Application of CT 3D reconstruction in diagnosing atlantoaxial subluxation

DUAN Shao-yin, LI N Qing-chi and PANG Rui-lin

Objective: To evaluate and compare the diagnostic value in atlantoaxial subluxation by CT three-dimensional (3D) reconstruction.

Methods: 3D reconstruction findings of 41 patients with atlantoaxial subluxation were retrospectively analyzed, and comparisons were made among images of transverse section, multiplanar reformating (MPR), surface shade display (SSD), maximum intensity project (MIP), and volume rendering (VR).

Results: Of 41 patients with atlantoaxial subluxation, 31 belonged to rotary dislocation, 5 antedislocation, and 5 hind dislocation. All the cases showed the dislocated joint panel of atlantoaxial articulation. Fifteen cases showed deviation of the odontoid process and 8 cases widened distance between the dens and anterior arch of the atlas. The dislocated joint panel of atlantoaxial articulation was more clearly seen with SSD-3D imaging than any other methods.

Conclusions: Atlantoaxial subluxation can well be diagnosed by CT 3D reconstruction, in which SSD-3D imaging is optimal.

Key words: Joints, atlantoaxial; Tomography, X-ray computed; Image processing, Computer-assisted

Atlantoaxial subluxation can be caused by trauma and nontrauma factors. Currently its diagnosis mainly relies on X-ray plain film and/or CT scan. It is sometimes difficult to get accurate assessment because the signs of dislocation cannot be clearly shown.

The images of CT three-dimensional (3D) reconstruction can directly exhibit the dislocated joint panel. In this study, findings in 41 cases diagnosed as atlantoaxial subluxation from June 1998 to April 2001 in our hospital were analyzed, and the features of images and the diagnostic value of CT 3D reconstruction were studied.

METHODS

CT 3D reconstruction was carried out in 41 patients with atlantoaxial subluxation, in whom 24 were females, 17 males, ranging in age from 10 to 70 years (mean 29.7). Twenty-eight cases were caused by injury, in whom 22 by road traffic accidents. The other 13 cases had no history of injury. The clinical symptom was cervicodynia and movement limitation for half a year to 1 year.

CT was performed with a spiral CT scanner (Siemens, Somatom plus 4). Image data of the atlantoaxial joint were obtained through the beam collimation of 3 mm or 5 mm, pitch of 1.5 mm. The image data in 19 cases were retrospectively reconstructed with the overlap of 0.9 mm or 1.4 mm. The workstation of SUN magicview 1000 was used in the 3D reconstruction, and it consists of multiplanar reformating (MPR), surface shade display (SSD), maximum intensity project (MIP) and volume rendering (VR). The images of MPR, SSD, MIP, VR and transverse section were compared.

RESULTS

Among the 41 patients with atlantoaxial subluxation, rotary dislocation involved in 31 patients (According to Fielding and Hawkins's classification, 9 belonged to type I, 12 type II, 5 type III, and 5 type IV), antedislocation in 5 and hinddislocation in 5. The dislocated joint panel was shown in 41 cases (Figs. 1-4), deviation of the odontoid process in 15 (Fig. 2), widened distance
between the dens and anterior arch of the atlas in 8, fracture in 8 (4 atlas fractures, 4 den of epistropheus fractures). All the 41 cases were correctly diagnosed with 3D images of SSD and transverse images. While with transverse images and 3D images of MPR, the diagnosis in 14 cases was suspicious and 7 missed, only 20 correct. (Table 1, Figs. 3-6).

**DISCUSSION**

**Imaging features of 3D reconstruction**

3D imaging methods of the atlantoaxial joint generally consists of MPR, MIP, VR and SSD. Each has its own characteristics: MPR image can show any section, eg, sagittal and oblique. Though it cannot get 3D perception, it can remedy the defects of transverse-images with the advantages of showing widened distance between the dens and anterior arch of

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**Fig. 1.** The axialview showing the dislocated joint panel of rotary dislocation type I in SSD image (the two white arrows).

**Fig. 2.** The hind view showing the joint panel of hind dislocation (the big black arrow) and the deviation of the odontoid process (the smaller black arrow) in SSD image.

**Fig. 3.** The antview showing the dislocated joint panel of rotary dislocation type II in SSD image (the black arrow).

**Fig. 4.** The same case as Fig. 3, showing the dislocated joint panel of rotary dislocation type II in SSD image (the black arrow).
Table 1. Atlantoaxial subluxation signs among 3D images of MPR, SSD, MIP, VR and transverse images

<table>
<thead>
<tr>
<th></th>
<th>MPR</th>
<th>SSD</th>
<th>MIP</th>
<th>VR</th>
<th>Transect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocated joint panel</td>
<td>blurred</td>
<td>clearest</td>
<td>blurred</td>
<td>clear</td>
<td>blurred</td>
</tr>
<tr>
<td>Deviation of the odontoid process</td>
<td>clearest</td>
<td>clearest</td>
<td>clear</td>
<td>clearer</td>
<td>clearer</td>
</tr>
<tr>
<td>Widened atlanto-dens space</td>
<td>clear</td>
<td>clearer</td>
<td>clear</td>
<td>clearer</td>
<td>clearer</td>
</tr>
<tr>
<td>Fracture</td>
<td>clearest</td>
<td>clear</td>
<td>clearest</td>
<td>clear</td>
<td>clear</td>
</tr>
</tbody>
</table>

the atlas. MIP can obtain 3D image by choosing the tissue of the highest or lowest density, e.g., bone or air. The original section image should be thinner (< 3 mm), otherwise the edge of 3D image is obviously dentiform. However, the image shows the mini fracture line more clearly by decreasing the thickness of the structure than SSD or VR. VR, with the advantages of showing the four kinds of tissues or structures by selecting their CT value range and imaging parameters, is the most advanced imaging method in 3D reconstruction. Even reconstructed with thicker section images, still can get good quality images with smooth edge and rich hierarchy. But it cannot well show the dislocated joint panel of atlantoaxial subluxation, owing to the overlap of bone structure. SSD 3D image can show the surface structure of the bone, skin and internal surface of organs by selecting their CT value range. It has great advantages in showing the dislocated joint panel and diagnosing atlantoaxial subluxation, and can use routine section image without being retrospectively reconstructed.

Diagnosis of atlantoaxial subluxation

Clinical presentations for patients with atlantoaxial subluxation are cervicodynia and movement limitation. The leading cause is injury (28), among which road traffic accidents account for a large part (22) in our series. The result is in accordance with other report. The direct signs in images are dislocated joint panel of the atlantoaxial articulation and widened distance between the dens and anterior arch of the atlas. The indirect sign is deviation of the odontoid process. Some researchers found that the transverse images of CT and its MPR image could ascertain diagnosis and were the preferred methods for assessing the atlantoaxial dislocation and fracture. But in our series, we found 14 suspicious diagnosis and 7 missed diagnosis. SSD, MIP, VR 3D reconstruction imaging can make up the shortcomings of the above-mentioned two methods by showing and measuring the joint panel of atlantoaxial dislocation. We can get a correct diagnosis and an exact measurement by analyzing and observing the 3D images, which enable us to understand transect anatomy and the features of....
SSD 3D imaging increases the accuracy of diagnosis without reconstruction with thinner (< 3 mm) CT scan, and without increasing the X-ray dosage and cost. When dislocation is accompanied by minifracture, the thinner (< 3 mm) CT scan and MIP 3D imaging are needed, by which the fracture line can be more clearly showed.

The diagnosis of atlantoaxial joint injury can be established on X-ray plain film with open-mouth position and lateral position and/or CT scan. In X-ray plain film, the deviation of the odontoid process and widened distance between the dens and anterior arch of the atlas can be possibly shown, implying the atlantoaxial joint injury. But the sign of X-ray plain film cannot be found in all the patients, while the deviation of the odontoid process can be shown in normal people. So X-ray diagnosis cannot always be accurate and get a quantitative diagnosis. The transverse images and 3D reconstruction image (MPR, MIP, VR, SSD), CT transverse images and MPR are sectional images. They only show the deviation of the odontoid process and widened distance between the dens and anterior arch of the atlas, but cannot clearly show the dislocated joint panel. MIP, VR, SSD images are three-dimensional and can show the dislocated joint panel, but MIP and VR 3D images can not well show and measure the overlap of structures. Only SSD 3D reconstruction imaging can show clearly the dislocated joint panel, and thus leads to accurate diagnosis of atlantoaxial subluxation. All the 41 patients got correct diagnosis with SSD 3D in our series. We believe SSD 3D imaging has good diagnostic value to these patients.

REFERENCES


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