ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LXII, N 1, 48 SECTIO D 2007

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Two and three- dimensional CT reconstructions used to evaluate traumatic spinal canal stenosis

Prompt treatment of spinal injuries requires quick and precise evaluation of the damage. In certain types of injuries complex structure of the vertebral column poses diagnostic difficulties. Computed tomography is a technique of choice used to visualize the continuity of the vertebral structures, narrowing of the spinal canal and to identify and locate free bony fragments (6). Two-dimensional (2D) and three-dimensional (3D) reconstructions essentially complement computed axial tomography (CAT) images.

The purpose of study was to verify the usefulness of 3D reconstructions in the detection of traumatic stenosis of the spinal canal and to evaluate the character, size and location of indented thoraco-lumbar bony fragments creating the narrowing as well as their spacial characteristics.

MATERIAL AND METHOD

The study included 28 patients, 14–78 years old (11 females and 17 males) with a complex fracture of different spinal regions treated at the Clinic of Traumatology, Medical University of Lublin in 1997–2005. In 16 patients CT results were correlated with the operation findings.

Following A.P. lateral (or diagonal) and targeted radiograms the patients were taken to the 2nd Radiological Department, Medical University of Lublin for CT scans on SOMATRON ART (Siemens) matrix 512x512 pixels.

CAT scans were supplemented with 2D reconstructions (sagital and coronal plane) and spacial 3D reconstructions created from the sets of high quality axial slices, 2, 3, 5 mm thick, 150 H.U. bony threshold assumed for spacial reconstructions. To obtain 3D models the most advantageous rotary aspects, angled and axial cuts were captured. Front projections: anterior and posterior, lateral and diagonal, top and bottom were made, cutting off the parts of the reconstructed image from the inside of the spinal canal sagital sections cross-cut the foramina and interfacet joints. Intracanal 3D reconstructions, anterio-posterior, diagonal and posterio-anterior were extremely useful to evaluate the fracture of the posterior parts of the vertebral arch. The indications to perform 3D reconstructions included evaluation of spinal canal stenosis, inconclusive radiological and clinical findings unexplained by cross-cuts and 2D images aside complex injury and evaluation of the inner surfaces of the spinal canal.

RESULTS

The most common cause of compressed vertebral body fragments indented into the spinal canal was posterior dislocation.

In 12 cases 3D reconstructions cutting through the midline of the spinal canal revealed narrowed lumen due to indentations caused by compressive fracture of the vertebral body into the lumen of the spinal canal (Fig. 1). In 6 patients the fragments were anteriorly rotated by 90°–60° with simultaneous displacement by 3–8 mm, anteriorly and vertically, similarly to the fragments rotated by 30°–150°. In 7 patients with axial compressive fracture indented fragments occupied most of the canal lumen. Operatively the fragments were bigger than the vertebral body loss suggesting their vertical displacement. With bone fragments located inside the canal 3D reconstructions visualized their spacial corelations and topographic location in the spinal canal.

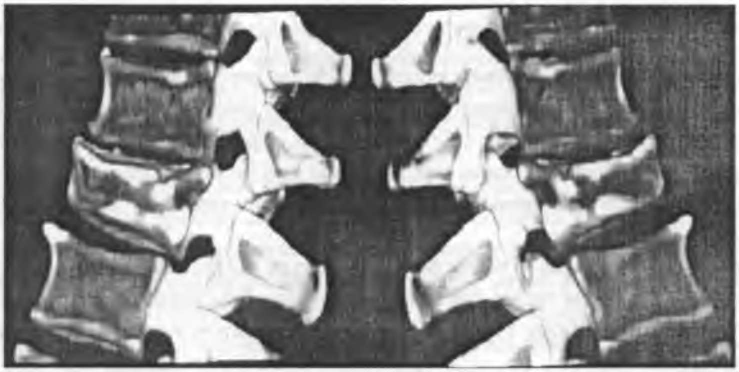

Fig.1. Patient Ch.Z., female, 75 years old, with compressive decrease of the vertebral body height with indentation of the posterior margins creating stenosis of the spinal canal. In the bony window crevice of the fractured vertebral arch visible on the right side

In comminuted fracture the results revealed intracanal indentations of the fragments from the upper area, especially posterio-superior margins (6 cases). Top and back projections were made after cutting off dorsal part of the vertebral body. 3D reconstructiions showed the direction of the indented fragments and their contours. In 5 cases the fragments came from the inferior parts of the vertebral body (Fig. 2). 3D reconstructions displayed the degree of fragments rotation in the spinal canal and their vertical dislocation. In 5 cases it was posterior dislocation, anteriorly and vertically rotated. In comminuted compressive fracture with bony fragments displaced into the spinal canal medial cuts showed the degree of injury and extent of traumatic narrowing of the spinal canal.

3D images defined the number, size, position, degree of rotation and diagonal inclination of the bony fragments dislocated into the canal lumen. In 8 cases fine fragments undetactable on 2D reconstructions were visualized successfully.

Intracanal spacial reconstructions in top projections especially demonstrated indentations of the posterior surface of the spinal canal. The degree of canal narrowing is essential in compressive spinal luxation of the vertebral bodies due to injury. They were detected on sagital cross-cuts 2D reconstructions; however, the contours of the spinal canal were better visualized on 3D models after cutting off at the sagital plane, especially the indentations of the anterior wall of the canal with simultaneous rotation, luxation and displacement of the vertebral body.

3D models reconstructed internal surface of the spinal canal, voluminal proportions and topographic location of the traumatic changes inside.

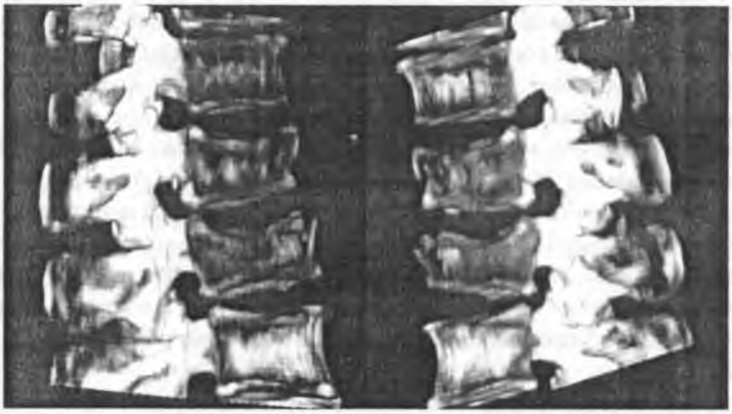

Fig. 2. Patient K.J., male, 36 years old, with decreased height of L1, of compressive character with slight displacement of a bony fragment into the spinal canal. Uneven contour of the fractured vertebra with non-homogenous bone structure. Angled kifotic bend of the spinal column at this level. Decreased width of the intervertebral space TH12–L1. Deformed intervertebral foramen L1–L2

DISCUSSION

2D images reconstructed the character of the compressive fracture to the vertebral body. To evaluate narrowing and extent of posttraumatic deformation of the spinal canal 3D reconstructions were valuable. Optimal positioning of intracanal fragments, their vertical and horizontal displacement, rotarion and inclination are essential.

2D and 3D reconstructions detect the extent and locate displaced bony fragments and define their spacial corelations. They can detect the position of displaced backwardly bony fragments formed as a result of acute axial compression and demonstrate fracture stability and reposition of the bony fragments (7).

3D reconstructions optimally visualize internal space of the spinal canal and enable precise evaluation of its narrowing, exactly evaluate fragments indented into the spinal canal, define degree of their rotation, fragmentation and locate the fragments. The degree of obstructed patency due to indented fragments into the spinal canal was evaluated as slight (0–20%), moderate (20–50%) and severe (> 50%) (5). Our results revealed obstructed patency of the spinal canal due to the vertebral body fragments in 50% cases examined.

Narrowing of the spinal canal due to free indented fragments is typical of axial compressive damage (10). Bony fragments may be separated from the vertebral body in the region of the intervertebral foramen.

In the mechanism of excessive bend axial compression occurs aside anterior rotation of the indented fragments. In case of narrowed spinal canal due to displaced fragments 3D reconstructions are very important as they reproduce the width of the canal lumen.

2D reconstructions have limited spacial picture definition. Thus intracanal indentations of bony fragments with luxated vertebral body may not be visualized precisely. Clinically it is essential to evaluate the crevice route and displacement of the fragments prior to their reposition. In the fractures of the anterior spinal column the field of cross-cuts of the spinal canal was narrowed by 56% mean, in the fractures of the posterior column by 61%. Surgical reduction of the indented fragments decreased the degree of narrowing down to 19% (anterior column) and 29% (posterior column (9).

3D reconstruction provides visualization of the inner surfaces of the spinal canal, enables evaluation of its narrowing and degree of compression of the intervertebral foramina.

Thre-dimensional chatacter of traumatic injuries to the vertebral structures requires spacial reconstruction (12). 3D technique is useful to detect compressive fractures and intracanal indentations of the posterior wall fragments with simultaneous rotation and luxation of the vertebral bodies (11).

In the material studied 3D reconstructions were the technique of choice used in complex traumatic injuries of the spine. In traumatic stenosis of the spinal canal 3D images visualize displaced intracanal fragments, fractured vertebral bodies and traumatic luxation of the vertebral bodies.

In our material stenosis due to bony fragments occurred in 50% of the cases examined. Narrowing of the spinal canal due to free indented fragments is typical of axial compressive damage (9). The majority of the fragments formed during defragmentation of the upper part of the vertebral body with sagital crevice.

Spinal canal contours were better visualized on 3D reconstructions compared to 2D models, which produced insufficient data in case of fractures with rotation and displacement of bony fragments. 3D technique better outlines displaced fragments and precisely defines fracture stability. Coronal plane cross-cuts and cross-cuts through the spinal canal can locate intracanal fragments.

CONCLUSIONS

Three-dimensional reconstructions enhance diagnostic potential of multiplanal cross-sections in 60% patients and axial cross-sections in 76% patients. 3D technique was significantly better in comparison to 2D in visualizing spinal canal stenosis and locating intracanal bony fragments. They defined the size, shape, location, degree and direction of bony fragments rotation and their spacial corelations inside the spinal canal producing a complete three-dimensional model of displacement.

Defining optimal position of a bony fragment, its inclination and degree of rotation in the spinal canal, direction of intracanal displacement, vertical and horizontal was essential. Compressive changes to the vertebral bodies with fragmentation and displacement of the bony fragments into the canal lumen, medial cross-cuts reveal the degree of deformation and extent of posttraumatic spinal canal stenosis.

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SUMMARY

In our study we evaluated secondary 2D and spacial 3D CT reconstructions used to detect traumatic narrowing of the spinal canal and spinal bony fragments. The material included 28 patients treated for spinal injury who had CT scans performed and supplemented with secondary reconstructions. 3D reconstructions enhanced diagnostic potential of CAT by the evaluation of morphology of the spinal canal stenosis and spinal fragments in additional dimensions and defined spacial correlations in the narrowed and deformed spinal canal.

Rekonstrukcje dwuwymiarowe i trójwymiarowe KT w ocenie urazowych zwężeń kanału kręgowego

Oceniono kliniczną wartość wtórnych rekonstrukcji dwupłaszczyznowych i przestrzennych tomografii komputerowej w ujawnianiu zwężeń urazowych kanału kręgowego i odłamów kręgosłupa. Materiał obejmuje 28 chorych leczonych z powodu urazu kręgosłupa, u których wykonano badania KT uzupełniane wtórnymi rekonstrukcjami. Zwiększyły one możliwości diagnostyczne osiowej tomografii komputerowej o ocenę morfologii zwężeń i odłamów kręgosłupa w dodatkowych płaszczyznach oraz umożliwiły określenie ich stosunków przestrzennych w zwężonym i zniekształconym kanale kręgowym.