

## **The reliability of MRI diagnosis of anterior and posterior longitudinal ligament of lower cervical spine.**

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### **Abstract**

**The use of medical imaging technology MRI can provide the basis for the clinical diagnosis of anterior and posterior longitudinal ligament of the lower cervical spine, help to develop a reasonable treatment plan, and reduce the incidence of missed diagnosis and misdiagnosis. Therefore, the study on the reliability of MRI detection technology in the anterior and posterior longitudinal ligament injury of the lower cervical spine is very important for clinical diagnosis and treatment. Retrospective analysis of 53 cases of anterior and posterior longitudinal ligament injuries caused by physical exercise in a hospital from February 2010 to April 2015 was conducted. On the one hand, preoperative imaging diagnosis evaluation results and surgical exploration results were comparatively analysed. On the other hand, the differences of the diagnostic results under three different criteria of T1D, T2L and T2T were comparatively analysed, in order to carry out the consistency and reliability of MRI test in the diagnosis. By analysing the results, it can be seen that the deviation between the MRI and the results of the operation is small, and it has a good consistency. When the T2T standard is used for analysis, the specificity, sensitivity, accuracy, negative and positive predictive values are all higher. According to the study results, in the diagnosis of the anterior and posterior longitudinal ligament of the lower cervical spine, the T2T standard is used to detect the MRI image, which can be widely used in clinical practice.**

**Keywords:** Lower cervical spine, Ligament, MRI, Sports injury.

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### **Introduction**

With the continuous development of human society and more needs of people health, sports activities are more and more in-depth into people's lives. When people in the physical exercise, it may be because of lack of adequate guidance or not master the correct way of exercise, resulting in damage to the exercise process [1]. On the other hand, in order to pursue better sports performance, mistake and accident will occur because of the high intensity of exercise or movement difficulty of athletes in daily training or in competitive sports. When the force acts on the cervical spine to produce impact, compression, or other forces, it may cause severe injury of cervical vertebrae, including vertebrae displacement, fracture and ligament injury, and severe disruption of the nerve conduction may lead to paralysis of the limbs, breathing difficulties, and even life-threatening [2]. The stability of the spine, to a large extent, depends on the integrity of the structure of the bone and surrounding soft tissues. As the spinal endogenous stability factors, ligament and intervertebral disk have a very important role. Too much extension or flexion of the cervical spine may cause injury to the ligaments.

The clinical diagnosis of the injury of the front and back ligaments is very important. If the misdiagnosis occurs, it may

be due to improper selection of treatment options and make the patient appears cervical instability, long-term chronic pain in the neck, neurological symptoms and other long-term complications [3]. Therefore, the diagnosis of the anterior and posterior longitudinal ligament injury of the lower cervical spine by medical imaging technique is very helpful to make the clinical treatment plan. At present, the clinical medical imaging techniques are X-ray, Computed Tomography (CT), MRI and so on.

Some medical image modality is compared. X-rays are used to take an image or photograph and is advances by fast and easy method of imaging. CT is a method of examining body organs by scanning them with X-Rays and using a computer to consider a series of cross-sectional image. It is advances because tomographic acquisition eliminates the superposition of images of overlapping structure but for per examination high dose is used. Different imaging detection techniques are different, and for the diagnosis of ligament and similar soft tissue, the results of MRI detection are better. MRI has many advantages such as useful for scanning and detecting the abnormalities in soft tissue of organs like brain or heart, it is safe because it do not use radiations and the information's about blood circulation and detects the problem related to that.

Though MRI has these many advantages, it has some drawbacks such as it produce loud noise while processing and consumes high electric current so that the MRI scanner is very expensive.

In previous studies, it is difficult to accurately diagnose the injury of ligament by X-ray or CT technology, which is not conducive to the development of clinical treatment plan and treatment effect. And there are three different standards of T1D, T2L and T2T for the diagnosis of ligament injury, which are different in the diagnosis. Transverse or Spin-Spin T2 relaxation time is a fast in measurement, robust in solid/Liquid water separation but it is distorted by diffusion in internal gradients. Longitudinal or Sin-Lattice T1 relaxation time is intensive to diffusion in internal gradients but slower measurement and averages over long timescale. Through a retrospective analysis of the cases of anterior and posterior longitudinal ligament injury of the lower cervical spine caused by sports related activities from 2015 to 2010 in a hospital, it is very important to study the reliability and consistency of MRI detection technology in the diagnosis of MRI.

## Application of MRI Imaging Technique in the Diagnosis of Anterior and Posterior Longitudinal Ligament of the Lower Cervical Spine

### *Lower cervical anterior and posterior longitudinal ligament injury*

Cervical vertebra refers to the site between the body thoracic and the head. According to the anatomical structure, it is composed of seven parts. Its flexibility is strong, the frequency in the physical activity is higher, and the load is heavy [4]. The ligaments and intervertebral discs are connected with the vertebral body, the protrusion, and the vertebral arch of the cervical vertebrae. Ligaments mainly include the Anterior Longitudinal Ligament (ALL) and Posterior Longitudinal Ligament (PLL), the auxiliary ligament contains the ligament (ISL) and the Yellow Ligament (LF), and the specific structure is shown in Figure 1. The anterior and posterior longitudinal ligament is relatively thin, the posterior longitudinal ligament has toughness, and the anterior longitudinal ligament is relatively weak [5]. Under physiological load, the position of each vertebral body is normal, the nerve root injury or stimulation, deformity or pain will not happen. The main function of the ligament is to make the vertebral activity can be maintained, so that in the exercise process, it can absorb energy to achieve the protection of the spinal cord [6]. In recent years, more and more people pay attention to the stability of the soft tissue. As a function of the coordination of the ligament, the stability of the motion segment plays a key role. Among them, ALL and PLL are the important components of the anterior and middle columns. When the two are broken by trauma, it will cause cervical instability, if no timely and correct diagnosis; it may seriously damage the human nervous, and bring sustained severe pain for patients [7].

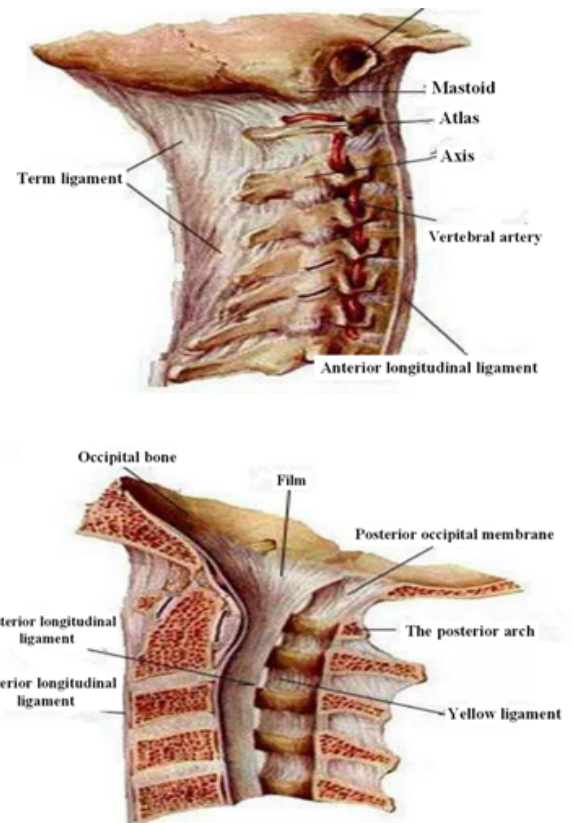


Figure 1. Schematic diagram of cervical spine anatomy.

In sports, as the head and neck may be subjected to backward violence, it will lead to injury of cervical spine cord because of excessive extension of the cervical spine. At the same time, it will be accompanied by soft tissue injury. Because in the X-ray and CT images, it is difficult to clearly see the vertebral fracture and dislocation, so the cervical spine injury is also referred to as no fracture and dislocation of cervical spine injury [8]. In the spine, the structure of the soft tissue directly affects the stability of the spine. When the anterior longitudinal ligament and the yellow ligament are injured, the stability of the spine will also be affected and needs to be treated with surgery. The main cause of ligament injury is the acute extension of violence. When the cervical spine is impacted by external forces, the posterior structure of the cervical spine is often the support point of the external force. The anterior longitudinal ligament and intervertebral disc will be affected by the first, resulting in the rupture of the ligament tear or intervertebral disc [9]. Due to the neck vertebrae is acted with the extension of compression force, the shear force acting on the dislocation site causes the rupture of the ligament and the rupture of the intervertebral disc, resulting in the separation tendency of anterior column, posterior column and middle column of vertebral body, and further fractures are separated, which can lead to the spinal canal decompression in an extreme time [10].

Dislocation of the lower cervical spine is often occurring in the C3-C7 segment. Clinical manifestations are the anterior dislocation and posterior dislocation of the lower cervical

spine, often accompanied by dislocation of the lower cervical spine and single/bilateral dislocation of the joint, and dislocation of the lower cervical spine dislocation is the most common [11]. In clinical practice, the compression stretch is relatively small, about 10%. According to the degree of injury, the dislocation of the joint is divided into 4 degrees. I: Sprain and damage are mainly concentrated in the yellow ligament, interspinous ligament and joint cyst, and it may cause serious subluxation; II is the unilateral dislocation, the dislocation of the joint capsule alone appears with tear, and with the phenomenon of articular process fracture; III is the bilateral dislocation, that is, there may be a fracture of the articular process, the posterior longitudinal ligament often fracture, and the longitudinal ligament is not affected; IV is a bilateral dislocation accompanied by the cervical spine dislocation, all ligaments are ruptured, and the vertebral artery may also be damaged [12]. Therefore, the anterior and posterior longitudinal ligament often happens in grade III injury and above. At this time, the overall damage of the cervical spine reflected is serious, which is a great threat to the health of the human body. In order to facilitate the diagnosis description, the ASIA motor function score method is often used. Specifically, the limbs are divided into 4 parts. Each part is composed of 5 muscles separately, the sum of the strength of the group is the score [13].

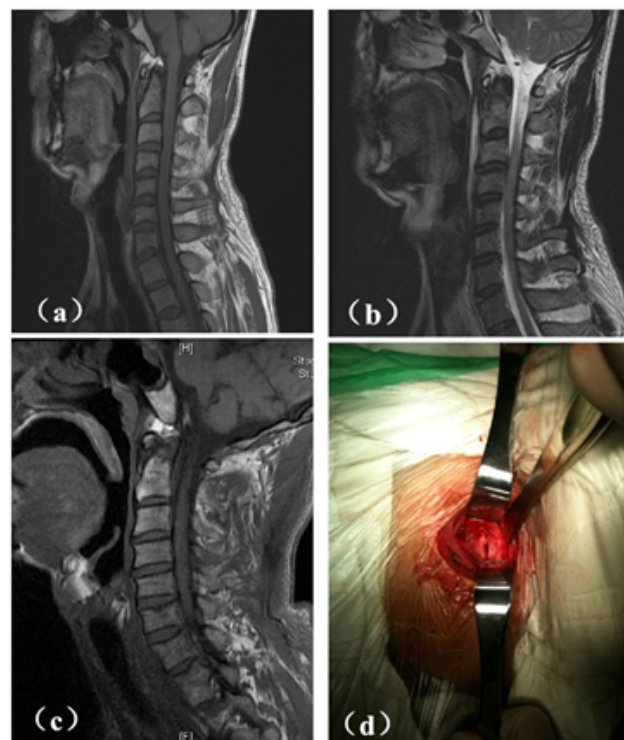
### **Application of MRI Imaging Technique in the Diagnosis of Anterior and Posterior Longitudinal Ligament Injury of Lower Cervical Spine**

Since 1960s, Magnetic Resonance Imaging (MRI) has been applied in medical diagnosis and treatment, which has achieved good clinical results. Because it does not radiate in the process of use, it will not cause trauma to the patient; At the same time, it has the characteristics of good soft tissue contrast, which can be used to reconstruct the image of cross section, sagittal plane and coronal plane according to the needs; During the examination, patients can accomplish image scanning without physical changes [14]. Because of these characteristics, MRI technology has become one of the conventional detection methods of cervical spine injury patients for imaging. The spinal ligament is a fibrous structure, and the MRI pulse sequence is a thin band signal region. In the study of ALL and PLL damage, researchers use the continuous medium of T1 weighted images or the strip of T2 weighted images, and irregular high signal to determine the ALL and PLL damage. When compared with X-ray and CT imaging, it can be more accurate for clinical diagnosis, and verify the correct rate of diagnosis combined with the anatomical structure of the actual damage to [15].

Cervical spine injury is one of the common causes of violence in the process of exercise, such as over flexion, extension, rotation and axial force load, it is easy to cause cervical injury. In sports, the most common is the cervical spine caused by injury violent collision of the football in the conflict, which is often accompanied by the injury of the anterior and posterior longitudinal ligament. For medical image detection of cervical

spine injury, the X-ray and CT technology is easy to cause missed diagnosis. The missed diagnosis may cause that the clinical diagnosis of the patient's condition is not allowed to judge. Therefore, the development of a treatment plan is not suitable, which can lead to treatment delay, more serious cases, and may cause the patient to appear persistent pain, and even directly cause nerve damage. In the analysis of the ligament status, we need to use MRI imaging technology, as far as possible to reduce the missed diagnosis of cervical spine injury [16]. In the medical image diagnosis of cervical spine injury, the surface sensitivity of MRI detection technique used to detect the injury of the cervical spine is lower than that of the CT image. But in the detection of the ligament, MRI has high sensitivity.

Taking the three medical images of anterior and posterior longitudinal ligament injuries as an example, in Figure 2, the specific test results are as follows. Figure 2a is T1W1 anterior cervical swelling soft tissue, and the anterior longitudinal ligament of C3-4 appears continuity of the "black line" interrupt; Figure 2b is T2W1 high signal before the visible edema, and C3-4 anterior longitudinal ligament has partial loss, the overall thinning; In Figure 2c, there is continuity interruption in the anterior longitudinal ligament of C4-5 space in the proximal stump up; It can be seen from Figure 2d, in the operation process, the anterior longitudinal ligament is completely broken, and there is damage to the disc. MRI images can be clearly detected in patients with cervical ligament injury, and combined with the exploration of the operation process, they are mutually confirmed.



**Figure 2.** Study on the application of MRI in the diagnosis of ligament injury.

During exercise, especially for older people, because there will be a certain degree of ossification of the ligament, and therefore the ligament injury may be more likely caused by external effects [17]. MRI is used to directly observe the posterior ligament complex. Imaging for anterior subluxation plays a decisive role, but in practical clinical applications, it is difficult to promote in clinical diagnosis because of the relatively high cost and lack of feasibility. Therefore, X tablets can be used to carry out a preliminary examination, and when MRI assessment is needed for the ligament damage, the MRI test can be selected for clinical diagnosis [18]. In the existing research, in the detection and diagnosis of cervical MRI in patients with cervical spine trauma, the positive disc injury, positive ALL damage, and negative PLL damage are more reliable. For the acute injury of cervical spine and the doubt stability, with the recognition of the clinical manifestations of difficult to do the flexion and extension, MRI detection is the recommendation. When the cervical spine injury is particularly severe, the clinical manifestations of the patients are coma, vague awareness, unclear expression, severe pain, unable to move and other similar symptoms, it is necessary to carry out MRI detection. In the MRI examination, in order to ensure that patients have sufficient activity for passive flexion and extension, logs is rolled to the sides to protect the spine in the lateral position [19]. If the patient is difficult to bear the pain of flexion and extension, MRI detection is not suitable. And in the acute case, because the patient is too painful or difficult to carry out cervical spine activity, MRI detection and diagnosis of M ligament damage cannot accept high false negative rate and false positive rate.

## Clinical Data and Methods

### Clinical data

In order to study the reliability of MRI detection and diagnosis of the anterior and posterior longitudinal ligament of the lower cervical spine, a retrospective analysis is used to study the injury of the anterior and posterior longitudinal ligament of the lower cervical spine caused by physical exercise in a hospital. The time period of the study is from February 2010 to April 2015. All patients through the analysis are involved in sports related activities and cause cervical injury, and X-ray and CT images are needed to ensure that there is no dislocation or fracture in the vertebral segment of the patient. Taking into account the persistent neck pain and mental injury to do the MRI examination, the combination of anterior or anterior surgery is the main method before treatment. There are 53 patients in the study, including 31 males and 22 females, and the male to female ratio is 1.41:1 (Table 1). The average age of the patients is  $42.2 \pm 5.8$  years old, and the age is from 18 years old to 65 years old. For the analysis of the causes of ligament injury, 19 people are damaged in the daily physical exercise, 22 people injured in the training, 8 people damaged in the game, 4 people are other sports related reasons. Further analysis of the causes of injuries, because the daily physical exercise intensity of the older is too large, falls, bruises and other sports situation are caused by the rigid body; On the

other hand, in football, gymnastics and other daily training process, the possibility of injury is larger.

**Table 1.** Clinical data of patients.

Age	Average age	42.2 ± 5.8
	Max/min	65/18
Gender	Male/female	31/22
	Male to female ratio	1.41:1
Cause of injury	Physical exercise	19
	Physical training	22
	Sports competitions	8
	Other related reasons for sports activities	4

After MRI examination, for the patients with cervical spine injury or non-fracture dislocation with spinal cord injury diagnostically assessed by medical image detection, they are carried on with the anterior surgery or the surgery combined surgery of anterior and posterior approaches. The diagnostic results are compared with the results of surgical exploration. The patients are subjected to MRI and, the average interval is 3.8 d, the longest interval is 23 d, the shortest is 1 d. The average time interval between injury and surgical treatment is 8.1 d, the longest time interval is 53 d, and the shortest is 2 d. After surgical exploration, there are 78 motion segments, specific for: 2 C23 segments (2.6%), 11 C34 segments (14.1%), 22 C45 segments (28.2%), 30 C56 segments (38.5%), and 13 C67 segments (16.7%).

The criteria for case selection are as follows: (1) There is a clear history of blunt trauma of the neck, and the neurological symptoms of the spinal cord injury are obvious; (2) The reasons for the injury of the patients are sports related activities, and the reasons for the injury are classified statistics; (3) Patients complete the X-ray radiography, CT images and MRI examination in the preoperative, and all medical imaging data are completed; (4) Through the evaluation of medical imaging data, it is clear that there is no obvious fracture and dislocation of the vertebral body in the lower cervical spine; (5) All patients are treated with anterior cervical spine surgery or anterior and posterior combined surgery. The contents needed to record include: (1) The patient's general information, such as the patient's gender, age, cause of injury, length of stay, etc.; (2) Clinical symptoms, such as neurological signs and symptoms of the patient, the ASIA motor function score; (3) Medical image data, including the X-ray film, CT image and MRI detection results; (4) Surgical treatment data, including the surgical treatment program, intraoperative exploration results.

### MRI imaging diagnosis and surgical exploration

The equipment of MRI image inspection is the MAGNETOM Skyra 3.0T intelligent magnetic resonance imaging produced by German company SIEMENS. This equipment is the more advanced core resonance equipment introduced in our country



at present. It not only has the characteristics of fast examination, but also has the advantages of high reliability. Due to the use of the 70 cm large aperture short magnet design, the environment for examination of patients is more comfortable. When the device is used for checking and scanning, the magnetic examination of the various parts of the body such as the cardiovascular, the chest, the nerve system, the joint, the pelvis and the like can be carried out. With the three dimensional multi angle observation of the patient's body structure, the image quality is relatively high, which can greatly improve the accuracy and reliability of the diagnosis of the disease. The sequence of the examination includes sagittal plane T1WI, T2WI and STIR, layer thickness 3-4 mm, and the layer spacing is 1mm. All patients are first performed X-ray examination of the cervical spine, cervical spine without excessive flexion of the examination in order to prevent the aggravation of the patient's symptoms. The CT scan and MRI examinations are completed before surgery, and MRI diagnosis is performed by experienced surgeons and radiologists. The record of image data contains three different standards, and the related characteristics of surrounding soft tissue injury include ALL, MRI characteristics of PLL, anterior and posterior longitudinal ligament, intervertebral disc injury degree, avulsion fracture, anterior hematoma and high signal.

Taking part of MRI image detection evaluation as an example, in Figure 3: Figure 3a is T1WI anterior cervical swelling soft tissue, and the anterior longitudinal ligament of C3-4 appears continuity of the "black line" interrupt; Figure 3b is T2WI high signal before the visible edema, and C3-4 anterior longitudinal ligament has partial loss, the overall thinning; Figure 3c and Figure 3d is T2WI anterior cervical T2L, in which ALL tear appears.



Figure 3. MRI imaging examination of anterior and posterior longitudinal ligament injury of lower cervical spine.

Table 2. Clinical data of patients.

Parameter name	Definition or formula
True positive number	Diagnosis of injury by surgical exploration confirmed the correct number of cases
True negative number	Number of correct cases confirmed by surgical exploration and non-injury diagnosis
False positive number	Number of cases of injury diagnosed by surgical exploration
False negative number	Number of cases of non-injury diagnosis by surgical exploration
Specificity	$\text{True negative number} / (\text{true negative number} + \text{false positive number}) \times 100\%$
Susceptibility	$\text{Positive number} / (\text{positive number} + \text{false negative number}) \times 100\%$

All patients in the study are treated with surgery. Before surgical treatment, anterior cervical spine stabilization should be ensured. For the dizzy or older patients, the single anterior column injury is done with surgical treatment to avoid the increase of halo brace related morbidity. The main treatment options are two kinds, one is anterior and posterior combined surgery, and the two is anterior resection and bone graft fusion and internal fixation. The doctors doing the surgery are experienced, who can be skilled to complete surgical operations, such as the intervertebral disc removal, vertebral subtotal resection, fusion and plate internal fixation. In the course of the operation, observe whether there is a hematoma in the anterior fascia of the vertebral body in a real time. If there is a hematoma, then look at the extent of its range. Uses X ray machine with C type arm to fix the damage segment, and the layer by layer will be exposed, so as to explore the ALL integrity or damage degree. Corresponding to the preoperative MRI diagnosis, there are major projects that need to be explored during the operation: (1) To explore the extent of the rupture of the fiber ring, whether the nucleus pulposus appears, and make clear the injury degree of the intervertebral disc; (2) The integrity of the adjacent segment ALL is determined downward or upward; (3) For the intervertebral disc extraction or subtotal resection of vertebral body, appropriate length of the plate is selected to fix the vertebral body.

### Statistical analysis method

The statistical analysis of the data of the patients mainly includes the MRI detection method, using three criteria for the consistency analysis and diagnostic value analysis of ligament injury. The results obtained by the surgical exploration are used as the gold standard, respectively. Ligament injury showed in MRI diagnosis and no injury in the operation is regarded as the false positive result, and the ligament injury not found in MRI diagnosis and found in the operation is regarded as the false negative result. The specific definition and calculation methods are shown in Table 2. Based on this, the accuracy, specificity, sensitivity, positive and negative predictive values of MRI diagnosis of anterior and posterior longitudinal ligament injury of the lower cervical spine are studied.

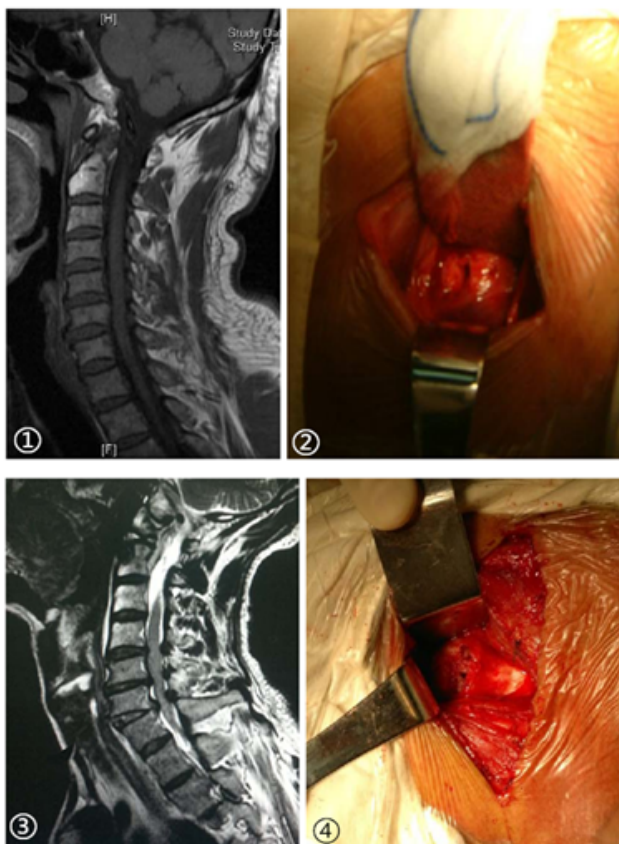
Accuracy	$(\text{true positive number} + \text{true negative number}) / (\text{positive number} + \text{true negative number} + \text{false positive number} + \text{false negative number}) \times 100\%$
Positive predictive value	$\text{True negative number} / (\text{positive number} + \text{false negative number}) \times 100\%$
Negative predictive value	$\text{True negative number} / (\text{positive number} + \text{false negative number}) \times 100\%$

## Analysis and Discussion of the Results

Through the analysis of the MRI image, we can see that there are 43 sections of ALL damage and 23 of PLL damage (Table 3). But in the operation, the number of ALL and PLL damage segment is 41 and 20, respectively. It can be seen that there is a certain deviation of MRI images detection in the diagnosis of ligament injury and surgery, but the deviation is small. Compared with the damage detected in the surgery, the number of segments detected by MRI images has a high of 6.8%.

**Table 3.** Statistical distribution of the movement stage of surgical exploration of ligament injury.

Motion segment	C2/3	C3/4	C4/5	C5/6	C6/7	Total
ALL damage	1	3	13	17	5	39
PLL damage	0	1	2	13	2	18
Total exploration segment number	2	11	22	30	13	78



**Figure 4.** MRI examination of image diagnosis and surgical exploration results analysis.

Take two cases for example. And in Figure 4, Figure 4a and Figure 4b are for the same patient. MRI shows that continuity of the anterior longitudinal ligament of the C4-5 segment is interrupted and the anterior longitudinal ligament is completely ruptured during operation. The Figure 4c is THAT C6-7 segment shows discontinuous interruption of longitudinal ligament, ALL thickening, and the Figure 4d shows ligament rupture during operation.

The assessment indicators of ALL, PLL damage using different MRI characteristics are shown in Table 4, including the specificity, sensitivity, accuracy and negative and positive predictive value, and its specific calculation is shown in Table 2. It can be seen from Table 4, all the indexes obtained by T1D are lower, which is not suitable for the diagnosis of the injury of the anterior and posterior longitudinal ligament of MRI. Although the use of T2L has a high specificity, the sensitivity is low. The index value is higher when using T2T, which shows that the reliability of PLL and ALL damage diagnosis is higher when using MRI detection technology.

**Table 4.** Reliability analysis of ALL and PLL damage diagnosis based on different MRI features.

Evaluation index (%)	ALL		PLL			
	T1D	T2L	T2T	T1D	T2L	T2T
Specificity	41.8	79.4	90.2	54.3	95.6	91.8
susceptibility	56.8	55.2	88.7	65.1	49.4	90.3
Accuracy	47.5	71.3	90.2	55.3	95.6	91.1
Positive predictive value	41.2	64.8	87.6	31.9	70.1	72.7
Negative predictive value	62.4	71.38	92.9	80.3	88.5	97.1

Because the conventional X-ray film and CT examination can directly display and check the situation of bone injury, but it is only able to provide indirect evidence for the cervical soft tissue structure, such as ligament injury. And in the judgment of soft tissue injury using cervical flexion and extension, it may cause the risk of acute stage of cervical spine injury. In patients with unconsciousness or severe pain conditions, it can result in false positive rate and false negative rate [20]. MRI examination for soft tissue injury has high specificity and sensitivity, and especially in ligament injury examination, it can fully reflect the pathological changes of the patients, which is currently widely used in the evaluation of cervical ligament injury and spinal stability. At present, the detection of cervical ligament injury using MRI detection technology is a common recognition. But in previous studies, the empirical analysis of MRI test results and surgical findings is less, and it is difficult to carry out quantitative analysis of the reliability of MRI on

the diagnosis of ligament injury. In judging ALL, PLL damage, T2T standard has a high specificity, sensitivity, accuracy, and positive and negative predictive value is also higher, which is the reason of the only standard of the ligament injury currently.

## Conclusions

In order to study the consistency and reliability of MRI detection in diagnosis, a retrospective analysis is made on the patients who are injured in the anterior and posterior longitudinal ligament of the lower cervical spine, which was caused by physical exercise during February 2010-April 2015. According to the inclusion and exclusion criteria, a total of 53 cases are included in the case, and the ratio of male to female is 1.41:1. It can be seen from the comparative analysis of exploration results and detection results with MRI of ligament injury that, movement segments of ALL, PLL damage by MRI detection are 43 and 23, and the segment number of ALL, PLL damage in actual detection is 41 and 20, respectively. There is a certain deviation between MRI image detection and surgical exploration, but the deviation is small, and compared to the operation, the number of damaged segments has a high of 6.8%. The reliability evaluation index of MRI test is further analysed with three standards of T1D, T2L, and T2T. When the ALL standard is used, The specificity, sensitivity, accuracy, positive predictive value and negative predictive value is 90.2%, 88.7%, 90.2%, 87.6%, 92.9%, respectively. At the same time, the each evaluation index of PLL is 91.8%, 90.3%, 91.1%, 97.1%, 72.7%, respectively. The evaluation indexes of the other two criteria are relatively low. Thus, in the actual clinical application, the diagnostic reliability of MRI based on the T2T standard for the diagnosis of anterior and posterior longitudinal ligament of the cervical spine is high.

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