Narrative Review

LOWER LIMB TENNIS-RELATED INJURIES

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ABSTRACT

Tennis is among the world's most popular sports, widely practiced in the West at both amateur and professional levels. It is a fast-paced sport characterized by abrupt directional ranges, shots, and movements with significant forces at play. It is also often practiced outdoors in different weather conditions, on various types of terrain, with unsuitable clothing, and by players who are often inadequately physically and technically trained. This leads to a high rate of injuries among athletes of all levels; among the various body portions involved, the lower limbs are those most frequently affected, given their crucial role in movement. The injuries that can be encountered are many: joint and ligamentous involvements of the hip, knee, and ankle; tendon and muscle injuries of large muscle groups involved in movement; stress fractures and soft tissue lesions from repeated microdamage; injuries to skin and skin adnexa. These injuries substantially affect the affected person and, if not adequately treated, can deter the tennis player from playing the sport. This is even more evident in the professional athlete, where a sudden return to sport is of vital importance.

KEYWORDS: *tennis, sport, injury, lower limb, joint, ligament, hip, knee, ankle, muscle*

INTRODUCTION

Tennis, originating in England, has evolved globally and is now Italy's fourth most popular sport, ranking first among individual sports. Its growing recognition is largely due to the success of top Italian players. The sport involves rapid movements, sudden directional changes, and explosive gestures, particularly in the dominant upper limb, which place significant stress on the musculoskeletal system. Without proper technique and preparation, these stresses can lead to injuries, primarily affecting the lower limbs.

Tennis injuries vary by age and gender. Under 25, acute trauma-related injuries are more common, while over 25, functional overload injuries prevail. Female adolescents often experience patellar issues and lumbar pain, while male adolescents have a higher incidence of contusions, abrasions, ankle injuries, and lumbar pain.

Acute injuries occur when a force exceeds the strength of the affected structure, though they are less common in tennis due to limited physical contact. Chronic injuries stem from repeated stress and are influenced by factors such as playing surfaces, footwear, weather conditions, and individual predispositions like muscle imbalances. Poor athletic preparation increases injury risk, often leading to "weekend injuries" in sporadic players. Effective treatment requires categorizing injuries by anatomical location and tissue type.

Received: 19 February 2024
Accepted: 24 March 2024

Hip

The hip is often the tennis player's weakest link, subjected to considerable stress yet frequently overlooked by athletes. Specific movements and technical gestures in tennis largely engage this joint. For instance, the forehand executed in an 'Open Stance', where the muscles on the dominant side produce a large force in the loading phase, has an effect on the hip during the thrust phase and subsequently affects the trunk, upper limb, and racket; the joint is also stressed in the stop after the shot. This stress is particularly pronounced among professional athletes, where greater power can lead to body elevation and return to the same side. The continuous repetition of such actions can result in damage to the joint capsule, acetabular labrum, muscles (especially the bi-articulars), tendons, and ligaments that support and stabilize the joint, resulting in reduced stability, reduced ROM, and pain. Among the most frequently encountered problems are femoral-acetabular conflict and lesions of the acetabular labrum (6).

Femoro-acetabular conflict (FAI) is an ever-increasing condition typical of sports with rapid changes of direction and jerks on hard terrain, which subject the hip joint to continuous trauma. The overall incidence of FAI diagnosis is 54.4 per 100,000 person-years, with a consistent increase observed between 2000 and 2016 (7).

Notably, female patients exhibit a higher incidence than their male counterparts (8). Its pathophysiology is related to the formation of a bony conflict between the femur and acetabulum, leading to a mechanical limitation to normal joint excursion with the presence of pain. There are different types of FAI: an alteration between the femoral head and neck with the formation of a bony outgrowth at the level of the neck, called CAM; an acetabular retroversion with an anterior conflict on the femoral neck, called PINCER; a mixed form between CAM and PINCER. Furthermore, a conflict can occur in the case of excessive joint laxity. The diagnosis, in addition to anamnesis, is based on the clinical-objective picture characterized by reduced joint excursion, pain exacerbated by prolonged sitting and exercises that lead to hip flexion, and the anterior impingement test (flexion, adduction, and intra-rotation from supine or FADIR).

The presence of pathology is confirmed with an X-ray examination that shows the presence of bony outgrowths and allows us to calculate specific indices for diagnosis (6). Treatment options vary based on severity, with conservative measures emphasizing strengthening exercises for mild to moderate cases. In contrast, the gold standard treatment in advanced conditions consists of arthroscopy to eliminate the bony outgrowths responsible for the conflict (8) (Fig. 1).

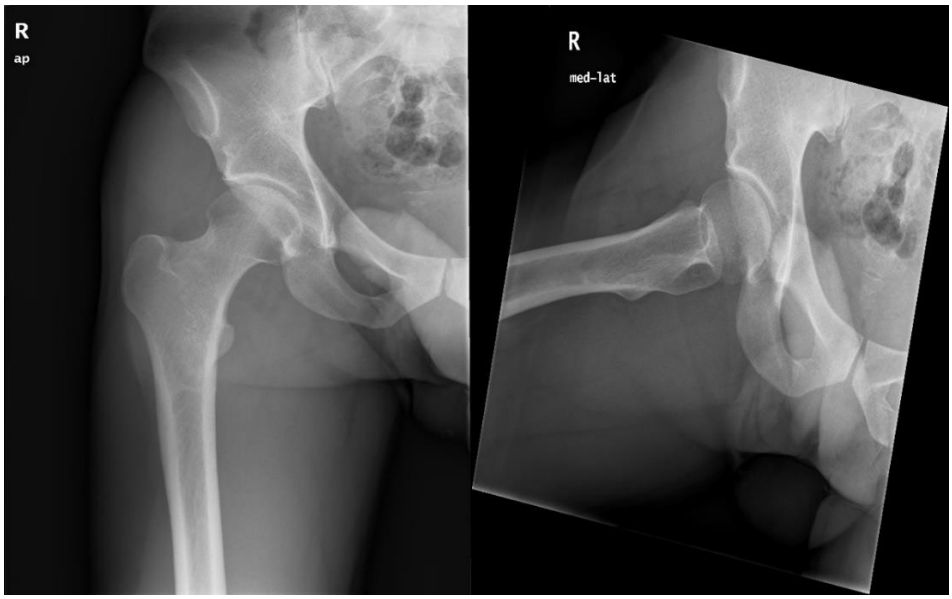

Fig. 1. *Hip X-ray of a 29-year-old male athlete, tennis player since adolescence. One notices the presence of an outgrowth of the acetabular labrum typical of the PINCER-type conflict.*

The acetabular labrum is a fibro-cartilaginous structure anatomically located in the rim of the cup and lines the femoral head. Its task is to widen the bearing surface of the acetabulum by supporting the load of the hip. Injuries to the labrum may result from overuse, acute trauma, or the presence of FAI.(9). Clinically, such injuries manifest as groin pain exacerbated by flexion and rotation, along with clicking or snapping sensation in the joint, constituting the clinical picture of a 'snapping hip'. The clinical diagnostic suspicion is confirmed by an Arthro-MRI with contrast to visualize labral tears (10). The treatment in this pathology is predominantly surgical via arthroscopy with sutures and/or regularization of

the lesions, yielding favorable outcomes even in elite athletes (10).

Knee

The knee is the joint most affected by sports injuries. Although knee injuries are not exclusive to tennis, they frequently arise due to the sport's demands, which involve constant lateral movements, abrupt stops, and flexion. Key injuries include meniscal tears, capsuloligamentous injuries, and extensor apparatus injuries.

Meniscal injuries in tennis players are a consequence of knee sprains induced by varo-valgus stress movements and rotational movements in sudden flexion extension. Clinically, they are characterized by sudden and significant pain, often necessitating withdrawal from play. In an isolated injury, pain is exacerbated by rotational movements and full extension of the affected limb. An important swelling may develop a few hours after the traumatic event, and mechanical joint locking may occur in the following days due to the interposition of the meniscal fragment between the femur and tibia.

The diagnosis is clinical-anamnestic supported by an accurate, objective examination with specific tests (Appley, McMurray, Cabot), which combined have a high sensitivity and specificity rate (11), and by specific instrumental examinations such as MRI. Meniscal lesions can be of multiple types and can be distinguished into longitudinal, transverse, radial, flap, and 'bucket-handle'. Furthermore, the location of the lesion is crucial because the healing capacity is contingent upon tissue micro-vascularization of the affected area (12).

It is possible to distinguish, according to Arnoczky, the red/red zone, adequately vascularized; the red/white zone, with partial vascularization; and the white/white zone, without vascularization (12). The gold standard treatment of meniscal lesions is arthroscopy, which facilitates direct visualization of the lesion, the possibility of employing meniscal adjustments and sutures and testing the stability of the meniscus and its possible interference with joint movement (13).

The important mechanical and proprioceptive functions of these structures should be kept in mind, which is why treatment should be as conservative as possible (14).

Knee ligament injuries are not among the most frequent injuries of tennis players; of all anterior cruciate ligament (ACL) injuries, which is the most frequent ligament injury of the knee, only a mere 1.8 percent occur during the practice of the sport (15). Such injuries predominantly arise from slips, abrupt directional changes, or abnormal falls during jumps. It is possible to distinguish anterolateral instabilities due to partial or total ruptures of the ACL and posterior instabilities due to ruptures of the posterior cruciate ligament (PCL), which are much rarer.

The diagnosis is based on history, clinical picture characterized by significant pain and swelling, specific objective tests (Lachman, Jerk, anterior and posterior drawer) (11), and MRI. The treatment of ACL injuries depends on the degree of instability, the age, and, above all, the functional demands of the patient. It can be conservative, aimed at increasing the muscular trophism and stability of the knee, or surgical, with various techniques available. Of these, to date, the most widely used is the 'all-inside' technique, which involves the use of allografts or synthetic grafts that 'mimic' the function of the ACL (16). This technique allows immediate loading and mobilization of the knee, return to normal daily activities in about 25-30 days, and the resumption of competitive sports in 5-6 months, with excellent clinical-functional results and low cases of residual instability (16).

Untreated ACL injuries have disastrous consequences in athletes, as knee instability increases the possibility of meniscal and cartilage injuries and predisposes to early arthrosis (17).

Injuries of the extensor apparatus are the most frequent pathologies of the knee in tennis players as it is subjected to overload due to constant semi-flexion work; the most frequent forms are tendinitis, chondromalacia, and patellar instability. The latter is favored by specific conditions such as muscular imbalances in the thigh, between flexors and extensors and between the vastus medialis and vastus lateralis fasciae of the quadriceps femoris, malalignment, external pressure, congenital ligament laxity (18). In addition, an increase in traumatic forms has been observed in recent years.

Patellar instability is more frequent in young females and is characterized by chronic and aggravating anterior pain. It is a pathology that, if not adequately treated, leads to the establishment of chronic inflammatory processes responsible in the long term for pictures such as patellofemoral arthrosis and tendon ruptures (18).

The diagnosis is based on anamnesis, clinical picture, and objective examination with specific clinical tests (Sage sign, J sign, apprehension test, Q angle measurement) (11). Imaging techniques, such as axial Rx of the patella (Marchant projection), which allows the staging of the pathology' severity by calculating the joint angles of the patella and femoral trochlea, and CT scans, which are useful for defining the condition of external hyper pressure (19), are fundamentals.

The treatment of patellar instability can be conservative and surgical. Surgical treatment is usually the main therapeutic choice for this pathology; reconstruction of the medial patellofemoral ligament (PFML) is among the most widely used techniques today (20) (Fig. 2).

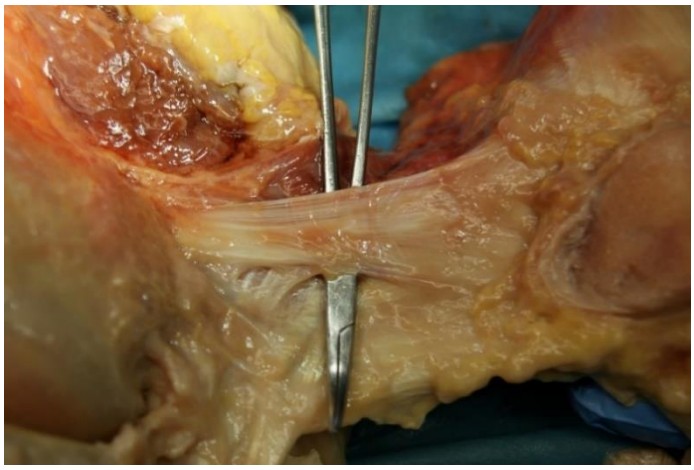

Fig. 2. *Cadaver image of the PFML, with its typical fan shape, representing the main medial stabilizer of the patella.*

Tendon injuries are often seen as stand-alone pictures or associated with patellar instability conditions, as they often share the same causes and consequences. The main role here is played by muscular imbalances and patellar malalignment with increased functional load on the tendon structures. The diagnosis is based on clinical examination and various instrumental methods such as X-ray, CT scan, biomechanical evaluation of muscle forces, kinetic and kinematic tests, and electromyography (21).

In young tennis players, osteochondrosis (i.e., inflammation of the growth cartilage) is widespread, especially at the proximal or distal insertion of the patellar tendon. When the inflammation affects the lower pole of the patella, Sinding-Larsen-Johanson's disease occurs; when the anterior tibial apophysis is involved, Osgood-Schlatter's disease occurs.

Osteochondrosis are pathology typically associated with muscular imbalances and functional overload with excessive traction at the tendon insertion points and tissue suffering such as to lead, in the most extreme cases, to the detachment of the part of bone connected to the tendon (11). Given the high incidence of tennis-related knee pathologies, prevention plays a key role; this is based on adequate athletic preparation aimed at strengthening the muscle-tendon, capsular ligament, and joint components with a correct balance of muscular forces, proprioceptive training, and improvement of playing technique (22).

Leg and foot

The legs and feet serve as the foundation for a tennis player's performance, where the demands for speed and explosive force are paramount. The pathologies that can be encountered are among the most diverse, ranging from muscle-tendon forms to rarer pathologies such as stress fractures. In addition, pathologies of the ankle and foot are very frequent, linked to the overloading of joints and rapid changes of direction on ever-changing playing surfaces.

Among the muscle-tendon forms, the typical tennis pathology is ‘tennis leg’, characterized by traumatic dislocation of the tendon of the inner twin muscle on the tendon blade of the soleus muscle. This condition, often referred to as a ‘calf tear’, typically occurs when making abrupt changes of direction that result in a contraction conflict between the mono-articular muscle of the soleus and the bi-articular muscle of the twin, causing it to rupture. The most affected individuals are short, male athletes between 30 and 40 years of age, with voluminous muscle mass and typically during the technical gestures of volley, serve, smash, and counterattack.

The diagnosis is anamnestic and clinical, highlighting a voluminous ecchymosis swelling in the sural region; sometimes, the palpatory finding of a rising muscle belly and lesion gap is possible. Confirmatory diagnosis is obtained by ultrasound, which also allows the extent of the lesion to be assessed in order to properly decide on treatment. Surgical treatment is relegated only to exceptional cases, and conservative treatment is based on immobilization and offloading, ice, topical and systemic anti-inflammatories, and physical therapy, with rather long recovery times (23).

The second most frequent form of musculotendinous pathology is Achilles tendonitis, which is more common under 30 years of age. Contributing factors include inappropriate footwear, anatomical variations, and hard playing surfaces. A chronic phlogistic process of the most vascularized portions of the tendon, such as the paratenonium and peritenonium, can occur, leading over time to ischemic suffering and tendon degeneration known as tendinosis. This is characterized by reduced cellularity, homogenization of the intercellular fibers, appearance of areas of cartilage metaplasia, and fatty infiltration.

Clinically, tendinitis presents itself with insertional pain that arises after sporting activity, stiffness with reduced dorsiflexion of the foot, increased thickness and pre-insertional tension (2 to 6 cm before insertion on the heel), presence of nodules and possible radiating pain in the sural region. In these cases, the treatment is conservative consisting on rest, cryotherapy, anti-inflammatories, orthotics, and physical therapy such as stretching and muscle strengthening; rarely, surgery with scarification and removal of the degenerated tendon tissue become necessary. If left untreated, tendinosis predisposes to subcutaneous rupture of the Achilles tendon.

This is the most frequent tendon injury with an increasing incidence in recent years, having risen from 11 to 37 cases per 100,000 population (24) and with a prevalence of approximately 11.7% in athletes. Overall, it is more frequent in individuals between 30 and 40 years of age who practice sports occasionally, the so-called ‘week-and-warriors’, i.e. people with sedentary jobs who practice sports at the weekend without adequate sports training. The rupture is characterized by an audible ‘crack’, many times without pain and usually during intense sport.

Thereafter, ecchymosis, retraction of the calf muscles, tendon gap on palpation, and reduced or absence of calf strength with positive Thompson's test is evident. Pain is awakened by local palpation and passive dorsiflexion of the foot. The diagnosis is supported by muscle-tendon ultrasound. Conservative treatment, which involves the use of a cast guard with a club foot to be worn for several weeks, is rarely used because it does not guarantee adequate healing with a high rate of recurrence. Treatment is, therefore, surgical with tendon suturing, rapid recovery, and low incidence of recurrence (25).

The most common ligament involvement occurs in ankle sprains, which represent the most frequent acute injury in tennis. It typically occurs during sharp turns, falls from a jump, and slips on the ground, especially on synthetic ground, which offers more friction and can block the shoe in lateral movements. The most affected ligaments are the ‘lateral’ ligaments, such as the anterior peroneo-astragalic (APA), posterior peroneo-astragalic (PPA) ligaments, and the peroneo-calcaneal (PC) ligaments.

Involvement of the sub-astragalic and medial ligaments is less frequent. Rarer is the involvement of the distal tibio-peroneal syndesmosis, whose involvement is responsible for tibio-astragalic instability, and tibia and fibula fractures.

The severity of the ligamentous injury depends on the degree and number of ligaments involved: Grade 1 involvement of the APA, Grade 2 involvement of APA and PC, and Grade 3 involvement of APA, PC, and PPA. Diagnosis is based on the exclusion of fractures and evidence of peri- and sub-malleolar swelling and ecchymosis, as well as anterior drawer and inversion maneuvers, to detect an unstable condition. Diagnostic completion is achieved by X-ray, which is useful to exclude fractures and syndesmosis openings, and MRI to highlight the degree of ligament injury. Treatment depends on the grade of the injury; grade 3 injuries require surgical treatment, grade 1 injuries are treated conservatively with ice, drainage, anti-inflammatories, and anti-edema, grade 2 injuries also require a brace for about 3 weeks.

In all cases, the return to sporting activity is gradual and must be preceded by a period of joint exercises, muscle strengthening, and proprioception (26) (Fig. 3).

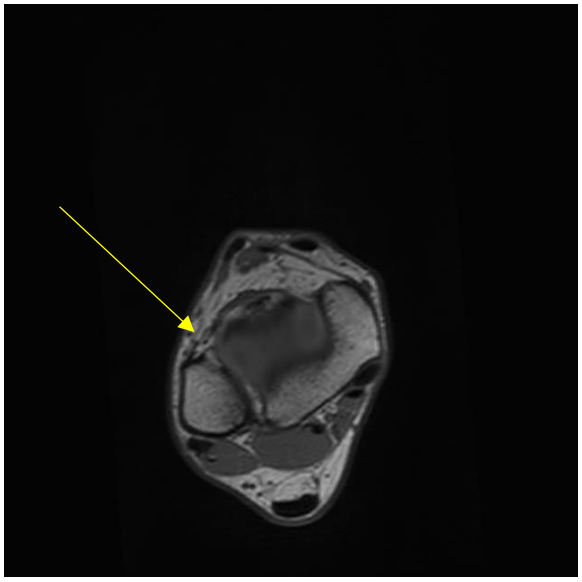

Fig. 3. *Ankle MRI, with the evidence of an APA injurie*

Foot-related pathologies in tennis are heel pain, plantar fasciitis, and tennis hallux. Heel pain refers to a painful syndrome localized in the hindfoot, which has several causes; the most frequent are insertional tendonitis of the Achilles tendon and Sever's disease. The latter is an apophysitis of the calcaneus, i.e., an osteochondrosis of the bony protrusion of the calcaneus in which the Achilles tendon is inserted.

Like the other forms of osteochondrosis, it affects young people under 16 years of age and occurs after strenuous exercise. The pain is aggravated by pressure on the calcaneus and, typically X-ray show an irregularity in the ossification areas of the calcaneus with the possibility of fragmentation of the growth nuclei.

Therapy is purely conservative with rest, anti-inflammatories, and orthoses. Insertional tendinopathy of the Achilles, on the other hand, is typical of the adult subject, linked to functional and repeated overload, and favored by Haglund's deformity and heterotopic calcifications of the bone-tendon junction, all conditions requiring surgical removal treatment.

Plantar fasciitis is a painful syndrome affecting the sole, favored by inadequate footwear and playing on hard ground. Etiology is related to repeated microtrauma that establishes an insertional syndrome of the plantar fascia at the calcaneus and/or metatarsals. Excessive pronation of the foot or forced contraction of the calf muscles contribute to its onset.

The diagnosis is based on an accurate history and physical examination that shows pain referred to the plantar surface of the heel that is more intense during walking, standing, and sports activity; sometimes pain may be referred to the midfoot. The pain is worse in the morning and during walking and then resolves during the day. X-ray examination is useful to exclude the presence of a bony spine, which can form in the case of chronic inflammation. Treatment is conservative, and prevention is fundamental, which must be carried out by wearing suitable footwear (27).

A rather frequent pathology among tennis players and runners is a subungual hematoma, mainly in the first toe and often bilateral. It is associated with an alteration of the nail plate, as in the case of a fungal infection, although the triggering cause is the continuous slipping of the foot inside the shoe with the crushing of the nail and back-flexion of the toes.

In the case of acute pain and severe hematoma, it is necessary to drain the blood to resolve the symptomatology, all in a sterile manner, observing proper rest from sporting activity. Prevention and treatment include the use of appropriate footwear in terms of size and elasticity, proper nail cutting, and the prevention of fungal and bacterial infections.

Sometimes, excessive and repeated dorsiflexion of the fingers can lead to the involvement of the metatarsophalangeal joint with localized pain and swelling and decreased dorsiflexion. On radiographic examination, a decreased joint space between the metatarsal head and proximal phalanx and subchondral sclerosis is revealed, configuring the clinical picture of ‘tennis toe’.

The treatment, initially conservative, often due to the persistence of pain, becomes surgical with debridement of the joint and, in the most severe cases, arthrosis to 20° dorsal flexion to allow optimal gait (25).

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