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CASE REPORT

Isolated lateral collateral ligament complex injury in rock climbing and Brazilian Jiu-jitsu

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Abstract We report two occurrences of high-grade tears of the lateral collateral ligament complex (LCLC), consisting of the anterolateral ligament (ALL) and fibular collateral ligament (FCL). One injury occurred in a rock climber and the other in a martial artist. Increasing awareness of isolated injuries of the LCLC will allow for appropriate diagnosis and management. We review and discuss the anatomy of the LCLC, the unique mechanism of isolated injury, as well as physical and imaging examination findings.

Keywords Anterolateral ligament · Fibular collateral ligament · Lateral collateral ligament complex · Rock climbing · Brazilian Jiu-Jitsu

Introduction

Alternative sports activities, such as rock climbing and Brazilian Jiu-Jitsu (BJJ), are growing in popularity [1, 2]. Each involves unique stresses on the body, resulting in atypical injuries and hence atypical findings on physical examination and imaging [3–5]. This can be a source of confusion for the clinician, and there is a paucity of information regarding optimal management of the subsequent injuries.

In 2013, Claes et al. elucidated the anatomy of the anterolateral ligament (ALL) [6]. Their research represented further investigation of anatomy tracing back to the French surgeon Paul Segond, who described in 1879, "a pearly, resistant, fibrous band which invariably showed extreme amounts of tension during forced internal rotation" of cadaveric knees and an avulsion fracture pattern at the proximal-lateral tibia, "definitely posterior and above the tibial tubercle" during such "forced internal rotation" [7, 8]. Claes et al. provided precise anatomic details of the ALL [6], which was found to originate from the lateral femoral epicondyle and insert onto the anterolateral aspect of the proximal tibia (Fig. 1). Regarding the proximal portion, both the fibular collateral ligament (FCL) and ALL are intimately related, and Claes et al. proposed the term "lateral collateral ligament complex" (LCLC) to encompass both structures [6]. Indeed, other authors have confirmed that the proximal fibers of the FCL and ALL are often integrated [9]. With regards to the distal portion, in a subsequent article by Claes et al., the authors confirmed that the Segond fracture is in fact a bony avulsion of the ALL [10], although other authors have found that fibers of the ITB are also involved [11].

Since the publication by Claes et al., there has been intense interest among the general public and in the medical literature with regard to the identification and function of the ALL [9, 10, 12–18]. As a result, orthopedic surgeons and radiologists are diagnosing abnormalities of the ALL with increasing frequency. In fact, in another recent publication by Claes et al., the ALL was shown to be concurrently injured in 79 % of knees with anterior cruciate ligament (ACL) injury [13].

Despite the close anatomic association between the FCL and ALL, isolated injuries to the LCLC have not been reported to the best of our knowledge. Rather, the majority of the

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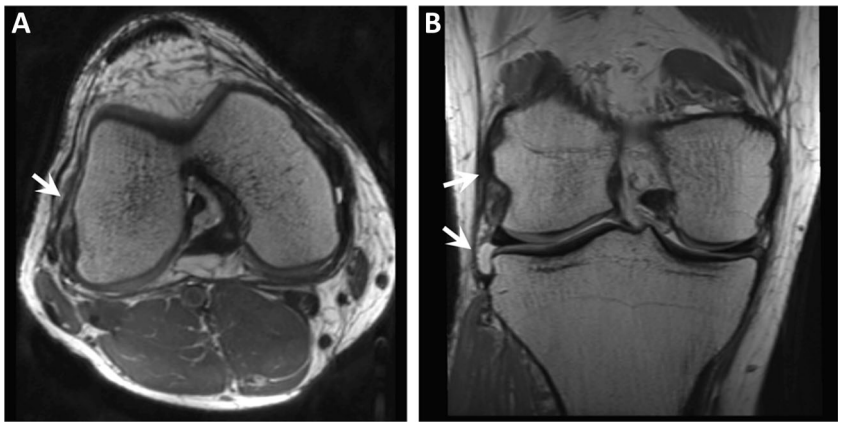

Fig. 1 Example of a normal anterolateral ligament. Intermediate-weighted SPACE images (TR 1,300 ms, TE 38 ms) reformatted in the axial (**a**) and coronal (**b**) planes show the normal appearance of an intact anterolateral ligament (*arrows*)

focus of injury to the ALL is in the setting of an ACL injury. Furthermore, unrepaired injury to the ALL in the setting of ACL reconstruction has been suggested to contribute to post-operative knee laxity [19]. As a result, ALL reconstructive techniques have been proposed in the literature [19] and by at least one vendor (Anterolateral Ligament Reconstruction using SwiveLock®; Arthrex, Inc., Naples, FL).

Recently, we encountered two cases of complete tears of the ALL with concomitant high-grade partial tears of the FCL. Unlike previously described mechanisms of injury to the ALL (valgus force on the knee with internal tibial rotation), the mechanism in our cases was varus force on a flexed knee with varying degrees of external tibial rotation. Furthermore, conservative treatment in our cases led to complete functional recovery. In addition to the presentation of a previously undescribed mechanism of injury to the LCLC, we review the anatomy and role of the ALL as well as magnetic resonance imaging appearances of the isolated injury.

Case report

Case 1

A 29-year-old experienced rock climber sustained an injury to his right knee while performing a heel-hook maneuver (Fig. 2). This maneuver is performed with the hip in flexion and external rotation, the knee in flexion, the leg in full external rotation, and a downward force applied to the heel that is hooked onto a climbing hold. The patient reported hearing two pops emanating from the knee joint in quick succession followed by moderate pain along the lateral joint line. Physical examination demonstrated no joint instability on the varus and valgus stress test, although the varus test did elicit significant pain.

Magnetic resonance imaging (MRI) was performed in three planes using a standard knee protocol (Fig. 3). This demonstrated a high-grade, partial-thickness tear of the FCL at the femoral attachment. In addition, the anterolateral ligament was completely torn at the proximal attachment with the distal attachment remaining intact. No other injuries were noted. Specifically, the cruciate ligaments and popliteus tendon were intact. Conservative management was recommended, consisting of non-weight bearing for 1–2 weeks followed by physical therapy. The patient progressively improved, reporting a return to full function by 6 months.

Case 2

A 42-year-old experienced BJJ competitor sustained an injury to his left knee during combat while executing an “open

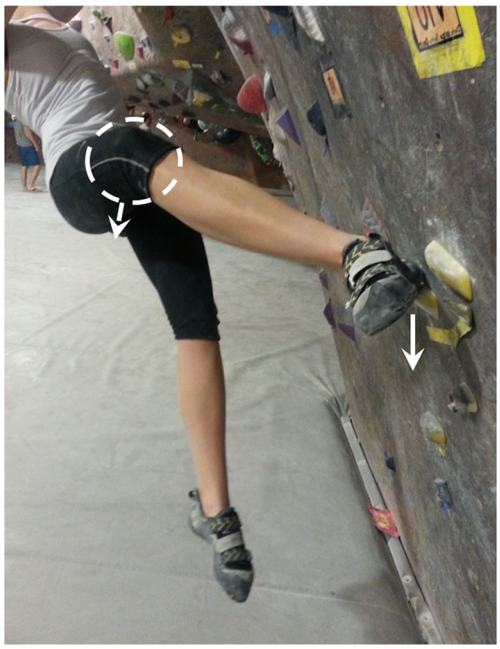

Fig. 2 Example of the rock climbing heel-hook maneuver. After hooking the right heel on a hold, a downward force is applied (*arrow*) with the knee flexed and leg externally rotated. The right knee is subject to varus and external rotation stress (*dashed circle and arrow*)

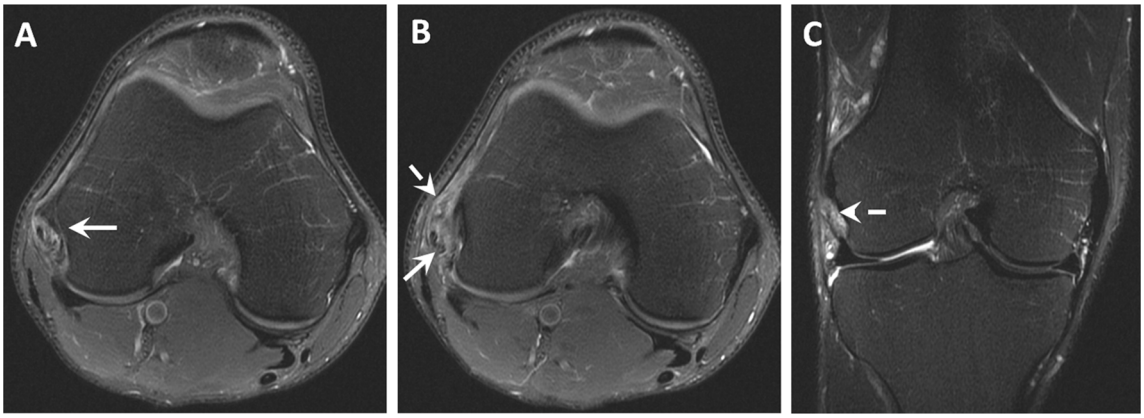

Fig. 3 Axial intermediate-weighted fat-suppressed (**a** and **b**, TR 3,367 ms, TE 42 ms) and coronal T2-weighted fat-suppressed images (**c**, TR 4,633 ms, TE 75 ms) show a high-grade, partial-thickness tear of the FCL at the femoral attachment (*arrows*), complete tear of the proximal portion of the ALL with irregular, retracted edges (*dashed arrow*), and surrounding edema

guard" position (Fig. 4). The patient was entangled with his opponent with his left hip flexed and externally rotated, the knee in flexion, and the leg in slight external rotation. As the opponent suddenly lunged forward, a varus force without internal tibial torque was applied to the patient's left knee. Both combatants reported hearing two audible pops from the knee, and the match was immediately stopped. The patient reported mild pain and swelling and sought medical attention. Physical examination demonstrated no joint instability on the varus and valgus stress test, although the varus test did elicit pain. The FCL was palpable but less robust than on the contralateral side. MRI was performed in three planes using a standard knee protocol (Fig. 5). This demonstrated a high-grade, partial-thickness tear of the FCL at the femoral attachment. In addition, the anterolateral ligament was completely torn at the proximal attachment with the distal attachment remaining intact. No other injuries were noted. Specifically, the cruciate ligaments and popliteus tendon were intact. Conservative management was also recommended, consisting of wearing a postoperative orthopedic knee brace locked in extension for 2 weeks followed by an unlocked brace for 4 weeks. The patient began physical therapy at 6 weeks, resuming moderate activity after 3 months and full competition without a brace at 7 months.

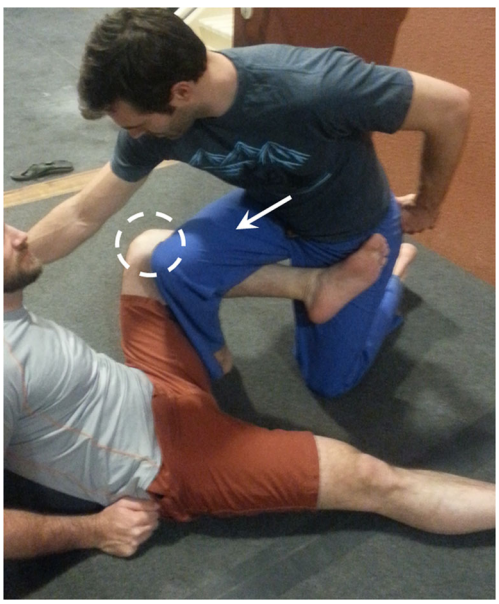

Fig. 4 Example of an open-guard position. As the top grappler in blue advances forward (*arrow*), the left knee of the supine grappler (*dashed circle*) is subject to varus stress in an externally rotated position

Discussion

The ALL is a distinct, extracapsular ligament that has received increasing interest in recent years because of the rediscovery and further investigation of anatomy by Claes et al. [6] tracing back to Segond [7]. Although the ALL originates from the femur, the precise origin remains somewhat controversial. Claes et al. described the femoral attachment as being over the lateral epicondyle, anterior to the attachment of the FCL, with interconnecting fibers between the FCL and ALL. However, Dodds et al. describe the ALL as being proximal and posterior to both the lateral epicondyle and FCL. Helito et al. describe the ALL as arising from the lateral epicondyle, distal and anterior to the femoral attachment of the FCL. The ALL has an oblique course, displaying firm attachments to the lateral meniscus and attaching to the proximal aspect of the anterolateral tibia approximately midway between the fibular head and Gerdy's tubercle [6, 14, 20].

The ALL has been described to be an important internal rotatory stabilizer of the knee, especially between 30° and 90° of flexion [13, 21, 22]. With ACL injuries, the classic mechanism is a valgus force on the knee with internal tibial rotation [23]. There is a strong association between ALL and ACL

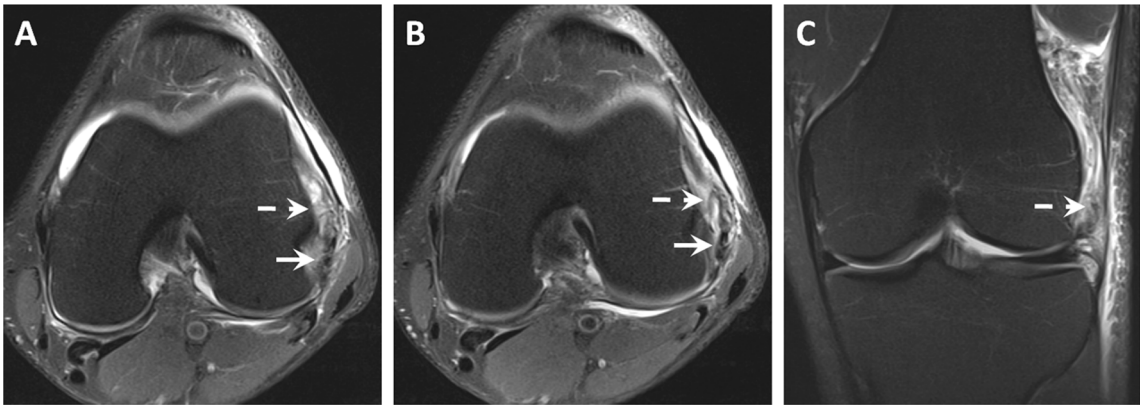

Fig. 5 Axial intermediate-weighted fat-suppressed (**a** and **b**, TR 3,367 ms, TE 42 ms) and coronal T2-weighted fat-suppressed images (**c**, TR 4,633 ms, TE 75 ms) show a high-grade, partial-thickness tear of the FCL at the femoral attachment (*arrows*), complete tear of the proximal portion of the ALL with irregular, retracted edges (*dashed arrow*), and surrounding edema

injuries, with concurrent ALL injuries reported in up to 79 % of knees with complete ACL rupture. In the setting of an ACL injury with concurrent ALL abnormality, the most common location of ALL injury is at the distal part of the ligament (78 %) [13].

Interestingly, both of our cases involved complete disruption of the ALL from the proximal attachment. The mechanism of injury was also strikingly different, with the mechanism in these cases being varus load rather than internal rotation at the knee. Although one previously hypothesized function of the ALL is to serve as a stabilizer during internal rotation of the leg, the injuries sustained in the cases above suggest an additional role as a lateral stabilizer during varus angulation, along with the FCL and closely associated popliteofibular ligament (PFL) [24, 25]. From the standpoint of treatment, it should be noted that physical therapy was sufficient in both cases to permit full recovery.

Regarding the prevalence of the activities under discussion, it should be noted that rock climbing has dramatically increased in popularity over the last 2 decades, particularly among younger individuals. Recent surveys suggest approximately 3 % of US individuals aged 6–17 and 4 % of those aged 18–24 participated in rock climbing in 2014 [1]. Much of this rise in popularity has been attributed to the increasing number of indoor climbing venues, which enable those with limited outdoor access to participate in the sport. The Climbing Business Journal reports that 28 new indoor gyms opened in 2013, bringing the number of commercial gyms to 310 in the USA at the start of 2014. This rate of growth is estimated to increase to 12.5 % by 2015 [2]. Indoor climbing in particular permits repeated movement at the limit of the participants' abilities, placing significant strain on ligaments and tendons.

These trends suggest that the incidence of climbing-specific injuries will increase. Although much has been written about the various overuse and strenuous injuries to the hand, forearm, and elbow unique to climbing, reported injuries to the lower limb consist mainly of traumatic foot, ankle, and leg fractures that occur secondary to falling [4, 26–28]. Our case suggests that climbing-related strenuous injuries do occur to the lower limb and moreover have unusual features involving recently elucidated structures. The climbing maneuver under investigation, the "heel-hook," has been previously described, although we believe incompletely [5]. In that previous description, the authors describe a heel-hook performed with a neutral hip rotation, which represents the minority of how such maneuvers are accomplished and places no varus/valgus forces on the knee. In contrast, most heel-hooks are correctly performed with at least some degree of external rotation of the hip, which places significant varus forces on the knee as the leg and hips are both flexed (Fig. 1). These forces place stress on the lateral aspect of the knee and in this instance resulted in acute ALL and FCL tears. Of note, the heel-hook maneuver is commonly performed in both indoor and outdoor rock climbing.

The rise in climbing's popularity is mirrored by that of Brazilian Jiu-Jitsu in the world of martial arts. This grappling martial art, in its sport form, consists of matches between two opponents where one achieves victory over the other by some form of "submission": either a joint-lock or a chokehold that forces the opponent to "tap out," ending the match. Its dominance as a fighting discipline in mixed martial arts contests has also led to a dramatic increase in the number of training academies.

There are many dynamic positions that occur during BJJ competitions; one of these, the "open guard," has evolved extensively in recent years. Multiple variations of this position and their associated techniques include intricate entanglement of limbs of both combatants, ultimately leading to a significant increase in twisting and varus/valgus injuries of the lower extremities [29]. We believe that isolated injuries of the LCLC would be more common in grapplers than in striking martial artists who primarily kick and punch, especially with these progressive positions and techniques.

Conclusion

These cases demonstrate an uncommon injury pattern involving a recently elucidated anatomic structure sustained during two separate but increasingly popular activities. Knowledge of the anatomy associated with this injury pattern and familiarity with its mechanism are important for appropriate clinical and imaging diagnosis. Both patients achieved complete functional recovery and return to their respective activities at pre-injury levels with conservative management.

Conflict of Interest No conflict of interest.

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