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Value of magnetic resonance combined with dual-source spectral computed tomography in improving the clinical diagnosis and treatment efficiency of lumbar disk herniation

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SUMMARY

OBJECTIVE: This study aims to investigate the value of magnetic resonance combined with dual-source spectral computed tomography in improving the clinical diagnosis and treatment efficiency of lumbar disk herniation.

METHODS: Two hundred patients with lumbar disk herniation were enrolled. Magnetic resonance and dual-source spectral computed tomography were used to perform the diagnosis. The treatment efficiency and effectiveness of different diagnostic methods were determined.

Results: Eighty cases of lumbar disk herniation, 40 cases of prolapse, 33 cases of bulge, 27 cases of sequestration, and 20 cases of nodules were diagnosed based on pathologic evaluation. magnetic resonance detected lumbar disk herniation in 172 cases, with a detection rate of 86.00%. Dual-source spectral computed tomography detected 171 cases, with a detection rate of 85.50%. Magnetic resonance combined with dual-source spectral computed tomography detected 195 cases, with a detection rate of 97.50%. There was no significant difference between magnetic resonance and dual-source spectral computed tomography ($p>0.05$), but compared with the combined detection, there was a significant difference ($p<0.05$). One hundred and two cases of calcification, 83 cases of spinal cord deformity, 70 cases of intervertebral disk degeneration, 121 cases of intervertebral disk gas, 85 cases of dural sac compression, and 78 cases of nerve root compression were surgically demonstrated. The detection rate of diagnostic signs based on imaging by magnetic resonance or dual-source spectral computed tomography alone was lower than that of combined detection ($p<0.05$).

Conclusion: Magnetic resonance combined with dual-source spectral computed tomography can improve the diagnosis and treatment efficiency and effectiveness of lumbar disk herniation.

Keywords: Magnetic resonance. X-ray computed tomography. Hernia. Efficiency.

INTRODUCTION

Lumbar disk herniation is a common spinal surgical condition that frequently occurs in males and can be manifested as lumbago, sciatica, and other symptoms[1]. The main underlying mechanism of lumbar disk herniation is that the partial or complete rupture of the annulus fibrosus of the intervertebral disk accompanied by the nucleus pulposus protrusion beyond the normal boundary of the lumbar disk compresses the nerve, thus resulting in a constellation of symptoms[2]. Lumbar disk herniation is undoubtedly an inconvenience with respect to the activities of daily living and work for those affected. Currently, the early diagnostic modes of lumbar disk herniation include computed tomography (CT) and magnetic resonance (MR). Specifically, the direction of lumbar disk herniation and local tissue shadows can be clearly shown by

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imaging examinations, which help physicians detect the changes in lumbar motion from different positions and establish a definite diagnosis[3]. With the progress and development of imaging technology, multispectral CT has replaced the previous mode of blindly increasing the width of the detector, thus significantly improving the temporal resolution[4]. To compare the application effect of different diagnostic modes, a total of 200 patients with lumbar disk herniation between December 2018 – December 2019 were selected as research subjects to discuss and analyze the diagnosis and treatment efficiency of MR combined with dual-source spectral CT.

METHODS

Patients

A total of 200 patients with lumbar disk herniation who were admitted to our hospital between December 2018 – December 2019 were selected as the research subjects. There were 113 males and 87 females, ranging in age from 26–53 years (mean age, 44.5±18.5 years) with disease duration from 1–10 years (mean disease duration, 8.0±2.0 years). All patients were given dual-source spectral CT and MR diagnoses. All subjects participated voluntarily in this study with informed consent from their families and approval by the Ethics Committee of our hospital.

Inclusion and exclusion criteria

The inclusion criteria were as follows:

I. patients presenting typical lumbar disk herniation images on routine CT scanning,
II. patients accompanied by lumbago and symptoms of leg pain and numbness caused by nerve root compression for ≥3 months, and
II. patients without symptoms of lumbar spondylolisthesis or a lumbar compression fracture.

The exclusion criteria were as follows:

I. patients with severe osteoporosis;
II. patients with giant intervertebral disk protrusion or significantly reduced muscle strength;
III. patients with liver, kidney, cardiovascular, or cerebrovascular disease;
IV. patients with rheumatoid arthritis, ankylosing spondylitis, or other spondylitis lesions; and
V. patients with lumbar tuberculosis or tumors.

Dual-source spectral CT diagnosis

A 64-row dual-source CT [SOMATOM Definition Flash; Siemens (China) Co., Ltd., Beijing, China] diagnostic instrument was selected for dynamic continuous scanning. Patients were assisted to assume a supine position, with a soft cushion placed under the sacrococcygeal region at a height of 25 cm. The pelvis was immobilized with a fixing band to maintain lumbar hyperextension, and the motion angle was stretched from an extension position of 20° to a flexed position of 20°. The patient was instructed to get trained before scanning, wherein the center line of the position should be consistent and the speed should be uniform in motion. Scanning parameters were set as follows: tube voltage, 80 kV; tube current, 110 mAs; layer thickness, 0.6 mm; and the rotation speed, 0.5 s/round. The function was reconstructed to 10; the L3–S1 lumbar disk spectral CT scan was performed first, with the obtained images transmitted to an Inspace workstation. The key where the optimal contrast image of the spinal cord near the lumbar protrusion site was located was acquired using the contrast-to-noise ratio. Matter was then separated to obtain single energy images and calcium- and water-based images to find the ideal protrusion area. Then, the core, center, and base of the lumbar disk protrusion with a diameter of 5 mm were measured, and the mean value was taken as the lumbar disk sample value. The content of water and calcium in the lumbar disk was measured, and the protrusion area was measured at the sagittal layer of the lumbar disk protrusion site.

MR diagnosis

A 1.5 T MR equipment (GE Medical Co., Wuhan, China) was selected as the examination instrument. The patient was instructed to be in a supine position, given a three-plane location. Sagittal SE T1 and T2 scans were performed in the lumbar region (Figures 1A and B). A one-layered scan was performed for most of the lumbar disks, and a three-layered scan was performed for a small part of the lumbar disks. All patients were then subjected to transverse and sagittal scans and, if necessary, a coronal scan (Figure 1C). Attention was paid to the changes in spinal stenosis and the lumbar disk signal and whether there was spinal cord compression, a dural sac, or a bulging lumbar disk.

Diagnostic criteria

The detection of patients with lumbar disk herniation by using different diagnostic modes was compared according to the results of the surgical pathology. Two imaging physicians with extensive experience in film reading were selected to evaluate the diagnostic results. The diagnostic standards for lumbar disk herniation were as follows:

I. the patient lost physiologic activity in the lumbar region, had spinal scoliosis, and had obvious tenderness near the affected vertebral region, and the lumbar activities were restricted;

II. the lumbar region was accompanied by a medical history of trauma, cold and damp exposure, and chronic strain;
III. there was muscular atrophy or dysesthesia in the innervation area of the lower limbs, and the patellar reflexes were absent; and
IV. the intervertebral disk was narrowed, and there was proliferation of osteophytes at the edge of the lesion[5].

Statistical analysis

All statistical analyses were carried out using SPSS17.0 software (SPSS Inc., Chicago, IL, USA). The enumeration data were presented as number and rate and were compared using χ^2 test. The measurement data were presented as mean±standard deviation and were compared using *t*-test. Furthermore, $p<0.05$ was considered as statistically significant.

RESULTS

Comparison of diagnosis results among MR, dual-source spectral CT, and combined detection

Among the cohort of patients, 80 cases of lumbar disk herniation, 40 cases of prolapse, 33 cases of bulge, 27 cases of sequestration, and 20 cases of nodules were detected by surgical pathologic evaluation. MR detected 172 cases of lumbar disk herniation, with a detection rate of 86.00%. Dual-source spectral CT detected 171 cases of lumbar disk herniation, with a detection rate of 85.50%. MR combined with dual-source spectral CT detected 195 cases of lumbar disk herniation, with a detection rate of 97.50%. There was no apparent difference between MR and dual-source spectral CT in detecting lumbar disk herniation, and the difference was not statistically significant ($p>0.05$). However, there was a statistically significant difference when MR or dual-source spectral CT was compared with the combination of MR and dual-source spectral CT ($p<0.05$) (Table 1).

Comparison of diagnostic signs among MR, dual-source spectral CT, and combined detection

Among the cohort of patients, 102 cases with calcifications, 83 cases with spinal cord deformities, 70 cases with intervertebral disk degeneration, 121 cases with intervertebral disk gas, 85 cases with dural sac compression, and 78 cases with nerve root compression were detected during surgery. The detection rate of spinal cord deformities and intervertebral disk deformation by MR was higher than that by dual-source spectral CT, but the detection rate of calcifications and intervertebral disk gas by MR was lower than that by dual-source spectral CT. The detection rate of diagnostic signs based on imaging by MR or dual-source spectral CT alone was lower than that by combined detection; there was an apparent difference between any two groups, and the difference was statistically significant ($p<0.05$) (Table 2).

DISCUSSION

Lumbar disk herniation primarily occurs due to lumbar disk degeneration and partial or complete rupture of the annulus fibrosus accompanied by the nucleus pulposus protrusion, which stimulates and compresses the nerve roots and cauda equina, thus causing symptoms such as lumbago, lumbar and leg pain, lower limb numbness, or sciatica[6]. Lumbar disk herniation is one of the particularly common spinal degenerative diseases in clinical practice. As the aging trend of the population has

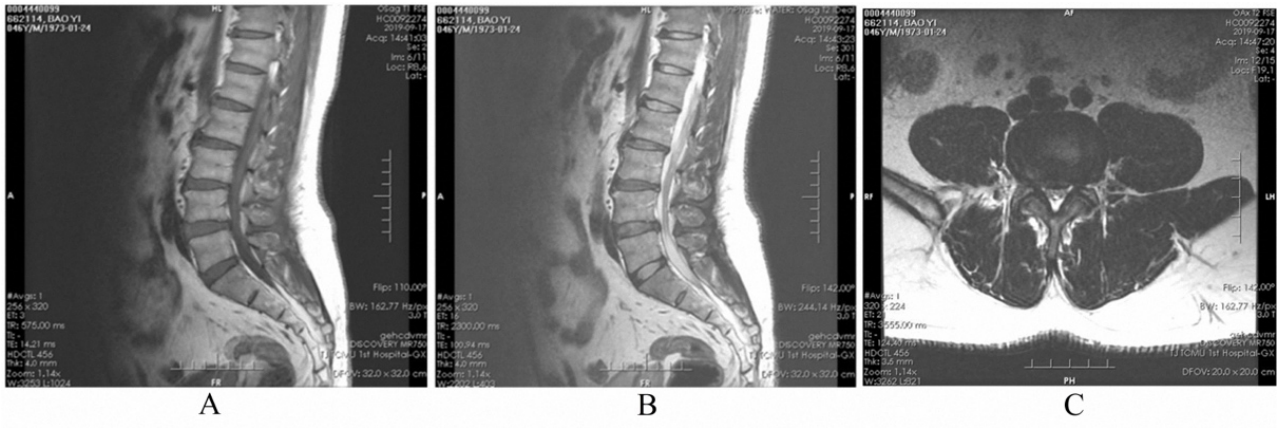

Figure 1. Representative sagittal T1-weighted image: (A) T2-weighted image; (B) and representative transverse T2-weighted image; (C) of the lumbar region by using magnetic resonance scanning obtained from a 46-year-old patient.

intensified in recent years, the incidence of lumbar disk herniation has gradually increased. Factors such as age, damage accumulation, pregnancy, and heredity are all risk contributors for lumbar disk herniation[7]. Bending, lowering the head, or sitting for a long time, strain accumulation, and exogenic action can cause rupture of the annulus fibrosus and backward protrusion of the endplate[2]. With an increase in age, the intervertebral disks gradually degenerate and the water content of the nucleus pulposus and annulus fibrosus decreases, which causes the loss of elasticity and appearance of fissures in the nucleus pulposus and annulus fibrosus[8]. Patients in the early stage of lumbar disk herniation often present with lumbar and leg pain and numbness of the lower limbs, but these symptoms can progress to intermittent claudication and cauda equina syndrome as the degeneration progresses, causing a serious impact on activities of daily living and work.

Currently, clinical examinations utilize lumbar X-ray plain films, CT, MR, and other imaging modes, but X-ray plain films have low specificity and sensitivity in the detection of lumbar disk herniation and thus have limited application in the clinical setting[9]. The MR diagnostic technique can show spinal nerve lesions, contour, and nerve root morphology, which demonstrates lesions in the lumbar disk and identifies other space-occupying lesions in the spinal canal[10]. The CT diagnostic mode can help physicians identify bulges, prolapse, protrusion, and other conditions indicative of lumbar disk herniation. In some cases, facet joint hyperostosis, vertebral hyperplasia, calcifications, and thickening of ligamentum flavum can be demonstrated; however, nerve root compression is more difficult to demonstrate by CT[11]. Clinical studies have reported that the routine CT has a lower detection rate for far lateral lumbar disk herniation, so the dual-source spectral CT based on the progress and development of routine CT has been widely used. Dual-source spectral CT can fully show different matters by adjusting the keV and, compared with the routine CT mode, optimize the signal-to-noise ratio, thus clearly demonstrating nerve root compression and intervertebral facet joint compression[12].

In this study, all patients had MR or dual-source spectral CT examinations alone or in combination. There was no significant difference between MR and dual-source spectral CT in the detection rate of lumbar disk herniation and clinical imaging signs, respectively, but their combination significantly improved the detection rate and showed no significant difference with surgical findings. It is concluded that CT scan, as an important method for clinical auxiliary diagnosis of lumbar

Table 1. Comparison of diagnosis results among magnetic resonance, dual-source spectral computed tomography, and combined detection.

Diagnostic mode	MR	Dual-source spectral CT	Combined detection
Case number (n)	200	200	200
Prolapse [n(%)]	34(17.00)*	33(16.50)*	38(19.00)
Bulge [n(%)]	28(14.00)*	27(13.50)*	32(16.00)
Protrusion [n(%)]	71(35.50)*	72(36.00)*	78(39.00)
Sequestration [n(%)]	23(11.50)*	22(11.00)*	27(13.50)
Nodules [n(%)]	16(8.00)*	17(8.50)*	20(10.00)

*p<0.05 compared with combined detection. MR: magnetic resonance; CT: computed tomography.

Table 2. Comparison of diagnostic signs among magnetic resonance, dual-source spectral computed tomography, and combined detection.

Diagnostic mode	MR	Dual-source spectral CT	Combined detection
Case number (n)	200	200	200
Calcification [n(%)]	85 (42.00)*	93 (46.50)*[a]	100 (50.00)
Spinal cord deformity [n(%)]	76 (38.00)*	72 (36.00)*[a]	81 (40.50)
Intervertebral disk deformation [n(%)]	63 (31.50)*	57 (28.50)*[a]	70 (35.00)
Intervertebral disk gas [n(%)]	101 (50.50)*	113 (56.50)*[a]	120 (60.00)
Dural sac compression [n(%)]	76 (38.00)*	77 (38.50)*	84 (42.00)
Nerve root compression [n(%)]	66 (33.00)*	65 (32.50)*	76 (38.00)

*p<0.05 compared with combined detection; [a]p<0.05 compared with magnetic resonance. MR: magnetic resonance; CT: computed tomography.

disk herniation, has a fast scanning speed, and the dual-source CT further scans the different lumbar flexion and extension activities in a four-dimensional (4D) mode to improve the diagnostic rate. Of note, there is a relatively small amount of radiation exposure with the dual-source CT scan[13]. MR is helpful to determine the specific site and severity of the lesion in all directions and in multiple sequences, with high resolution and safety (i.e., no radiation exposure), but MR shows lower sensitivity in the detection of hyperostosis, ligament calcification, and other conditions[14]. The combination of MR and dual-source spectral CT has full advantage of the synergistic effect to visually and clearly depict lumbar disk herniation from a dynamic perspective, thus providing a more objective and reasonable reference for clinical treatment strategies.

CONCLUSIONS

MR combined with dual-source spectral CT can improve the diagnosis and treatment efficiency and effectiveness of lumbar disk herniation, and it is worth popularizing and application in clinical practice. This study still has some limitations. The sample size of this study is relatively small. Larger sample will make the results more convincing. More subjects should be enrolled in the future studies for obtaining more satisfactory results.

AUTHORS' CONTRIBUTIONS

JW: Conceptualization, Writing – review & editing. **LW:** Data curation, Formal Analysis. **CC:** Data curation, Formal Analysis. **YL:** Writing – original draft. **HL:** Writing – original draft.

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