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REVIEW

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## From the central pivot to the peripheral knee injuries in the skier: a narrative review

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**Summary.** The improvement in the technology in the last 20 years has showed its main effect on the increase of the speed in the curves, thus leading to a rise of knee injuries. In fact, the most injured zone of the body was the knee (35,6 %) and the distal part of the lower body (11,5%), with ACL lesion as the most frequent diagnosis (49% of all the injuries to the knee) due to a trauma in valgus and external rotation in most of cases. The MCL is involved in the 15-20% of the cases while the LCL in only the 4,2% of the patients. Unique epidemiology and distinct mechanisms of injuries are peculiar for skier's knee while evaluation and treatment is similar to evaluation and treatment of knee injuries in other athletes. In this narrative review we aimed to highlight the current evidences in skiers' traumatology with special focus on the treatment nowadays proposed in the international literature and to the return to sport. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** knee, ACL, MCL, LCL, MRI, ski

### Introduction

There are few studies available evaluating alpine skiing competitions. In literature, the incidence of the lesions increased from the slalom (4,9 injuries / 1000 races) to the giant slalom (9,2 injuries / 1000 races) to the superG (11,0 injuries / 1000 races) to the downhill (17,2 injuries / 1000 races). With this ratio, all the specialties resulted as equally dangerous. The 45% of all the injuries in the World alpine skiing competition was detected during official competitions or in the world championship and only the 25,1% during regular training on the snow. The most injured zone of the body was the knee (35,6 %) and the distal part of the lower body (11,5%), with ACL lesion as the most frequent diagnosis (49% of all the injuries to the knee). In professional alpine skiing there is a higher overall risk of injuries in the male skiers compared to the females. Differently, in amateur skiing, the female skiers have twice higher risk of serious injuries to the

knee compared to the males. The peripheral knee is less injured compared to the central pivot in the series reported in the literature. The MCL is involved in the 15-20% of the cases, while the LCL in only the 4,2% of the patients. Rare events in the skier are the lesions of the PCL and of the external posterior aspect of the knee, with a rate that is less than 1%. Also rare are knee dislocation (1,2 %) (1).

### Injury mechanism

Usually, a trauma in valgus and external rotation. This is particularly valid in very skilled skiers. Among the beginners, external rotation in valgus and the "ghost foot lesion" are the most common injury mechanism. Falling from the skis after losing control, the skier takes a half-sitting position with the gravity center going posterior to the feet. The posterior aspect of the ski acts as a lever, pointing on the opposite side to the

foot (“ghost foot”), determining a forward directed acceleration and causing anterior translation of the tibia, eventually leading to ACL rupture. The “boot lesion” is another common injury mechanism to the ACL. After a jump, the skier touches the snow first with the posterior aspect of the ski. This determines an anterior passive force from the boots on the tibia, eventually causing ACL rupture (2). Both the mechanisms are based on translational forces without torsional forces, thus explaining the lower incidence of associated meniscal tears in the skiers than in non-skiers. Another hypothesis to explain the lower rate of associated meniscal tears is the reduced plantar overload that skiers have compared to other sports, even in case of a violent rotation of the knee (5). Regarding dislocation (both with low and high energy) that can occur during skiing, the biomechanics involves the forced hyperextension leading first to ACL rupture, then PCL rupture and an injury to medial or lateral structures according to the type of trauma (varus/valgus).

## Diagnostic

First level imaging like X-rays and CT-scans are still considered to be highly reliable. Anyways, considering the frequent involvement of the capsule and the ligaments from the center pivot and the periphery, MRI has a fundamental role. For ACL rupture, MRI has a sensibility of 87%-94% and a specificity of 91%-94% (3). It has been shown that 83% of non-skiers had a bone edema on the lateral femoral condyle and the 78% on the postero-lateral border, thus suggesting valgus stress. In skiers instead the 81% has bone edema on the posterior aspect of the tibial plateau, proving thus that ACL rupture happens in hyperflexion while only the 40% had bone edema on the lateral femoral condyle, without valgus stress (1). For a proper follow-up is useful to highlight how the mean healing time of bone edema goes from 12 to 42 weeks, as demonstrated in literature. The remission is related to individual factors, such as the presence of osteoarthritis, the age and the type of bone edema (according to Vellit classification). Starting from this data, Boks et al. (4) recommend to have a follow-up with a MRI at 10 weeks, 6 and 12 months from the diagnosis.

## Treatment

Surgical treatment is the gold standard in the ACL ruptures, especially in the young athlete: surgical timing is a crucial aspect. The reconstruction after acute injury can be performed in the professional athlete, to allow a quick return to the competitions. For the most people, the surgery has to be scheduled after an appropriate rehabilitation period, once reached 90° in flexion of the knee. The results in terms of ROM and stability have not shown difference between the patients treated <48 hours from the trauma and patients treated >3 weeks after the trauma. Different techniques are described in literature, from the riparation to the reconstruction, with or without augmentation. The reconstruction is performed with grafts: gracilis and semitendinosus (Lindeman-Bousquet technique) or the central third of the patellar tendon with a small bone piece, taken from the patella (Kenneth-Jones technique) are the most common solutions and are well described in the literature. The results are excellent for both techniques and the return to sporting activity is in 6 months after the surgery. The Kenneth-Jones technique has shown a low re-rupture rate (5). Even if it has been widely demonstrate that a non-surgical treatment of an ACL rupture can lead to functional limitation and residual instability, a non-surgical approach can be used in inactive patients or also in amateur sportsmen. The rehabilitation protocol has to start immediately after the trauma and has the goal of reducing the local swelling, regain a full articular ROM and a good state of the quadriceps muscle. In I degree lesions (medial laxity in valgus stress <5 mm) and II degree (medial laxity in valgus stress 5-9 mm) of the MCL the treatment has to be conservative, with positive outcomes in the 98% of the patients and complete return to sporting activity. In III degree (almost always associated with ACL ruptures) the treatment has to be operative. It can be in one or two steps but the surgical indications helps to minimize the possibility of residual instability that, when chronic, is not easy to treat. When there are high-degree lesions in athletes and/or patients with heavy functional requests, we choose a surgical treatment to better restore the anatomy and to maintain a performance level equal to that previous to the lesion. In case of lesion of the superficial bands of the MCL,

it can be reinserted using titanium anchors, possibly in its anatomical site. When the deep bands of the MCL al ruptured, all the postero-medial compartment has to be re-tensioned (meniscofemoral ligament, femoro-tibial ligament and postero medial capsule) with reasorbable suture stitches. The same can be done for isolated lesions of the LCL, but in III degree lesions an involvement of all the postero-lateral structure and/or an ACL lesion is more common. Thus a more aggressive approach, surgery included, has to be immediately considered. The results depend on the severity of the lesion and on the athlete's functional requests. In fact, 82% of the athletes with a II degree lesion got back to the same performance level they had before the injury, while the 75% of the athletes with a III lesion got back to competitive levels, due to the residual instability (6). Knee dislocations are uncommon and are defined by complete disruption of the integrity of the tibiofemoral articulation (7). They are challenging injuries to manage and are associated with the risk of potentially devastating immediate and short-term complications, including popliteal artery injuries, common peroneal nerve injuries, acute compartment syndrome, and deep venous thrombosis, and controversy still exists regarding their optimal treatment (8).

## Return to sport

Haida et al. (9) performed a retrospective epidemiologic study aimed to analyze the influence of the ACL rupture on French alpine skiers' postinjury performances from 1980 to 2013. The results show that skiers who suffered ACL tears were able to achieve podium success after injury, but it depended on their ages at the time of the ACL ruptures: the probability of obtaining better performance after this injury is higher if the rupture and subsequent recovery occur before the peak-performance age of 25 years. Moreover the authors show that the time necessary to achieve better performance after ACL rupture is on average 3.8 years for men and 3.1 years for women. Nevertheless, Ardern et al (10) showed that at 12 months after ACL surgery, 67% did not return to competitive sport, and only 33% tried to return to competition. Despite the severity of these injuries, a recent systematic review has demonstrated that

some level of sport participation is possible after multiligament knee injuries (MLKIs) for more than half of patients, but returning to preinjury levels of sport after surgical treatment is low, at just 22% to 33%. To our knowledge, return to sport and postinjury performance after isolated MCL and LCL injuries in elite athletes have not been studied in alpine skiing. Sonney-Cottet et al (11) reported a case of a 25-year-old world-class downhill skier sustained bilateral knee dislocations after a fall at a speed of approximately 120 km/h during an international competition. Single-stage surgery was performed on each knee to manage all reconstructions and repairs. Ten months after the accident, he was able to return to skiing; 666 days after the accident, and after intensive training, he was asymptomatic and able to return to the Alpine Ski World Cup, referring to his knees as 'practically normal'.

## Conclusion

Knee injuries in the skiers have a specific epidemiology and pattern of lesion. Anyway, nowadays there are not peculiar difference in the treatment compared to other sports. We think that a major commitment in the scientific community in the identification of the risk factors could provide essential knowledge to encode new prevention projects.

**Conflict of interest:** Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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