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Exploration on evaluation effects of CT and low-field MR on the outcomes of patients undergoing microendoscopic discectomy via posterior interlaminar approach

Qingqiang Meng[a], Li Sun[b], Yan Sun[c]

Abstract

To observe and compare the advantages and values of CT and low-field MR in the evaluation of the outcomes of patients, undergoing microendoscopic discectomy via posterior interlaminar approach. A total 160 examinees screened by inclusion and exclusion criteria were enrolled, and a total of 800 intervertebral disks were involved. The first-echo image was collected by low-field MR; the effect of microendoscopic discectomy via posterior interlaminar approach was evaluated by CT, and the structural integrity distribution statuses of osseous endplate , cartilage endplate and fibrous ring were evaluated ; different degrees of intervertebral disc degeneration were analyzed by T2WI sequence, and the structural integrities of cartilage endplate, fibrous ring and osseous endplate were evaluated using low field double echo MR. The correlation among various indexes was analyzed, and the correlation analysis of the two categorical variables was conducted using rank correlation analysis. Low field MR sequence showed no significant differences in the structural integrities of osseous endplate and cartilage endplate among patients without low back pain symptoms (p > 0.05), the proportion of partial structure disappearance was the highest, and the proportion of complete structure disappearance was the lowest; while there was a significant difference in the structural integrity of fibrous ring, of which, the proportion of complete structure disappearance in low back pain group was higher , and the proportion of partial structure disappearance in non-low back pain group was higher, and there was a significant difference between the two groups (p > 0.05).The proportions of intact structure indicated no significant difference between the two groups (p >0.05). CT revealed no significant differences in the degree of postoperative intervertebral disc degeneration between the patients with or without low back pain (p > 0.05). There was no correlation between low back pain and intervertebral disc degeneration. Low field MR showed that the presence or absence of low back pain had correlation with the structural integrity, distribution, T2WI sequence and different degeneration degrees (p < 0.05). The presence or absence of low back pain has little correlation with the degree of postoperative intervertebral disc degeneration on T2WI. Low field MR showed that the structural integrities of fibrous ring and cartilage endplate are positively correlated with different degrees of intervertebral disc degeneration.

Keywords: CT; low field MR; lumbar transverse section; postoperative intervertebral disc degeneration

Introduction

Intervertebral disc endoscope is a minimally invasive surgical system specially designed for lumbar disc herniation. In 1982, it was first reported that the nucleus pulposus was removed by an endoscope, which was called the discoscope. In the 1990s, the technologies of percutaneous foraminal endoscopic lumbar discectomy and posterolateral transforaminal endoscopic lumbar discectomy (PELD or PED) were also successfully introduced into China [1]. In recent years, with the continuous progression of

[a] Department of medical imaging, BinZhou Second People's Hospital, Binzhou, Shandong, 256800, China
[b] Department of cardiology, BinZhou Second People's Hospital, Binzhou, Shandong, 256800, China
[c] Department of Extrathoracic Urology, BinZhou Second People's Hospital, Binzhou, Shandong, 256800, China
Correspondence author: Dr. Yan Sun, Department of Extrathoracic Urology, BinZhou Second People's Hospital, No. 339, Fudian Road, Zhanhua District, Binzhou, Shandong, 256800, China. Tel: +86-0543-7322488; Fax: +86-0543-7322488; E-mail: yuebugou3@163.com.

technologies, microendoscopic discectomy (MED) has been improved continuously, it includes the expandable endoscope that can enter the intervertebral disc through inter-laminar space to check the status of nucleus pulposus resection, and a few of articles mentioned the relief of lateral recess stenosis [2]. However, there is no special report on posterior endoscopic discectomy for lumbar spinal stenosis. In terms of the therapeutic effect of clinical endoscopic discectomy on lumbar disc herniation, a unified opinion is that this therapeutic effect is satisfactory [3]. Degenerative changes are the main cause of lumbar spinal stenosis [4]. At present, the pathogenesis of the lumbar spinal stenosis has not been fully elucidated, but it is generally believed that the intervertebral disc degeneration is an important factor leading to low back pain [5]. Before CT and MR were applied in clinic practice, lumbar discography was the main method for the morphological diagnosis of intervertebral disc lesions, especially the only method for the diagnosis of internal disc disruption [6]. With the application of CT and MR in clinic practice, the morphological diagnosis of lumbar intervertebral disc no longer depends on the discography, especially the MR T2W I images can be considered as signs of internal disc disruption, but its specificity and sensitivity are low [7]. 25% asymptomatic patients can also have high-intensity zone (HIZ), and 80% symptomatic patients have HIZ. Based on this phenomenon, MR cannot be used as an independent diagnostic evidence of internal disc disruption, low-field MR systems are meanwhile rare in clinical imaging. MRI systems with a lower field strength provide a reduced signal-noise ratio (SNR) and spectral differentiation [8]. CT discography can clearly show extent of intervertebral disc degeneration and degree of fibrous ring rupture after operation, and the shape of the nucleus pulposus can also be shown by 3D reconstruction. The sensitivity and specificity of CT in diagnosing internal disc disruption are higher compared with MR, interbody fusion is performed with bone grafts or interbody spacers, and may be supplemented with anterior cervical plating. Compressive pathologies at the vertebral body level may be addressed by simultaneous corpectomy. Postoperatively, low-field MR plays an integral role in routine screening of asymptomatic individuals, fusion assessment and evaluation of complications [9]. In this study, based on the display results of the cartilage endplate by low field MR, the fibrous ring, cartilage endplate and osseous endplatebe were displayed better, the tissue contrast in junctional zone between the vertebral body and the intervertebral disc can be increased; thus, the postoperative intervertebral disc degeneration can be well analyzed by imaging, and the influencing factors of the double-echo sequence in low field MR of cartilage endplate, upper fibrous ring and osseous endplate morphologies can be further analyzed to explore the correlation between these imaging characteristics and degree of postoperative intervertebral disc degeneration.

Materials and methods

From June 2018 to November 2019, the database of our hospital was retrospectively analyzed 160 patients with low back pain who received ineffective conservative treatment in our hospital and had postoperative intervertebral disc degeneration or herniation indicated by imaging examination were collected. All subjects signed the informed consent forms before operation. Discography was performed by two interventional experts with rich experiences. Inclusion criteria: The patients aged between 20-60 years, without gender preference; CT showed that at least one lumbar disc had varying degrees of degeneration. Exclusion criteria: MRI scan contraindications: Patients with MRI scan contraindications such as metal implants, internal pacemakers, stents, early pregnancy, birth control rings were excluded, and the patients with a previous history of infection, metabolic or hematological disease, or suspected tumor or endocrine dysplastic bone disease (renal bone disease, osteoporosis, abnormal parathyroid function, etc.) were also excluded. In this study, 160 patients (including 80 females and 80 males, aged 21-57 years old with an average age 43.25±8.69 years) were strictly selected and divided into two groups according to whether low back pain existed: non-pain group: there were a total of 80 patients, including 40 females and 40 males, the patients aged 21-57 years ,with an average age of 43.23±8.83 years; pain group: there were a total of 80 patients, including 40 females and 40 males, the patients aged 22-56 years, with an average age of 45.57±7.65 years.

Surgical method

A 1.8-2.0 cm long skin incision was made at the corresponding stenosis segment to establish a working channel to reach the interlaminar space. Through the characteristics of moving up, down, left and right and changeable angle of the intervertebral disc, the vertebral plate behind the outlet of the nerve root was excised, the thickened ligamentum flavum was excised at the back of the transitional part within the nerve root canal, the

inner edge of hyperplastic and cohesive articular process, the upper edge of the vertebral plate and the transitional part of the superior articular process were excised, so as to relieve the posterior bone and soft tissue compression; the nerve root was retracted, the osteophyte in the posterior edge of the vertebral body was flattened with a punch, and it was decided to remove the bulged intervertebral disc according to the movement degree of the nerve root and the dural sac pulsation to relieve the pressure from the front area.

Exmation method

Under the guidance of C-arm, percutaneous discography was performed. CT examination was carried out within 15 minutes after discography, the presence or absence of pain and the degree of pain were observed and recorded during discography. MR examination was carried out within 1 hour. Axial CT scan was used for patients without intervertebral disc prolapse (slice thickness 3 mm, inter-slice spacing 3 mm, tube current 110 110mAs, tube voltage 130 KV, bone window reconstruction, rotation time 3s/circle,convolution kernel reconstruction 70 s) The patients with intervertebral disc prolapse underwent L3-S1 spiral CT scanning (tube voltage 130 KV, slice thickness/collimation configuration 1 mm, bone window reconstruction, convolution kernel reconstruction 70 s, tube current 110 mAs, rotation time 0.8 s / circle, bed entry distance 9 mm, reconstruction interval 0.8 mm, reconstructed slice thickness 1.25 mm), spinal sagittal plane reconstruction and intervertebral disc plane tomographic reconstruction were carried out.

MR examination: Sagittal SE sequence T1WI (matrix 256×256, 9 slices, slice thickness 5 mm, inter-slice spacing 2 mm, acquisition time 4.3 min) and T2WI (matrix 256×256, 3 slices for each intervertebral space, a total of 3 intervertebral spaces, slice thickness 4 mm, inter-slice spacing 1 mm) and T2WI (matrix 256×256, 3 slices for each intervertebral space, a total of 3 intervertebral spaces,slice thickness 4mm , inter-slice spacing 1mm and acquisition time 7.2 min).

CT image analysis

The imaging sign of degeneration of each intervertebral disc segment was observed and evaluated and then judged according to the median sagittal images; the most widely used Pfirmann classification method was adopted [10], and all observations were made independently by two physicians in this study.

Low field MR image analysis

Low field MR was used to analyze cartilage endplate, fibrous ring and vertebral endplate. The structural integrity status was divided into intact structure, partial structure disappearance and complete structure disappearance; during the judgment of structural integrity, it was required that the structural signals observed at each sagittal plane were continuous without interruption. According to the upper and lower distribution of the structural integrity of each intervertebral disc, the structural integrity was divided into intact structure on both sides, intact structure on one side, incomplete structure on both sides [11]. Two doctors conducted independent observation to evaluate the imaging signs of degeneration at each intervertebral disc segment and made statistical analysis.

Statistical analysis

SPSS23.0 software system was used for all data analysis. Chi square test was used to compare the structural integrity and integrity distribution of cartilage endplate, fibrous ring and osseous endplate among different degrees of postoperative disc degeneration, and the counting data was presented as percentage (%). The correlation analysis of the two categories of variables was conducted using rank correlation analysis, $p < 0.05$ indicated a obviously significant difference.

Results

CT and low field MR imaging analysis of the structural integrity and integrity distribution of the fibrous cartilage endplate and vertebral endplate

According to the serious side, the integrity status can be divided into intact, partially disappeared and completely disappeared statuses. The morphological integrity analysis of all fibrous rings, vertebral endplates and cartilage endplates showed that the degeneration severities of upper and lower cartilage endplates, fibrous rings and vertebral endplates were different, as shown in Figure 1.

CT analysis of the structural integrity proportions of fibrous ring, vertebral endplate and cartilage endplate

CT imaging results revealed that the proportion of complete structure disappearance was the lowest, and the proportion of partial structure disappearance was the highest. The distribution of structural integrity in all subjects included in the experiment was shown in Table 1.

Low field MR analysis of the integrity distribution proportion of fibrous ring, vertebral endplate and cartilage endplate

Low field MR imaging of structural integrity showed that the proportion of complete structure disappearance was the highest and the proportion of partial structure disappearance was the lowest in cartilage endplate, fibrous ring and osseous endplate in total subjects, as shown in Table 2.

Relationship between the degree of intervertebral disc degeneration and the clinical symptom grouping after operation

All intervertebral discs were graded according to Pfirrmann grading method, and analyzed by CT combined with low field MR imaging. The distribution of each grade was shown in Table3.

Analysis of the correlation between the structural integrity of the fibrous ring and the grade of postoperative disc degeneration in each group divided according to clinical symptoms

The imaging analysis of correlation between the structural integrity of fibrous ring and the distribution of intervertebral disc degeneration after operation was shown in Table 4 and Table 5 respectively. According to the clinical symptoms, the patients were divided into two groups: pain group and non-pain group. The proportions of different structural integrities of fibrous rings under different grades were comparatively analyzed between two groups, and the differences were statistically significant. the proportion of fibrous rings with partial structure disappearance was the highest in the grade 3-4 intervertebral discs in the pain group, and the intervertebral discs with different degrees of degeneration were related to the integrity of fibrous rings. The proportion of fibrous rings with partial structure disappearance was the highest in the grade 3-5 intervertebral discs in the no-pain group; the proportion of fibrous rings with complete structure disappearance was the highest in the grade 5 intervertebral discs in the pain group. The proportion of fibrous rings with intact structure was the highest in the grade 1-2 intervertebral discs in both groups. ⍰⍰

Discussion

Discoscopic surgery is a minimally invasive microscopic technique, which usually refers to the implementation of surgical procedures assisted by visual catheterization under the microscopic system [13]. Compared with thoracoscopy and laparoscopy technologies, the intervertebral discoscopy technology started relatively late, and its development still needs to be improved. Since the 1980s, with the development of micro technology, surgical instruments and optical fiber technology, the development of intervertebral discoscopy technology has also been achieved. Scholars at home and abroad have also been promoting the application of endoscopy technology in spine surgery. In 1982, the nucleus pulposus resection was performed firstly under an intervertebral endoscope, which was called discoscope, the study also reported that the lumbar intervertebral disc was resected through the posterolateral interlaminar space pathway, and the operation was successfully performed. In the 1990s in China, advanced foreign technologies were also introduced, which successfully carried out lateral intervertebral space endoscopic lumbar disc excision, and the endoscopic transforaminal lumbar disc excision was continuously promoted to clinical practice [14]. In the early 1990s, posterolateral transforaminal endoscopic lumbar discectomy (PELD or PED) and transforaminal endoscopic lumbar discectomy were also successfully applied in clinic practice, but their technical requirements were high [15]. In recent years, the microendoscopic discectomy （MED） via posterior interlaminar approach) has been gradually carried out in Europe and the United States, the discoscope is a new device developed on the basis of this technology [16]. The microendoscopic lumbar discectomy via posterior interlaminar approach can reduce the pressure during operation, remove the free nucleus pulposus and bone lesions, enhance the surgical operability, and greatly improve the excellent and good operation rate[17]. It has been reported that the excellent and good rate of the microendoscopic lumbar discectomy via posterior interlaminar approach is 93.8% [18]. However, due to the lack of long-term follow-up data in current research reports, it is highly praised only by spine surgeons based on its good clinical efficacy. Due to the lack of specificity in the current imaging diagnosis, it may not be possible to make an accurate diagnosis and further conduct an effective comparison of surgical prognosis and outcome [19]. The further development of imaging may be helpful in determining the prognosis of the microendoscopic lumbar discectomy via posterior interlaminar approach.⍰⍰

We can see in clinic that there are many changes in imaging results of patients after discectomy, and the disease continues to develop, so there often occur phenomena such as annular tear, decreased height of intervertebral space, decreased intervertebral disc signal, intervertebral

disc vacuum drafts, intervertebral disc calcification, ligament degeneration, osteophyte formation, spinal canal stenosis, changed bone marrow, disordered intervertebral disc arrangement. However, CT is a limited imaging technique for the observation of spinal cord injury. Although it can observe the broken fragments of spinal cord, the time of intervertebral disc herniation, and the swollen ligament compression of intervertebral discs, it cannot directly show the situation of spinal cord injury, and its effect is not good when there is no morphological change in the intervertebral disc and spinal cord injury [20]. With the continuous development of imaging technology, more high-resolution and highly sensitive imaging technologies have been introduced for post-discectomy evaluation. Low field MR can clearly show the spinal cord injury without any shape change, and has a high sensitivity to the changes in intervertebral disc signals, and it is increasingly used in the imaging and diagnosis of diseases in bone and joint system [21]. The present study also revealed that the cartilage endplate and its histopathological manifestations were relatively consistent in calcification and non-calcification. The bone samples of non-calcified cartilage endplate, intact intervertebral disc and calcified cartilage endplate showed medium to high signals in two layers in the area near the cartilage endplate. The morphological changes of cartilage endplate can be classified as signal loss. The calcified and non-calcified cartilage endplates are consistent with their histopathological features. There is also has a good consistency in abnormal cartilage endplate and vertebral endplate. The results of this study showed that the proportion of partial structure disappearance in non-pain group was higher, the proportion of complete structure disappearance in the pain group was higher, the difference was statistically significant ($p < 0.05$), The proportions of both were compared in the intact structure group, the difference was not statistically significant. CT examination results showed that there was no significant difference in the proportion of the degree of postoperative disc degeneration between the pain group and non-pain group, and there was no correlation between degenerative intervertebral disc and low back pain. Low field MR revealed that the presence or absence of low back pain was correlated with the structural integrity, distribution, T2WI sequence and different degeneration degrees. CT couldn't distinguish between painful and non-painful intervertebral discs, while low field MR had a high sensitivity to painful intervertebral discs, and a high sensitivity to the correlation of the structural integrity of fibrous ring and its integrity composition ratio with the pain, among which, there were a statistical obvious difference in the composition ratio of complete structure disappearance and partial structure disappearance of fibrous rings, and the diagnosis effect of low field MR was better. Combined examination of CT and low field MR could show structural integrity distribution of cartilage endplate, fibrous ring and osseous endplate, which had a positive correlation with the postoperative intervertebral disc degeneration, indicating that the postoperative intervertebral disc degeneration was correlated with the changes in the structural integrity distribution of cartilage endplate, fibrous ring and osseous endplate. Our study selected samples from retrospective sources, this has not been confirmed in prospective clinical studies and will be discussed in future studies.

In conclusion, through the low field MR for direct display of cartilage endplate, the morphological changes in cartilage endplate, fibrous ring and osseous endplate can be better observed, the morphologies of cartilage endplate, fibrous ring and osseous endplate can be directly imaged, low field MR has a better display effect especially on the changes in degenerative region and annular tear compared with the nucleus pulposus signal in the provious conventional sequence, and decreased degenerative intervertebral disc signal is more suggestive, and the results of this study suggest that low field MR has a greater advantage in the rehabilitation assessment of patients after discectomy compared with CT imaging , the combined use of low field MR and CT has a better evaluating effect on the outcome of microendoscopic discectomy via posterior interlam inar approach.

Disclosure of conflict of interest

None.

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Table and Figure legends

Table 1. **CT analysis of structural integrities of cartilage endplate, fibrous ring and vertebral endplate**

	Cartilage endplate（800）	Fibrous ring（800）	Vertebral endplate（800）
Completely disappeared	34（8）	74（18）	40（10）
Partially disappeared	498（124）	378（94）	468（118）
Intact	268（68）	348（88）	292（72）

Table 2. **Low field MR analysis of the integrity distribution proportion of fibrous ring, vertebral endplate and cartilage endplate**

	Cartilage endplate（800）	Fibrous ring（800）	Vertebral endplate（800）
Completely disappeared	578（120）	428（106）	448（112）
Partially disappeared	10（6）	24（6）	60（14）
Intact	268（68）	348（88）	292（74）

Table 3. **Relationship between the degree of intervertebral disc degeneration and clinical symptoms after operation**

	Non-pain（120）	Pain（680）	Summation	χ^2	*P*
Grade 1	16（18）	60（26）	76（20）		
Grade 2	40（50）	168（66）	208（52）		
Grade 3	34（64）	248（56）	282（70）	1.275	0.097
Grade 4	22（34）	118（22）	140（36）		
Grade 5	8（26）	86（14）	94（24）		

Table 4. **Correlation analysis between the structural integrity of fibrous ring and the grade of postoperative intervertebral disc degeneration in each group divided according to clinical symptoms**

Integrity	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	χ^2	Correlation coefficient	*P*
Completely disappeared	0（0）	4（4）	10（4）	10（18）	48（112）			
Partially disappeared	4（14）	20（24）	158（128）	88（150）	36（84）	15.248	0.678	0.000
Intact	56（186）	144（172）	80（64）	20（34）	2（4）			

Table 5. **Structural integrity of fibrous ring in postoperative non-pain group and the grade distribution of postoperative intervertebral disc degeneration in non-pain group**

Integrity	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	χ^2	Correlation coefficient	*P*
Completely disappeared	0（0）	0（0）	0（0）	0（0）	2（50）			
Partially disappeared	2（24）	18（90）	24（142）	22（200）	6（150）	20.678	0.575	0.000
Intact	14（176）	22（110）	10（58）	0（0）	0（0）			

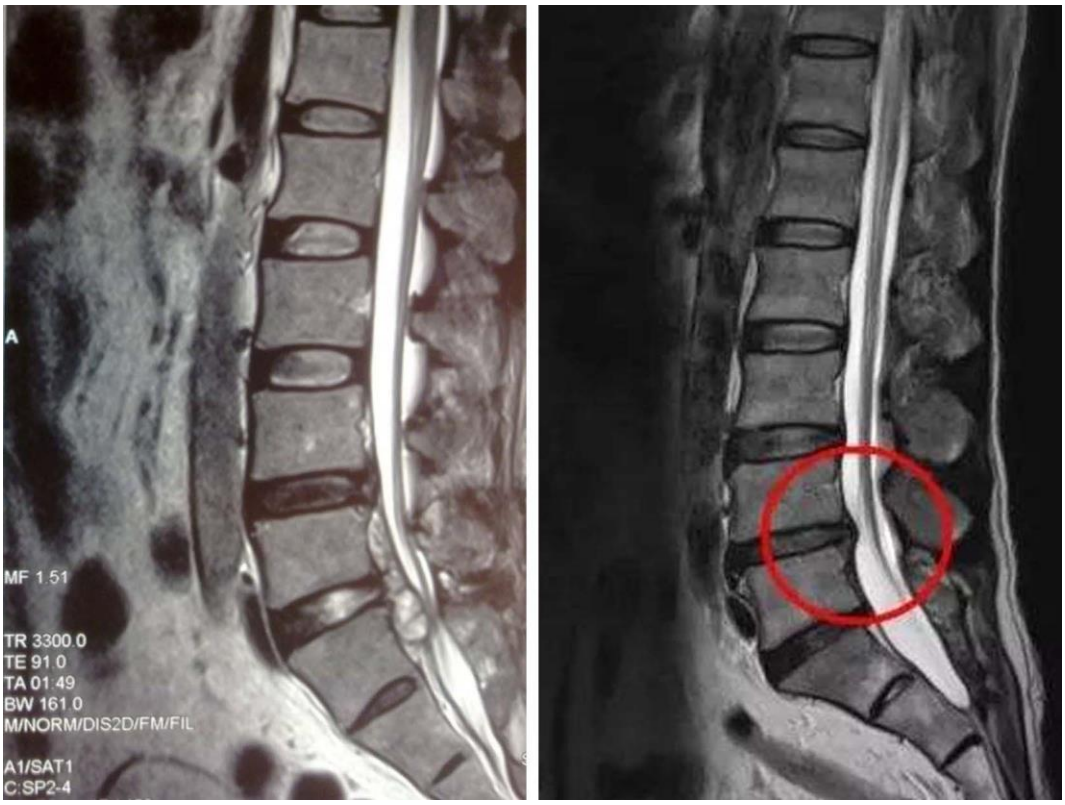

Figure 1. **CT and low field MR imaging of fibrous ring, vertebral endplate and cartilage endplate integrity and integrity distribution after operation.**