INTRODUCTION

Lumbar transverse process (LTP) fractures are regarded as minor trauma. Their causal factors are direct blunt trauma, violent lateral flexion extension forces, avulsion of the psoas muscle, and a malgaigne fracture of the pelvis. Treatment is generally confined to observation and pain control (1-4). LTP fractures are very often associated with abdominal visceral injuries. In trauma patients, a LTP fracture is a sign of possible associated abdominal or genitourinary injuries. Therefore, the diagnosis of a minor LTP fracture is very important (2, 3, 5).

Most accurate diagnostic tools reveal a fracture line on the axial images of computed tomography (CT) (Fig. 1). However, it takes considerable time to check all the axial images. This minor fracture is often overlooked because it is difficult to determine all the axial images in an emergency or under busy conditions (3, 4, 6-8). Three-dimensional (3D) CT volume rendering techniques (VRT) reorganizes the images based on the axial images by the two radiologists. The results of 3D CT volume rendering images were compared with the axial images and the diagnostic powers (sensitivity, specificity, and accuracy) were calculated.

Results: Seven of the 42 patients had twenty five lumbar transverse process fractures. The diagnostic power of the 3D CT volume rendering technique is as accurate as axial images. Reader 1, sensitivity 96%, specificity 100%, accuracy 99.9%; and Reader 2 sensitivity 100%, specificity 99.8%, accuracy 99.8%. The accordance of the two radiologists was 99.8%.

Conclusion: 3D CT volume rendering images can alternate axial images to detect lumbar transverse process fractures with good image quality.
Diagnostic Accuracy of the Volume Rendering Images of MDCT for the Detection of Lumbar Transverse Process Fractures

**MATERIALS AND METHODS**

**Patient Population**

We retrospectively evaluated 42 patients presenting with back pain after trauma that were selected between January and June of 2010. The patients were comprised of 27 males and 15 females which collectively had a mean patient age of 46.7 years old (4-79 years old). The causes of back pain for the 42 patients included traffic accidents (bicycle driver, motorcycle driver, automobile driver, automobile pedestrians, and automobile passenger), slips, or falls. As a result, the 42 patients presented with blunt trauma and 11 patients had accompanying scratches or superficial lacerations. All patients were evaluated by CT, and the mean interval time between trauma and CT were 113 minutes.

**Three-Dimensional CT Volume Rendering Techniques**

The CT scans were obtained on a 16-channel multi-detector CT scanner (Sensation 16; Siemens, Forchheim, Germany). CT data acquisition was performed in the craniocaudal direction with a collimation of 16 x 0.75 mm, a table feed of 9 mm per rotation, a 0.5-second gantry rotation time, a tube voltage of 120 kV, and an effective tube current of 200 mAs. The axial images were reconstructed with a slice width of 1 mm and a reconstruction increment of 0.7 mm using a bone algorithm (reconstruction kernel B50f); In Space of Siemens was used for the 3D CT volume rendering techniques.

**Image Analysis**

All images were read by two radiologists. Reader 1 was a musculoskeletal specialist with 13 years of experience and Reader 2 was a resident of the radiology department. Initially, the two radiologists examined the 3D CT volume rendering images independently. The consensus of the axial images was considered to be the gold standard for the detection of a LTP fracture. The 3D CT volume rendering images were compared with the axial images.

**Statistical Analysis**

To confirm the diagnostic value of 3D CT VRT, the diagnostic power (sensitivity, specificity, and accuracy) was calculated. To evaluate the accordance of the two radiologists, the Kappa value was calculated.

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Table 1. Diagnosis of a Lumbar Transverse Process Fracture: 3D CT Volume Rendering Images versus Axial Images of CT Scan

|            | Reader 1 | Reader 2 |
|------------|----------|----------|
| VRT image  |          |          |
| Patient number | 10       | 14       |
| Fracture number | 24       | 31       |
| Axial image  |          |          |
| Patient number | 10       |          |
| Fracture number | 25       |          |

Note. — Reader 1 = musculoskeletal specialist with 13 years of experience; Reader 2 = resident of the radiology department.
3D = three-dimensional, VRT = volume rendering techniques

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Fig. 1. A 43-year-old man presenting with a fall injury. A, B. Anterior (A) and posterior three-dimensional CT volume rendering images (B) show irregularly marginated discontinuity (arrows) of the left second and third lumbar transverse process. C, D. Axial images of CT shows proven definite fracture lines (arrows) at the left second (C) and third lumbar transverse process (D).
RESULTS

For the consensus of the axial images, 25 transverse fractures were diagnosed in 10 out of 42 patients with blunting trauma (Table 1), while 32 patients had no fractures. Eight out of the remaining 10 patients had multiple LTP fractures \((n = 4, 3 \text{ patients}; n = 3, 1 \text{ patient}; n = 2, 4 \text{ patients})\). The other 2 patients had a single fracture. An abdominal organ injury was accompanied in 2 of the 10 patients with LTP fractures. One patient had a hepatic hematoma and the other had multifocal liver lacerations.

On the 3D CT volume rendering images, Reader 1 diagnosed LTP fractures in 10 patients. Ten patients had 24 fractures. All 24 fractures were proven to be true fractures on axial images. However, Reader 1 missed one true fracture, he analyzed an unfused ossification on a 3D CT volume rendering image. Reader 2 detected 31 LTP fractures in 14 patients (Table 1). Six fractures were found not to be true fractures on axial images. Three fractures were unfused ossification centers, while the other three fractures were artifacts in old patients. The calculated diagnostic power of the 3D CT volume rendering images for the readers were as follows: Reader 1, sensitivity 96%, specificity 100%, accuracy 99.9%; Reader 2, sensitivity 100%, specificity 99.8%, accuracy 99.8%. The two radiologists diagnosed the same twenty-four true LTP fractures, and had different reports on seven fractures. One of the seven was an unfused ossification center. Other six fractures were false positives. The accordance of the two radiologists was 99.8% and the Kappa value between the two readers was 0.98.

DISCUSSION

LTP fractures are diagnosed in many patients with back pain after trauma. But, most LTP fractures are not fatal and conservative therapy is performed until the fracture is healed. (1-3). However, a LTP fracture is not a simple minor trauma. Sturm and Perry (2) reported that 21% of patients with LTP fractures have associated abdominal organ injuries. In addition, Miller et al. (3) reported that abdominal organ injuries accompanied LTP fractures in 48% of the 42 patients they examined. In the present study, 2 of 10 patients (20%) with LTP fractures had abdominal organ injuries including liver hema-

toma and multifocal liver lacerations. If there are LTP fractures in trauma patients, they are likely to be associated with abdominal or genitourinary injuries. Therefore, detecting LTP fractures is very important and they should not be overlooked (2, 3, 5).

The accurate diagnosis of a LTP fracture is possible by CT. Many axial CT images show an irregular discontinued line of a LTP, and we can detect fracture lines by careful check of all images. However, checking of all axial images is time consuming. In many cases, a LTP fracture could be overlooked because it is not easy to see all the CT images in an urgent situation. 3D CT volume rendering images allow rapid analysis of bony fractures. If they are accurate, rapid diagnosis of LTP fractures is possible. In thoracic cage fractures, Alkadhi et al. (10) report the diagnostic power (accuracy, mean sensitivity, specificity) of axial images (99%, 96%, 100%) and 3D CT volume rendering images (100%, 98%, 100%) (6). However, accuracy for the detection of LTP fractures has not been proven in the previous study.

Our present study was performed to determine the effectiveness of 3D CT volume rendering images for detecting LTP fractures. In addition, the diagnostic power (sensitivity 96%, 100% specificity 100%, 99.8% accuracy 99.9%, 99.8% by Reader 1 and 2, respectively) of this technique, were acquired. However, 3D CT volume rendering images have several problems when being used to diagnose LTP fractures. First, LTP fractures can be over-diagnosed in children. Growing children have ossification centers of transverse process. Further, ossification centers are located at the tip of a transverse process. This makes it difficult to differentiate ossification centers from true fractures because the 3D CT volume rendering images do not present a more accurate margination than axial images (Fig. 3). In the present

![Image](submit.radiology.or.kr) J Korean Soc Radiol 2012;66(1):77-82
There are many studies that have been performed to determine the usefulness of 3D CT volume rendering images for the detection of bony fractures. In specific lumbar LTP fractures, many studies concentrate on the importance of LTP fractures compared with conventional radiographic images and CTs. Our study was the first to diagnose LTP fractures by 3D CT volume rendering images. However, our study has some limitations. First, we have small sized patient groups. Consequently, it is difficult to generalize the accuracy for the diagnosis of lumbar transverse process fractures by 3D CT volume rendering images. Second, the two readers' experience were quite different. This point could lower the accuracy and
In conclusion, minor lumbar transverse process fractures in patients with blunt trauma should not be overlooked because this fracture can be a sign of abdominal organ injury. 3D CT volume rendering images can diagnose this fracture faster than axial images and can alternate axial images to detect lumbar transverse process fractures with a good image quality.

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다검출기 전산화단층촬영의 삼차원 용적표현영상을 통한 요추횡돌기골절의 진단적 정확도

이윤학 · 전동진

목적: 외상 환자의 요추횡돌기골절을 진단하는 데 있어 전산화단층촬영의 횡단면 영상과 삼차원 용적표현영상의 진단적 정확도를 비교하고자 하였다.

대상과 방법: 2010년 2월에서 6월에 걸쳐 외상후 허리통증을 호소하는 42명의 환자를 대상으로 2명의 영상의학과 의사가 독립적으로 삼차원 용적표현영상과 판독한 후에 확진을 위하여 전산화단층촬영의 횡단면 영상을 같이 판독하여 두 영상의 결과를 비교하였으며 삼차원 용적표현영상의 진단적 가치(민감도, 특이도, 그리고 정확도)를 산출하였다.

결과: 42명의 환자 중에서 7명의 환자가 25개의 요추횡돌기골절을 보였다. 다검출기 전산화단층촬영의 삼차원 용적표현영상의 진단적 가치는 판독자 1은 민감도 96%, 특이도 100%, 정확도 99.8%, 판독자 2는 민감도 100%, 특이도 99.8%, 정확도 99.8%였으며 두 판독자 간의 일치도는 99.8%였다.

결론: 다검출기 전산화단층촬영의 삼차원 용적표현영상은 좋은 영상의 질이 전체될 때 요추횡돌기골절의 진단에 있어서 전산화단층촬영의 횡단면 영상을 대체할 만하다.

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