Fractures of the Thoracic Spine in Patients with Minor Trauma: Comparison of Diagnostic Accuracy and Dose of Biplane Radiography and MDCT

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**Purpose**

The immediate detection of traumatic fractures of the thoracic spine is important for further therapy and clinical outcome. The screening criteria among trauma centers are a controversial issue. Current recommendations are that there is no need to acquire biplane radiographs if major trauma patients undergo a MDCT.

MDCT is superior to biplane radiography and much faster [1-5], provides a sensitivity and a specificity of nearly 100% [1], detects even the tiniest fractures revealing potentially unstable lesions [6], and the patient has to be tabled only once. But still the combination of biplane radiography and physical examination [7-9] is widely used especially in minor trauma patients.

The purpose of our study was to investigate the accuracy of biplane radiography in the detection of fractures of the thoracic spine in patients with minor trauma using MDCT as the reference and to compare the dose of both techniques.

**Methods and Materials**

**Patient population:** Almost 10,000 patients who were involved in traumatic accidents with suspected fractures of the spine were examined in our university trauma center between October 2008 and October 2012. Polytrauma patients with major trauma underwent MDCT straight away without radiographs first, and patients with lower index of suspicion had biplane radiography.

**Entry criteria:**
- minor trauma
- low to moderate back pain
- a biplane radiography examination first, followed by a MDCT in a timeframe of 10 days because of aggravation of the clinical symptoms

**Exclusion criteria:**
- abnormal neurologic exam
- pregnancy
- follow-up examinations after spinal surgery
107 patients were identified in our RIS who met the inclusion criteria. The mean age of the patients was 67 ± 20 years (range 25-98 years). 54 patients were male and 53 patients were female. A fourfold table was used for the classification of the screening test results.

**Biplane radiography:** The patients were examined using a high-end, flat detector direct digital system. X-ray imaging of Th 1-12 was performed in two projections (AP and lateral). Imaging parameters were: tube current of 20 mAs, FFD 100 cm, tube voltage of 81 kVp for AP projection, and 85 kVp for lateral projection, respectively.

**MDCT:** The images were obtained after a sagittal scout from C7 to L1 using a 256-detector row CT scanner. Imaging parameters were: tube voltage of 120 kVp, tube current of 250 mAs/slice, pitch of 0.985 and a collimation of 2 mm x 128 mm x 0.625 mm. Midline sagittal and coronar images were reformatted from the axial datasets with a slice thickness of 3 mm. The images in any case were viewed at a window level of 1000 HU, and a width of 2500 HU on state-of-the-art radiology workstations.

**Radiation dose calculation:** The radiation dose was adjusted according to the patient’s body size and body shape by automatically modulating the tube current. The modulated radiation dose was recorded in terms of DLP [mGy*cm], and the mean DLP as well as the range and the effective dose [mSv] were calculated.

**Image analysis:** Two radiologists with 4 and 3 year experience in musculoskeletal imaging, respectively, reviewed both the biplane radiographs and the MDCT images. Any discrepancy was solved by consensus after discussion. Both readers were blinded to the results of the MDCT. Those were used as the reference for the detection rate of fractures on biplane radiography.

**Statistical analysis:** The Chi-square test ($\chi^2$) was used to compare the diagnostic methods and the predicted fracture risk was calculated using the Odds Ratio (OR).

**Images for this section:**
**Fig. 1:** Lateral radiograph (a) showing a compression fracture of T12 in a 28-year-old woman which was confirmed in the sagittal reformation of a MDCT scan (b).
Results

Detection of fractures: MDCT revealed 77 fractures in 65/107 patients (60.7%). Most fractures were diagnosed in the thoracolumbar junction (Table 1). Biplane radiography was true positive in 32/107 patients (29.9%), false positive in 19/107 patients (17.8%), true negative in 23/107 (21.5%), and false negative in 33/107 patients (30.8%) (Table 2), showing a sensitivity of 49.2%, a specificity of 54.7%, a positive predictive value (PPV) of 62.7%, a negative predictive value (NPV) of 41.1%, and an accuracy of 51.4%.

10/10 fractures in the upper thoracic spine (T1-4) and 16/28 fractures in the middle thoracic spine (T5-8) were misdiagnosed on biplane radiography. However, none of these fractures was unstable. In the lower thoracic spine (T9-12) 25/39 fractures were true positive on biplane radiography. Of them, 3 unstable fractures were diagnosed as well on biplane radiography as on MDCT. #^2 was 7.6 and was significant (p= 0.01). OR was 5.2 and was significant (p< 0.0001).

Radiation dose: For biplane radiography, the average DLP of all examinations was 14.5 mGy*cm (range 1.9-97.8) (Table 3). The resulting gender-adapted effective Dose was 0.7 mSv on average.

For MDCT, the average DLP of all examinations was 374.6 mGy*cm (range 80.2-871). The resulting gender-adapted effective Dose was 7.5 mSv on average.

Images for this section:
<table>
<thead>
<tr>
<th>Thoracic Vertebrae</th>
<th>Number of Fractures in Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1</td>
</tr>
<tr>
<td>T2</td>
<td>1</td>
</tr>
<tr>
<td>T3</td>
<td>3</td>
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<td>T4</td>
<td>5</td>
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<td>T5</td>
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<td>6</td>
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<td>3</td>
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<td>T11</td>
<td>11</td>
</tr>
<tr>
<td>T12</td>
<td>19</td>
</tr>
</tbody>
</table>

**Table 1**: Distribution of 77 traumatic fractures of the thoracic spine in 65 patients. Most fractures were diagnosed in the thoracolumbar junction.
Table 2: Accuracy of biplane radiography in diagnosing thoracic vertebral fractures. Multidetector computed tomography (MDCT) reports were used as the reference.

<table>
<thead>
<tr>
<th></th>
<th>Patients with Thoracic Vertebral Fractures on MDCT</th>
<th>Patients without Thoracic Vertebral Fractures on MDCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractures on Biplane Radiography</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td>No Fractures on Biplane Radiography</td>
<td>33</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 3: Dose in terms of dose-length-product (DLP) for both biplane radiography (anteroposterior/lateral) and multidetector computed tomography (MDCT).

<table>
<thead>
<tr>
<th></th>
<th>Mean DLP</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biplane Radiography</td>
<td>14.5 mGy*cm ± 18.7</td>
<td>1.9 – 97.8</td>
</tr>
<tr>
<td>MDCT</td>
<td>374.6 mGy*cm ± 181.6</td>
<td>80.2 – 871</td>
</tr>
</tbody>
</table>
Conclusion

In contrast to recent studies [1,9] the sensitivity (49.2%) and the specificity (54.7%) of biplane radiography were unexpectedly low compared to MDCT. Considering the wide availability of MDCT that is usually necessary for taking significant therapeutic steps, the indication for biplane radiography should be very restrictive although none of the missed fractures were unstable. To our opinion, there are several reasons for misdiagnosis on biplane radiography (Figures 2,3):

1. The observer inexperience seems to be an important factor.
2. No clearly defined diagnostic algorithms to decide about imaging in patients with suspected fractures of the thoracic spine on physical examination.
3. We did not acquire a swimmers view of the cervical spine including the cervico-thoracic junction to reveal fractures in the upper thoracic spine at all.
4. Due to the inexperience of the referring physician, regions with signs or symptoms of a fracture may not be imaged at all.

The mean DLP on MDCT was 26 times as high as on biplane radiography (374.6 mGy*cm / 14.5 mGy*cm). The wide variation in DLP (1.9-97.8 on biplane radiography and 80.2-871 on MDCT) was primarily due to the varying body mass index of the patients.

With regard to the medical use of radiation as the largest source of exposure to the western population [10-12], resigning the biplane radiographs in our study and performing the MDCT scan as the only screening modality would decrease the radiation exposure in total. On the other hand substituting biplane radiographs for a MDCT scan in all of the almost 10,000 trauma patients in our institution would increase the body radiation dose dramatically. A step in the right direction is certainly the application of iterative reconstruction methods, which are able to reduce the body radiation dose at MDCT to a minimum while probably keeping the same diagnostic efficiency [13].

Images for this section:
Fig. 2: Anterior compression fractures of T4 and T5 which were missed on the lateral radiograph (a) and revealed in the sagittal reformation of a MDCT scan (b) in a 26-year-old man.
Fig. 3: Anterior compression fracture of T3 which was missed on the lateral radiograph (a) and revealed in the sagittal reformation of a MDCT scan (b) in a 40-year-old man.
References


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