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ORIGINAL PAPER

The unhappy triad of the knee re-revisited

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Abstract

Aim of the study To describe the surgical findings of the anterolateral complex in patients with the "unhappy triad" lesion of the knee.
Method One hundred and twenty-five consecutive patients presenting with acute anterior cruciate ligament (ACL) tears were selected for this study. Only cases, evaluated with a valgus stress test under fluoroscopy, with a medial opening more than 5 mm of the medial collateral ligament (MCL) were included in the study (11 patients). For the included cases, open MCL surgical repair was performed only in cases with a valgus stress test more than 10 mm as revealed by fluoroscopy (3 patients). All included cases (11 patients) underwent ACL reconstruction and exploration of the anterolateral complex that was then assessed, photographed, classified, and eventually repaired.
Results At clinical evaluation under anaesthesia, all patients presented a positive Lachman test and a pivot shift test graded as ++ in four cases and +++ in five cases, not valuable in two cases. At surgical exploration, the anterolateral complex was involved in all cases (11 patients): one case demonstrated a type I injury, eight cases a type II injury, two cases a type III injury, and no patient with a type IV injury (Segond's fracture). All anterolateral complex lesions were repaired by direct suture and re-tensioning.
Discussion On the basis of a recent analysis performed by other authors, we could speculate that injuries of ACL and anterolateral compartment occur in the very early phase of the injury when the knee is forced into internal rotation. The MRI evidence of bone bruising in the lateral compartment in most cases of the present series support the hypothesis of an internal rotation torque.
Conclusions The unhappy triad of injuries to the knee is actually a tetrad involving not just the ACL, MCL, and medial/lateral meniscus but also involved the anterolateral complex.

Keywords Knee · ACL · Multiple ligament injuries · Anterolateral complex

Introduction

The term "unhappy triad" was first used by O Donoghue identifying an injury affecting the anterior cruciate ligament (ACL), medial collateral ligament (MCL), and medial meniscus (MM) and occurred in an estimated 25% of acute athletic knee injuries [1]. While initially described as involvement of the medial meniscus, the advent of arthroscopy has changed the characterization of this injury. Shelbourne and Nitz [2] reported a higher prevalence of lateral meniscal tears, suggesting that this entity might be more accurately described as a triad consisting of tears of ACL, MCL, and the lateral meniscus (LM), a theory supported more recently by other authors [3–6].

Muller expanded this concept, in his book "The Knee: Form, Function and Ligament Reconstruction." He reported that "during routine exposure of fresh unhappy triad injuries we frequently found that they were actually tetrad injuries, the fourth component being a fresh lesion of the Antero-Lateral femuro-tibial Ligament" [7]. The author described this structure as a distal posterior portion of the ilio-tibial tract extending from the linea aspra, just below the femoral attachment of the lateral collateral ligament to the Gerdy's tubercle.

More recently, there has been a renewed focus on the anterolateral complex, particularly on the anterolateral ligament (ALL). Recent anatomic descriptions [8–12], biomechanical investigations [13, 14], and clinical studies [15–17] of the ALL showed the role of the ALL in the function of the knee.

Level of evidence: V (expert opinion)

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The purpose of this study is to describe the surgical findings of exploration of the anterolateral compartment of the knee (the ALL and the surrounding capsule) in patients presenting with the unhappy triad. Our hypothesis is that both the lateral compartment and medial compartment are extensively involved in the unhappy triad injury pattern, and thus is actually more a tetrad of injuries.

Materials and methods

From January 2013 to December 2016, 125 consecutive patients presenting to our institution with acute ACL tears were selected for this prospective study. All patients presenting with a positive Lachman test and a positive valgus stress at clinical evaluation were included in the initial study group for a total of 25/125 patients (20%). All patients were assessed clinically and radiologically with standard X-ray and 1.5 T magnetic resonance imaging (MRI).

Clinical evaluation was repeated under anesthesia and evaluation of severity of MCL injury was performed with the aid of a fluoroscope at 30° of flexion: 14 out of 25 (56%) patients with a medial opening between 0 and 5 mm (grade I of Hughston classification) were excluded from the final study group. The remaining 11 out of 25 patients (44%) were included in the final study group: eight patients with a medial opening between 5 and 10 mm (grade II Hughston) underwent conservative treatment of the MCL tear while three patients with medial opening more than 10 mm (grade III Hughston; Fig. 1) [18] underwent a surgical treatment of the MCL tear.

For all 11 cases, an accurate exploration of the anterolateral complex was performed at the time of surgery. The status of the anterolateral complex was then assessed, recorded, photographed, classified, and eventually repaired.

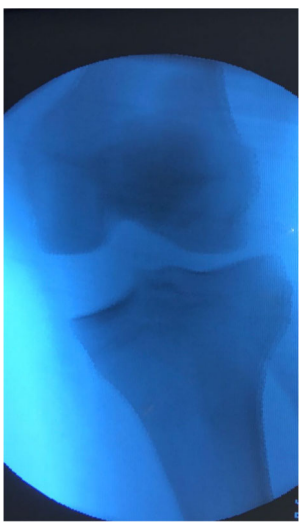

Fig.1 A type III lesion of medial collateral ligament (Hughston classification) under fluoroscope view (left knee)

A full diagnostic arthroscopy was then performed, including evaluation and treatment of chondral and meniscal pathology. A medial meniscus tear was present in seven cases: three cases were surgically repaired with an out-in technique, one case with an all-inside technique, and three cases were treated with a partial meniscectomy.

A lateral meniscus tear was presented in four cases: one case was surgically repaired with an out-in suture and three cases were treated with a partial meniscectomy.

No severe grade III or IV chondral lesions were detected.

Finally, for all 11 cases, a standard arthroscopically assisted anatomic single bundle two-incision outside-in technique using doubled gracilis and semitendinosus tendon (DGST) autografts was performed.

Inclusion criteria are summarized in Fig. 2

Surgical technique—MCL

The MCL was approached through an incision on the medial side of the knee (Fig. 3) over the site of injury as documented by arthroscopy and the repair of MCL injury was performed in two cases by a direct suture re-tensioning of the torn and stretched ligament using absorbable stitches; in the other case, the repair of MCL injury was performed using a single anchor. Over-constraint was avoided by repeatedly checking range of motion during the MCL repair.

Surgical technique—anterolateral complex

Before arthroscopic procedure, the lateral compartment was approached by a 5 to 7-cm long incision proximally extended from Gerdy's tubercle in a hockey stick fashion. The fascia lata was inspected and longitudinally split to expose the anterolateral complex. Injuries of anterolateral complex were accurately recorded, photographed and classified as proposed by Ferretti et al. [15] (Fig. 4), and eventually repaired by direct suture and re-tensioning of the complex through plication with absorbable stiches (2–0 Vycril, Ethicon, USA) in a parallel fashion with square knots.

Results

Of the 11 patients included in the study, there were six females and five males with a mean age of 23 years (range 16–31 years).

MRI evaluation revealed in all cases a tear of the MCL along with complete ACL tear. Moreover, bone bruises were documented in all 11 cases, affecting medial and lateral femoral condyle and tibial plateau (Fig. 5).

The clinical evaluation under anesthesia revealed for all patients a positive Lachman test; valgus stress test was

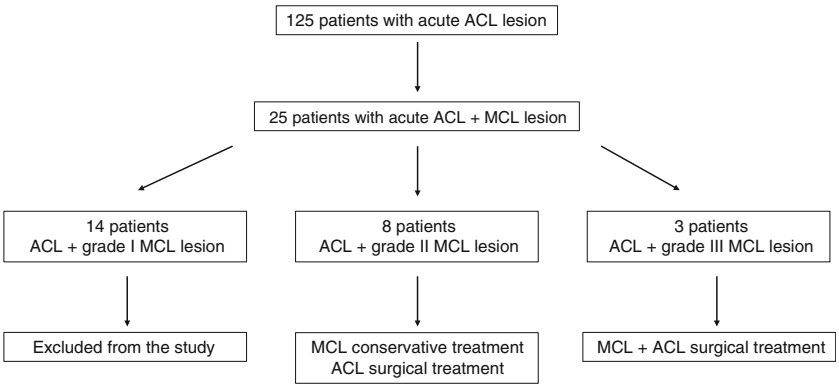

Fig. 2 Flow chart of inclusion criteria

positive in all patients: seven patients were graded as ++ and four patients as +++; a pivot shift test was easily evaluated in nine cases and graded as ++ in four cases and +++ in five cases while was unable to be assessed in two cases due to the significant instability of the medial compartment.

At surgical exploration of the lateral compartment, the fascia lata was apparently normal in seven cases and haemorrhagic in four cases. The fascia lata was incised along its fibres and the margins were elevated to expose the anterolateral complex from anterior to posterior. The anterolateral complex was frankly involved in all cases: there was one case of a type I injury (stretching and haemorrhages involving anterolateral capsule alone), eight cases of a type II injury (stretching and haemorrhages extending from anterior to posterior), and two cases of type III injury (complete tear of anterolateral ligament, ALL). There were no cases of type IV injury (bony injury, Segond's fracture) [15].

All the 11 anterolateral complex lesion cases were repaired as described in surgical technique paragraph.

Fig. 3 Surgical image of a left knee: a type III lesion of medial collateral ligament (Hughston classification)

Clinical and radiological results are summarized in Table 1

Discussion

The most important finding of this study is that injury of lateral compartment occurred along with the medial compartment in all cases of the unhappy triad. Thus, our initial hypothesis is confirmed. The unhappy triad should be considered a tetrad of injuries, the fourth component being a concomitant lesion of the lateral compartment. In fact, the most important findings of the study, as confirmed by surgical exploration, were the frankly involvement of the anterolateral complex in all cases, especially towards a lesion pattern which presented a stretching and haemorrhages of the anterolateral capsule. Similar to a previous study, where the Segond's fracture (type IV injury) seems to occur less frequently [15], this study seems to confirm this trend also in a pattern of unhappy tetrad, also because of the small number of patients included. Similar findings were reported by Muller [7], however, without a more detailed case series. In his findings, Mueller reported the prevalence of proximal injury of the anterolateral femuro-tibial ligament, described as a deep portion of the fascia lata. In our series, the fascia lata was only mildly affected in four cases and apparently normal in seven cases. The lateral injury was located deeply, at the level of capsular layer.

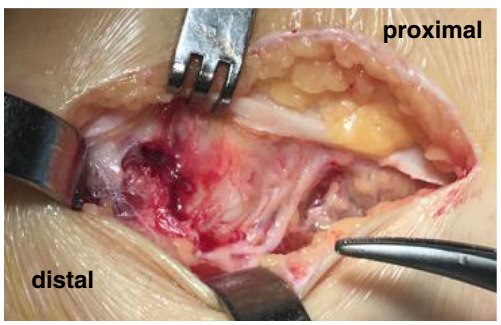

Fig. 4 Surgical image of a left knee: a type III lesion of anterolateral complex

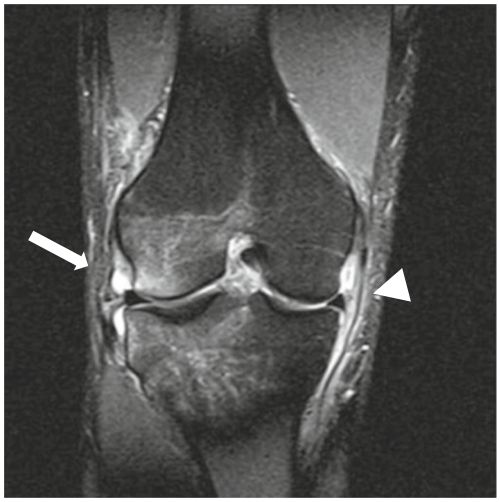

Fig. 5 Coronal T2-weighted MRI images with fat saturation of the right knee. Lateral side (white arrow): slightly thickened anterolateral ligament, abnormality of the ALL fibers, asymmetry of the inferior lateral genicular vessels (GV), bone bruising of the lateral femoral condyle and lateral tibial plateau. Medial side (white arrowhead): severe sprain high signal is seen inside and medial to the medial collateral ligament with partial disruption of the ligament. The medial meniscus is minimally displaced medially

There is a renewed interest the role of anterolateral secondary restraint in particular the ALL occurring with ACL tear in a "pivot shift like" injury [9, 10, 12, 19, 20]. Some authors have demonstrated a significant role in controlling internal rotation of the tibia by the ALL [21] and its contribution to the development of a pivot shift on clinical examination [13, 14, 22, 23]. This apparent synergy between the ALL and the ACL in controlling internal rotation is exemplified by the injury patterns seen in a "pivot shift like" injury where the anterolateral complex and ALL are often involved [15, 18, 24]. In a previous study, Ferretti et al. found that an injury to the anterolateral capsule and ligament occurred in 90% of apparently isolated ACL injuries [15]. They also proposed a classification of anterolateral complex injuries in different types: type I injury (stretching and haemorrhages involving anterolateral capsule alone); type II injury (stretching and haemorrhages extending from anterior to posterior); type III injury (complete tear of anterolateral ligament, ALL); type IV injury (bony avulsion, Segond's fracture). Even if this classification is still not yet widely accepted nor reproduced, this is the better way to describe this kind of injuries occurring along with an ACL tear.

Table 1 Clinical and radiological results

Clinical and radiological results (11 patients)	
Lachman test (under anesthesia)	
Negative	–
Positive	11
Jerk test (under anesthesia)	
Not valuable	2
0+	–
1+	–
2+	4
3+	5
Valgus stress test (under anesthesia)	
0+	–
1+	–
2+	7
3+	4
Anterolateral complex lesion (intra-operative)	
Type I	1
Type II	8
Type III	2
Type IV	0
Valgus stress test (under fluoroscopy, 25 patients)	
0–5 mm	14 (exluded from study)
5–10 mm	8
> 10 mm	3

This injury pattern to the structures of the knee could match an internal rotation, valgus overload mechanism, as seen in a pivot shift like injury. However, the mechanism of injury in patients with the unhappy triad is different than a standard pivot shift-like injury and it has been described as a result of a sudden abrupt valgus external rotation stress, primarily affecting the MCL and secondarily the ACL. In our series, all patients reported a clear valgus external rotation mechanism. Given the contrasting mechanisms of a pivot shift injury and a valgus extension rotation, we could not explain the prevalence of injury of lateral compartment as a result of a forced valgus external rotation of the tibia as seen in this tetrad of injuries. A Norwegian group performed two previous three-dimensional video analysis studies on a series of ACL tears occurring during indoor and outdoor sports activity as recorded and broadcasted by television [25–27]. They used a sophisticated software program [28] to more deeply analyze injuries in which all cases appeared a result of a clear valgus, external rotation mechanism. The authors concluded that tears of ACL occur in the injured knee in the first 40 ms when the knee is forced into valgus but the tibia is actually put into internal rotation, before the knee eventually collapses in external rotation. Therefore, in most cases, injury leading to an ACL tear is a valgus internal rotation stress. On the basis of their findings, the sequence of tears, in most cases, would be ACL, then the lateral compartment, and finally the medial compartment. Therefore, injuries of lateral compartment are possible in cases of unhappy triad, where injuries of anterolateral secondary ACL restraints occur before the trauma could extend to the medial compartment.

Even if seven patients out of 11 presented a pivot shift test 2+ or 3+, unfortunately, we were unable to make any reliable correlation between the prevalence and type of injuries of lateral complex and the grade of pivot shift test due to the relative small number of patients included in the present series. There was also an inability to reproducibly evaluate the pivot shift test in two out of 11 patients due to the concomitant severe valgus instability. Moreover, injuries of the MCL could affect degree of PS, making any statistical correlation unreliable [7]. Therefore, in cases of severe injury of MCL, the pivot shift test should be considered with caution in evaluation of rotational instability [29].

Another interesting finding of this study is that in the reporting of MRI findings by the musculoskeletal radiologist, the medial compartment pathology was carefully reported on while the changes to the lateral compartment seen at the time of surgery were not seen. Only recently have radiologists been aware of the anatomy and function of secondary restraints of lateral compartment, whose injuries often occur along with ACL tears. Few recently published studies deal with normal anatomy and pathological changes of these structures [30–34]. It seems logical as radiologists become more experienced and reliable such injuries will be more carefully evaluated and described.

The limitations of this study include low number of patients, lack of adequate follow-up, and a standardized method to evaluate clinical tests. Regarding the limited number of patients, we should consider that unhappy triad with complete clinical and radiological disruption of the MCL is not a common injury, as only 11 patients out of 125 acute ACL tears presented with this injury pattern.

Conclusions

The unhappy triad of injuries to the knee is actually a tetrad, involving not just the ACL, MCL, and lateral/medial meniscus, but also routinely involves the anterolateral complex.

Compliance with ethical standards

Conflict of interest All authors were fully involved in the study and preparation of the manuscript and that the material within has been and will not submitted for publication elsewhere. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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