elbow and spine examinations DT was conclusive even though in case of complex vertebral fractures also CT examination has been done. In 95/96 hand/wrist examinations DT was conclusive as CT has been done just in one patient with suspected scapholunate dissociation. DT was conclusive in 71/76 knee examinations where as in 5 cases CT has demonstrated a fracture. In 3/43 ankle/foot cases CT was mandatory to solve a persistent diagnostic doubt after DT. DT was conclusive in 24/26 shoulder examinations and CT was necessary for evaluating osteomyelitis and complex fracture. DT was conclusive in 48/52 hip/femur examinations as CT has been done in 4 cases. In both sternoclavicular examinations, DT was diagnostic but in one case CT was done to better evaluate a complex fracture.
Images for this section:

![Table 1](image)

**Table 1**

<table>
<thead>
<tr>
<th>Anatomic region</th>
<th>N°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-wrist</td>
<td>96</td>
</tr>
<tr>
<td>Elbow</td>
<td>46</td>
</tr>
<tr>
<td>Spine</td>
<td>59</td>
</tr>
<tr>
<td>Knee</td>
<td>76</td>
</tr>
<tr>
<td>Foot-ankle</td>
<td>43</td>
</tr>
<tr>
<td>Shoulder</td>
<td>26</td>
</tr>
<tr>
<td>Hip-Femur</td>
<td>52</td>
</tr>
<tr>
<td>Sternum</td>
<td>2</td>
</tr>
<tr>
<td>Total patients</td>
<td>400</td>
</tr>
</tbody>
</table>
Fig. 1: a)RX e b)DT: scaphoid fracture
Fig. 2: a) RX e b) DT: fracture of the scaphoid distal pole
**Fig. 3:** distal radius fracture healing and recent intrarticular fracture. DT (b) better depicts intrarticular fracture line than RX (a).

**Fig. 4:** a) patient underwent MR for trauma and persistent pain: abnormal MR signal of distal scaphoid pole. b) DT depicts fracture line

**Fig. 5:** scaphoid osteonecrosis: a) RX b) RX c) DT

**Fig. 6:** osteonecrosis of the lunate. a) RX e b) DT
Fig. 7: trauma, a) RX e b) DT. DT demonstrates Osteochondral Loose Bodies.
Fig. 8: Posttraumatic pain. MR (a) shows fracture of proximal radius and DT (c) shows trabecular fracture of radial head, not visible at RX (b).
Fig. 9: a) RX, b) DT, c) CT, d) CT 3D reconstruction: complex fracture of lateral humeral epicondyle and radial head.

Fig. 10: a) RX: suspected fracture of L3 transverse process; b) DT demonstrates ossification center.
Fig. 11: a)RX, b)DT e c)CT: old fracture of L1 and recent fracture of L3 with fragment dislocation.
**Fig. 12:** a) RX and b) DT: fracture of the infero-anterior part of the vertebral body of L2.

**Fig. 13:** a) DT and b) sagittal CT: fracture through the base of the odontoid with anterior fragment angulation.
**Fig. 14:** Small osseous displacement in tibial spines visible at DT with patient prone (b) and not recognizable at standard RX (a).

**Fig. 15:** Fracture of lateral tibial plateau. Comparison between RX (a), DT (b) and CT (c).
**Fig. 16:** trauma a-b) RX in AP and comparative axial projection: doubt of fracture; DT (c) tripartite patella.
Fig. 17: RX (a) and DT (b) of bipartite patella. Fracture line visible at DT, confirmed by CT (c).
**Fig. 18:** RX (a-c) and DT (b-d) Pain after knee prothesis placement.

**Fig. 19:** RX (a), DT (b), TC (c) and 3D CT reconstruction (d): Depression fracture of lateral tibial plateau with 10 mm of articular depression and fibula fracture.
Fig. 20: a) RX: bone fragment posterior to the talus; b) DT: talus fracture with detachment. Note also V metatarsus spiroid fracture.

Fig. 21: a) RX: bone fragment posterior to the talus; b) DT: accessory bone (os trigonum).
Fig. 22: a) RX: cortical medial talar dome irregularity; b) DT: evidence of underlying area of radiolucency roundish sclerotic margins indicated osteochondritis focus.
Fig. 23: a) RX and b) DT: Fracture of the lesser tuberosity recognizable at DT.
Fig. 24: a) RX and b)DT: fracture of clavicle sternal border.
Fig. 25: a) RX: Fracture of the greater trochanter; b) DT shows also intertrochanteric fracture.
**Fig. 26:** a) negative RX; b) DT shows possible fracture of iliopubic column, confirmed by CT (c,d).

**Fig. 27:** RX (a) equivocal RX; b) DT: subcapital cranial edge fracture.

**Fig. 28:** a) RX and b) DT) Bone healing evaluation with external fixator.
Fig. 29: a)RX and b) DT: periprosthetic fracture.
Conclusion

DT provides superior anatomical detail and enables to detect occult fractures at standard radiographic imaging, clarifying equivocal radiographic findings.

It should be considered as an effective adjunct of standard X-ray and should be chosen as the secondary imaging modality in case of inconclusive X-ray, due to its rapid execution and low radiation dose (1.5% less than CT dose as demonstrated in a recent study by Xie W, reference 6).

It has proven to be a very useful diagnostic modality as it reduces the number of supplementary CT or MR examinations. CT or MR are mandatory for complex fractures evaluation and for preoperative planning (references 6,7).

Personal information

Dott.ssa Paola Gollini
Ospedale Maria Vittoria, via cibrario 72, Torino
mail: paolagol@yahoo.it
phone: 011493250

References

1.'Optimizing parameters for flat panel detector digital tomosynthesis', Haruhiko Machida et al, Radiographics 2010;30:549-562;


3.'Evaluation of the diagnostic performance of tomosynthesisin fracture of the wrist',Ottenin Ma, AJR 2012 jan, 198(1):180-6;

4.'Tomosynthesis of the wrist and hand in patients withrheumatoid arthritis: comparison with radiography and MRI', AJR 2014 feb; 202(2):386-90


7. Comparative study of DTS and CT in the skeletal trauma imaging evaluation and radiation dose', Xie W et al, Eur J RAd 2013