

## MRI DIAGNOSIS OF OCCULT FRACTURE PATTERN OF ANTERIOR CRUCIATE LIGAMENT INJURY IN TAEKWONDO ATHLETES

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### ABSTRACT

This paper explored the fracture pattern of anterior cruciate ligament (ACL) injury in Taekwondo athletes, for the purpose of improving the clinical diagnostic value of MRI. To analyze the effect of MRI diagnosis in detecting the occult fracture pattern of ACL injured knee joint, we randomly selected 1300 Taekwondo athletes with ACL injured knee fracture from a hospital, and conducted retrospective analysis of their clinical data and analyzed the distribution characteristics of their lesions. According to the results, it can be concluded that the probability for occult knee joint fracture with ACL injury was 92% (1200/1300), the probability for occult knee lateral compartment fracture with ACL injury was 85% (1100/1300). Regarding the fracture type such as lateral femoral condyle fracture, tibia lateral frontal fracture, and lateral tibial plateau posterior fracture, the probabilities for them with ACL injuries were 80% (800/1000), 67% (600/900), and 89% (400/450), respectively. In addition, lateral tibial plateau posterior fracture, lateral femoral condyle fracture, and occult fracture of the anterior intercondylar area were all observed in combination with ACL injury. Analysis of the data showed that knee joint occult fracture was the indirect embodiment of ACL injury, with a strong association between the two. However, lateral tibial plateau posterior fracture, lateral femoral condyle “kissing contusion” and occult fracture of the anterior intercondylar area were not as associated with ACL injury.

**Keywords:** Taekwondo Athlete, Anterior Cruciate Ligament Injury, Knee Joint, Fracture Pattern, MRI Diagnosis.

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### Introduction

Taekwondo athletes are extremely likely to suffer ACL injury during their daily training and competition (See Fig.1). Normally, such injury is diagnosed and treated with arthroscopy, however with the progress of advanced techniques, non-invasive diagnosis methods have been widely used in clinical practice. Among the non-invasive diagnostic methods, MRI is the most common one. MRI diagnosis can realize diagnostic results of high reference value and enjoys advantages such as clearly showing the injured parts and the injury degree, extremely high sensitivity, compatibility, specificity and accuracy, with all these indexes being 90% higher than those of other diagnostic methods<sup>(1-5)</sup>.

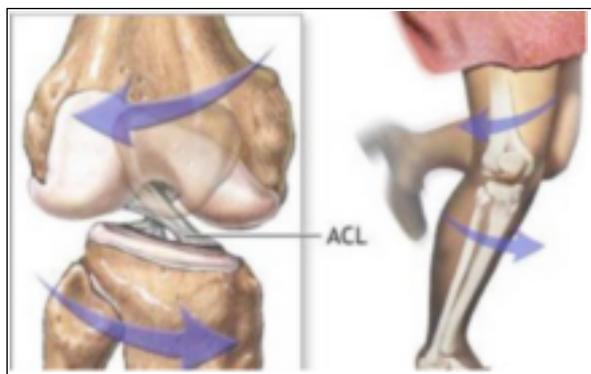


Fig. 1: Knee joint with ACL injury

However, as ACL injury gradually moves from the lateral femoral condyle area to the medial femoral condyle area in an inferior diagonal direc-

tion and is in a scattered distribution, ordinary sagittal position images become not as informative, since tibial anterior intercondylar area and full images cannot be seen in the same layer, such that in some cases they cannot be accurately diagnosed. On this basis, the indirect embodiment effect of ACL injury becomes vitally significant. In this paper, the occult fracture of knee joint was demonstrated based on real cases (See Fig.2), and the occult fracture pattern of ACL injured knee joint was analyzed. .



Fig. 2: Occult fracture of the knee joint.

## Method

### Subjects

1300 patients with knee joint fracture with ACL injury, who had been admitted to our hospital (WHICH HOSPITAL ?) from Jan 2010 to WHICH MONTH? 2016, were randomly selected as subjects. Among the patients, there were 650 patients with left knee fracture, 650 with right knee fracture; there were 700 males and 600 females, with age ranging between 15-28, with an average age of  $(20.6 \pm 2.4)$  years. MRI diagnosis was applied to all patients within 2h to 4 months after getting injured. In previous conventional tests, fracture symptoms were not shown, whereas by MRI diagnosis, ACL injury was confirmed in 310 patients according to clinical features.

Vectra-type 0.5T superconducting MRI machine was adopted to diagnose knee fracture with ACL injury, wherein limbs were in cylindrical launch and the surface coil was the receiver ???. In ordinary situations, the MRI machine supplied axial TIW positioning images, sagittal T1W, T2\* images, and coronal T2\* images. In addition, to detect the cause of the ACL injury the sagittal oblique was T1W and T2\* images within a 12° oblique angle. The TIW parameters belonged to the SE series, TR/TE 300/25ms, Nex2-4; T2\* image parameters

belonged to the GRE series, TR/TE 300/25ms, FA25°, Nex4; FOV16-18 cm, the thickness of device adjustment parameter was 5mm, with a matrix of device adjustment parameter was  $160 \times 256$ <sup>(6-8)</sup>.

## Results

ACL injury criteria were determined according to MRI diagnosis. These criteria together with the arthroscopic diagnostic results, it was found that there was a total of 1200 patients with ACL injury, including 800 patients with complete tear and 400 with partial tear.

There were 1200 cases with ACL injury out of 1300 occult fracture cases, indicating an ACL injury rate of 92%; There were 1000 cases with ACL injury out of 1200 occult fractures of lateral knee joint, indicating an ACL injury rate of 83%.

There were 800 cases with ACL injury out of 1000 occult fractures of lateral femoral condyle, indicating an ACL injury rate of 80%. There were 600 cases with ACL injury out of 900 occult fractures of lateral tibial plateau, indicating an ACL injury rate of 67%. They also included 400 cases with ACL injury out of 450 occult fractures of posterior lateral tibial plateau, indicating an ACL injury rate of 89% and 360 cases with ACL injury out of 380 occult fractures of anterior lateral tibial plateau, indicating an ACL injury rate of 94%.

In addition, there were also lateral femoral condyle occult fracture and lateral tibial plateau posterior occult fracture (kissing contusion), as shown in Fig. 3. The total number of the two types of fractures was 160, all of which were combined with ACL complete tear. Moreover, there also existed lateral femoral condyle fracture. There were 180 occult fractures of the anterior intercondylar area, with the ACL being torn, including 30 complete tear and 150 incomplete tear.



Fig. 3: Occult fracture of the lateral tibial plateau posterior.

## Discussions

From the perspective of clinical analysis, it was found that knee joint occult fracture with ACL injury was very common among Taekwondo athletes. Previous reports showed that the occurrence rate of knee joint occult fracture with ACL injury is as high as 80%, in contrast to the occurrence rate of dominate fracture of knee joint with ACL injury at 60%. Many scholars believe that the causes for knee joint fracture or injury are related to rotation movement, eversion movement, and sharp deceleration. Some researchers have also conducted comprehensive analysis on the detailed injured parts of knee joint occult fracture with ACL injury. In this paper, the occurrence rate of knee joint occult fracture with ACL injury reached 92%(1200/1300) according to our data.

Based on the current results, the injury mechanism of ACL was involved with 3 major factors. Firstly, due to the effect of valgus stress, the lateral tibial plateau was affected. Normally, when internal rotation is performed, the medial collateral ligament acts as a pivot, and thus displacement of the knee joint lateral parts will be generated, which will lead to anterior subluxation, and thus the over stretching of ACL, and finally the occurrence of tear. The quick repositioning of the tibia, also known as pivot shift, directly affects the lateral tibial plateau posterior by making it collide with the lateral femoral condyle, and resulting in occult fracture. Some scholars proposed occult fracture pattern, which is a key sign for ACL complete tear (See Fig.4) to a certain degree<sup>(9,10)</sup>.



**Fig. 4:** completely torn ACL.

Secondly, some researchers believed that during the pivot shifting process, the lateral tibial plateau posterior which has been repositioned collides with the anterior horn of the lateral meniscus and lateral femoral condyle, and resulting in occult fracture. Thirdly, over stretching of the knee joint

will cause some adverse consequences such as ACL tear, and the lateral tibial plateau posterior which has been repositioned collides with the anterior horn of the lateral meniscus and lateral femoral condyle. However this mechanism is related to a certain defect to a certain degree and cannot explain the occurrence of occult fracture.

Regarding ACL anterior, the main focus is the anterior intercondylar area, where the avulsion fracture is an important current reference standard for X-ray diagnosis of ACL injury. It can be inferred that the occult fracture type at this area can be confirmed as avulsion fracture, which shares similar mechanism with dominant avulsion fracture. It was found that both ACLs were subjected to the tensile effect caused by exceeding the physiological limits<sup>(11,12)</sup>.

In this study, there were 180 patients with occult fracture of the anterior intercondylar area, with an ACL injury rate of 100%, with 150 patients being completely torn, 120 patients with occult fracture of lateral compartment of the knee. Therefore, it can be inferred that occult fracture of the anterior intercondylar area has a vital reference value, pointing to a singular phenomenon of ACL injury.

It is worth noting that the diagnosis of occult fracture of the anterior intercondylar area should be conducted by relevant data such as axial and coronal images. If sagittal image was used, it would increase the error rate of diagnosis to a certain degree<sup>(13-15)</sup>. In this study, there were 50 patients whose sagittal images were not correct and signals at the anterior intercondylar area were not perfect, such that the diagnostic result was not correct. However, the coronal images and axial images can reflect the detailed injured parts and showed that such phenomenon was mainly caused by bone marrow congestion. In addition, there were 30 patients with both anterior intercondylar area occult fracture and lateral tibial plateau posterior occult fracture. No matter in axial images or in coronal images, it can always be seen the two lesions not only showed a normal bone marrow signal but also an insignificant abnormal signal band.

Previous experience suggested that regarding the occult fracture of the anterior intercondylar area, the abnormal signal of bone marrow was very common and was of limited value; however regarding the occult fracture of lateral tibial plateau posterior, the signal became relatively strong and may even reach the upper tibia shaft.

In this study, we conducted comprehensive analysis of the occult fracture of special parts and described cases of ACL injury. Only when the ACL injury can be directly embodied, can the MRI diagnosis be correct, and the results can be of clinical value. It mainly included the following aspects: continuous discontinuity of ACL, displacement of fractured ends, blur outline, swell shape. T2\* image normally showed an enhanced ACL inner signal or low signal fiber fuzzy interrupt. There were 50 patients with ACL injury in this study. Through conventional plane scanning, it showed occult fracture of lateral tibial plateau and lateral femoral condyle, but the ACL was not completely displayed. Through oblique sagittal T1W and T2\* images with a 12° oblique angle, clearer scan results can be observed, in which ACL injury was directly imaged, with 20 cases of complete tear and 30 cases of partial tear.

### Conclusion

In summary, according to the current results, occult fracture of the knee joint or occult fracture of the lateral part of the knee joint can indirectly embody ACL injury to a certain degree, which is of reliable reference value clinically. The occult fracture of the lateral tibial plateau posterior, occult fracture of the lateral femoral condyle and occult fracture of the anterior intercondylar area must infer ACL injury. Regarding the occult fracture of these parts, conventional scan layer cannot accurately diagnose ACL injury. Only when an ACL injury is comprehensively shown and the clinical diagnosis is conducted through direct imaging, can the effectiveness of MRI in diagnostic ACL injury be improved to the largest degree.

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