Module 4. Special Sports and Competitions

4.1 A cycling team´s doctor

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1. Introduction

Cycling is a sport that has different competitive specialties with their characteristics. Now, the one that preferably involves a team of several runners is in the back on the road. Therefore, given the length we want to give to these manuals, we will study what unique characteristics this sports specialty has and how the team doctor should deal with them.

The first and most outstanding thing is whether cycling can be defined as a team sport. Anyone aware of the different sports broadcasts and who remembers the struggle between cyclists to be the first to reach a goal would not hesitate to classify it as an individual sport. Still, cycling has many characteristics of a team sport.

In the competitions that we will later describe, the cyclists compete against each other for building teams, making the different components from each team to collaborate, each one with a specific and different function within the team, so that in the end, one of them is the first to reach the goal. As in all team sports, individual contribution is significant.

And, meanwhile, backstage, there is a whole more complex and numerous teams of technicians, as it increases the competitive level of the squadron, where a team doctor must be present.

2. Features of this sport

Cycling is famous for being a challenging sport. When talking about sports, it is hard to understand toughness. There is always toughness when doing physical activity in adverse environmental conditions. However, when we relate toughness to caloric cost, we can consider cycling as one of the sports in which the caloric cost during the competition is one of the highest.

In a competition in stages, the caloric requirements usually are:

- Between 4000 and 5000 kcal (17 to 21 Mega Joules) (MJ) for men.
- Between 2000 and 3600 kcal (8 to 16 MJ) for women per event.

In one-day competitions:

- 8000 kcal (32 MJ) for men.
- 4000 kcal (17 MJ) for women.

There are competitions with higher caloric costs, such as different *Ironman* competitions or many competitions from other types of crossings.

Road cycling has always been considered a long-distance sport, but we cannot forget that it shares certain features with intermittent sports, like football or basketball. Similarly, cycling is a sport that we could consider extensive aerobic. However, while the intensity forwards are usually very high in other sports and of concise duration (less than 15 seconds), these forwards can be of different intensities and durations in cycling. Therefore, it is advisable to follow physical training that teaches the cyclist to face the race at different intensity levels.

Some cycling competitions can be surprisingly long, and so is the athletes' ability to follow them daily. This is partly because the muscles involved in the actions always work concentrically, never eccentric, so the muscle is less likely to get injured. In addition, during the competition, there are no clashes between cyclists or bruises to recover quickly from the efforts made. However, the diet should ensure a correct energy intake and be accompanied by appropriate anti-inflammatory measures (both physical and physiotherapy) and sufficient rest. A particular case is when a fall occurs; then, all forecasts become useless, and all deadlines and timetables must be restructured.

3. Features of the competition

Road cycling is organised in different competitions, which consist of moving from one point to another. They can vary a lot regarding distance and characteristics of the trail (conditions of the ground, consecutive climbing, and descending from slopes; when these slopes are very long, we call them "passes"). Many times, the competitions usually last many hours. Therefore, a system must be organised to provide some type of food and drinks during the competition. We can distinguish several kinds of competitions mainly:

Figure 1: Types of cycling competitions

Source: Authors' work.

4. Physical characteristics of the cyclist

As we said before, there are different specialties in road cycling, and these correspond to different typologies.

Anthropometry. The anthropometric characteristics of cyclists do not make them very different from other long-distance athletes. However, we should note that not always the ideal anthropometric profile is the one that comes to mind as the first idea, promoted by our exposure to the different media, because this is the profile of the cyclist we know as *a climber*. In other words, the one who is more adapted to the competition includes much climbing to mountain passes.

Of course, road cycling usually involves climbing to passes, and these are decisive in developing competitions. Still, it is convenient that cyclists do not have long spans, and their body weight is limited. Therefore, it is essential that the fat component is low, and their non-active mass is as low as possible. (Cheung and Zabala, 2017; Chevalier, Enon, Walder, Barral, Pillet et al., 1986; Pons, Riera, Galilea, Drobnic, Banquells and Ruiz, 2015)

But, many times, the different competitions do not include climbing, or it has little relevance. Then the ability to develop excellent skills becomes more important, which is easier for those cyclists of greater body size. Therefore, the characteristics of the same competition layout will select the most adapted cyclists.

Female cyclists are not usually as thin as male cyclists, mainly because competitions do not usually include much climbing. Still, they must also control that their non-active component is never excessive.

Physiology. Like all athletes adapted to long efforts, cyclists usually show a significant parasympathetic system predominance. This becomes bradycardia that can be severe with a particular frequency.

As we said before, as they go through high caloric costs, and accomplishing those tasks in a minimum time is necessary to obtain sporting performance, delivering vital energy is crucial in the cyclist's performance. This is what we know as *maximum oxygen consumption* (VO_2 max). The higher the power, the better. Therefore, those athletes who have a higher VO_2 max will be favoured in their performance. When the race includes climbing, as the fight against gravity and carrying a lower weight regarding the power delivered will prevail, those runners who present a VO_2 max relative to weight (VO_2 max/kg) will be more favoured.

Many authors have published data on the VO_2 max, absolute, or relative to weight, typical of cyclists. Still, the data are always limited to the characteristics of the cyclists with whom these authors have worked and are usually tiny samples. Based on our experience, we can point out that professional cyclists tend to have VO_2 max values greater than 4.7 l / min, depending on their body size. Their VO_2 max/kg is usually higher than 72 ml/

kg/min, so those runners with the highest performance present values between 80 and 85 ml/kg/min. These data are lower in women (Tables 2 and 3).

5. Characteristics of the bicycle

Cycling is still a cyclist-bicycle binomial, and, therefore, keeping the bicycle in good condition is as important as keeping the cyclist in good shape. In high-competition cycling, this task is carried out by the mechanics. This task involves high responsibility because the wrong adjustments of this binomial cause a large part of the microtrauma mentioned above.

Cyclists usually use two bikes for competition:

- One is the usual bicycle, with the necessary modifications for high performance, adjusted to the individual characteristics of each cyclist (Pons et al., 2015).
- On the other hand, the other will be adjusted for the time trial competition and is known as the goat.
    - The dimensions of this bicycle are not the same as the previous one, but rather that the cyclist has a more aerodynamic position. This position is not

comfortable and, if used for a long time, it would cause tendinopathies and back pain. But, as it is used only occasionally, its use in competition does not usually lead to significant side effects, which an adequate physiotherapy session can correct.

6. The most frequent pathology

The most common pathology in cycling is trauma.

A relatively frequent event is a fall, and this can lead to skin injuries of different severity (wounds, excoriations, scrapes, abrasions, or even lacerations) and, very frequently, fractures, both at the level of the extremities and the spine or hip. This means that the doctor of a cycling team must be prepared to act in cases of emergency and on the field.

It is not a question of writing a discourse on trauma, but it is worth remembering that the most common fractures in cycling affect the upper limb and are usually those of the clavicle or the bones of the forearm and wrist.

The most common part of the clavicle fracture is the middle third of the clavicle segment because its weakest point is at the junction of the middle and lateral third of the clavicle.

The pathology that causes the most deaths in cycling is a concussion, which usually occurs after a fall, accompanied by a blow to the head. Nowadays, cases have decreased a lot thanks to helmet use in all types of cycling competition, but concussions should never be discarded. Whenever there is a fall with a blow to the head and a loss of consciousness, it is essential to practice a brain scan to monitor a subdural hematoma.

The most common areas of cycling overuse injuries are the knee, lumbar spine, cervical spine, glutes, Achilles' tendon, wrists, and forearm.

Table 1: Differential diagnoses in overuse injuries

DIFFERENTIAL DIAGNOSTICS IN OVERUSE INJURIES			
Knee	Column	Ankle and foot	Hand
• Patellofemoral syndrome • Chondromalacia • Tendinopathy of the quadriceps tendon • Patellar tendinopathy • Iliotibial band syndrome	• Ruptured disc • Foraminal stenosis • Facet joint syndrome	• Achilles' tendinopathy • Metatarsalgia • Interdigital neuralgia	• Ulnar neuropathy • Radial neuropathy

Source: Authors' work.

But the most frequent type of pathology in cycling is, by far, tendinopathy, especially of the lower limb. We will be particularly interested in:

- patellar tendon;
- quadriceps tendon;
- lateral ligaments of the knee;
- tendon of the fascia lata;
- Achilles' tendon.

Finally, it is interesting to remember the presence of a cycling pathology: endophibrosis of the external iliac artery, described by Chevalier et al. in 1986. Since then, this pathology has been described practically only in cyclists (some sporadic cases in walkers) and is related to pedalling, and the kilometres travelled (patients usually accumulate more than 250,000 km). Typical symptoms include:

- pain;
- loss of power and/or cramps in the affected limb while training with maximum effort.

The patient's lack of atherosclerotic risk factors makes the clinical suspicion of arteriopathy difficult.

7. Role of the team doctor

And, in the end, what should be the role of the team doctor? At first, it will depend on the team's level and, therefore, on the number of health-related professionals who are part of it. Whenever any of them is missing, the possible problems that may arise must be assumed by some of the team members in emergencies and must seek the collaboration of external professionals to monitor the issue.

A cycling team doctor usually faces the most common prevention and treatment of rare pathologies and emergencies, both in the race and daily life.

Thus, therefore, compliance with the vaccination schedule, sports fitness reviews, management of pathologies inherent to continuous travel and journeys, everyday trivial pathology, and control of products consumption potentially related to doping will be the reasons for common areas of concern.

Together with the mechanic and, where appropriate, the biomechanics, you must remember to check the status of the cyclist-bicycle binomial.

Many times, if we do not have a dietitian in the team, we will have to manage, with the probable help of the team's physiotherapist, the adequacy of the daily intakes in and out of the competition. Besides, control the perfect condition of the food bags and drinks for the athletes during the competition and the diets provided to the team's cyclists in the team hotels.

8. Cyclist control

The cyclist's periodic control will be based on a complete medical history. We will be able to expand periodically, taking advantage of the many occasions we will have to comment on different aspects, ensuring that they can be done with sufficient privacy. We must consider that the competition calendar is extensive in the spatial sense and, therefore, we will share many hotel and travel hours.

It is essential to identify minor warning signs: competitions are very long, and simple pimples can evolve into boils, minor respiratory infections can turn into pneumonia, small cavities can evolve into phlegmons.

Periodically, it will be interesting to perform control electrocardiograms so that the tremendous bradycardial response mentioned earlier does not result in undesirable pathologies. Athletes should do an echocardiographic examination. It should have lower periodicity for high-level cyclists, not greater than biannually.

We must not leave the respiratory examination aside. The respiratory system will be the target of infectious and allergic processes throughout the cyclist's life. These athletes ventilate more than 100 l / min for more than 5 hours a day and are exposed to the inhalation of multiple antigens and pollutants that increase their antigenic response. In addition, the parasympathetic predominance that they usually present works against them by favouring bronchoconstriction.

Athletes should do a stress test with electrocardiographic control once a year. The purpose is to monitor the cardiological response to low and high load efforts.

Likewise, regular blood tests are essential to monitoring different enzymes and metabolites related to performance and, especially, to watch iron stores. These stores are required especially during high-intensity training and in competitions. Management of these stores is not usually easy due to diet control, and, frequently, we must resort to oral supplementation.

A serology test should be done occasionally, as asthenia, which usually accompanies some viral infections that can evolve sub clinically, is sometimes unnoticed. This is so, except for a slight decrease in performance, which at the competitive level can be very important.

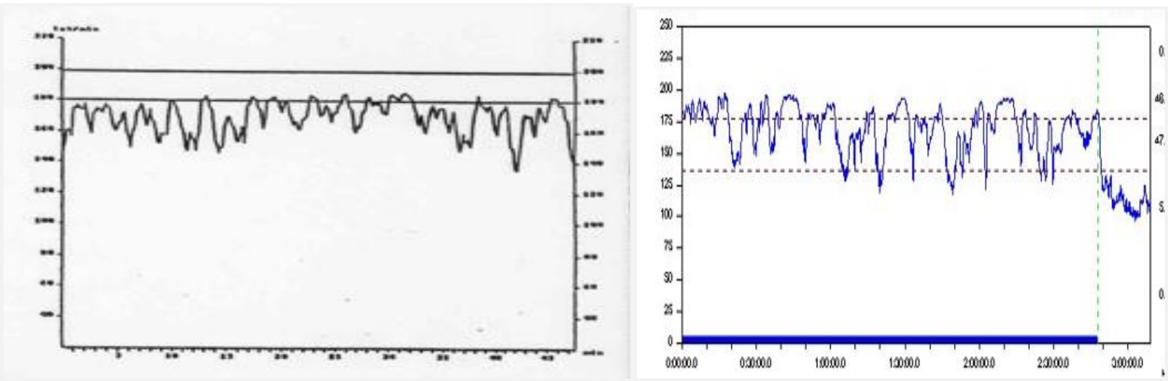
We must be strict in limiting the competition when there is an active viral process. After the competition, there is a decrease in cellular immunity, and any subclinical viral process will exacerbate and become chronic.

If the team does not have its physiologist, the team doctor will probably have to assume those functions related to training control. We will share this information with the physical trainer.

Finally, we must also consider that many competitions occur in height or extreme environmental conditions, either cold, heat, or rain. It would be good to know how to manage adaptation and physical performance in different environmental situations and their health risks, not only as regards cyclists but also for monitoring other team members. Besides, we should have protocols ready for action to solve emergencies that may arise.

Tables and figures

Figure 2: Heart rate behaviour during a football game (left) and a Cycling competition (right)



Source: Authors' work.

Table 2: Approximate caloric cost for an athlete of 70 kg

Ironman	Triathlon	9400 kcal
Milan Sanremo	Cycling	7800 kcal
Paris Dakar Stage	Motorcycling	4000 kcal
Marathon	Athletics	3000 kcal
90-minute game	Football	800 kcal

Source: Authors' work.

Table 3: Percentiles for maximum oxygen consumption, in absolute values or relative to weight, in male cyclists belonging to the Federació Catalana de Ciclisme (n = 290)

	VO2max	VO_2max/kg
	(l/min)	(ml/kg/min)
5th percentile	3.60	55.2
25th percentile	4.14	62.1
50th percentile	4.52	66.8

75th percentile	4.90	71.6
95th percentile	5.43	78.4
99th percentile	5.81	83.2

Source: Authors' work.

Table 4: Percentiles for maximum oxygen consumption, in absolute values or relative to weight, in female cyclists belonging to the Federació Catalana de Ciclisme (n = 50)

	VO_2 max (l/min)	VO_2 max/kg (ml/kg/min)
5th percentile	2.49	44.9
25th percentile	2.90	50.7
50th percentile	3.10	54.7
75th percentile	3.37	58.8
95th percentile	3.73	64.6
99th percentile	4.00	68.6

Source: Authors' work.

4.2 Sports pathologies: tennis

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Introduction

Tennis is one of the most practiced sports worldwide, with more than 200 countries affiliated with the International Tennis Federation and with one of the highest federation licenses (Pluim, Staal, Windler and Jayanthi, 2006).

As in many other sports, there are *amateur*, semi-professional and professional participants. Many injuries are common to other sports, but it is essential to consider that tennis has a rather particular profile, which can vary depending on the age or level at which it is played (Pluim and Safran, 2004).

The different equipment used, the constant changes in the playing surface during the season, the biomechanics of each athlete, the physical demands of a competitive calendar, and an extremely demanding ranking scoring system result in an injury profile that differs from other racket or throwing sports.

All sports injuries, including tennis, are a common cause of disability and, in some cases, absence from work. This can have a high cost on an economic, personal, and social level.

Aspects to consider in tennis injuries

Before developing the most frequent injuries in tennis, it is essential to know this sport more specifically.

Tennis is a sport in which great aerobic efforts (duration of matches or championships) are mixed with anaerobic efforts (the power of strokes, races, and sudden direction changes from one side to the other). This is combined with various strokes and mechanics that result in a very particular injury profile.

As in most sports involving overhead gestures, overuse and repetitive microtrauma can adversely affect the shoulder and elbow.

Regarding acute injuries by indirect mechanism, they tend to involve the lower extremities to a greater extent.

Biomechanics

Four central biomechanical regions should be considered as the weakest points in the tennis player: in the upper limb, the shoulder and elbow, on the trunk, the lumbar spine, and finally, the lumbopelvic area. A repeated and continuous overload produces the impact of these anatomical areas without proper compensation.

The serve mechanism (Figure 3), one of the most aggressive strokes in tennis, begins with the recruitment of muscle fibres at the level of the *calf* and quadriceps muscles. Later, it is transferred to activate the lumbopelvic region and from the spine to the shoulder, elbow, wrist, and hand to end with a sudden eccentric contraction of the abdominal muscles in trunk rotation and practically plyometric unipodal support to start the sprint. For example, Kibler (1995) calculated that the leg-hip-trunk component produced 51% of this sporting gesture's kinetic energy.

Figure 3: Complete serve mechanism

Source: [Untitled image on full-serve mechanism]. (sf). Retrieved from https://guillec0ria.es.tl/Solo-Tenis.htm

If these anatomical locations are considered, according to various epidemiological studies, the injuries could be distributed as follows (Pluim et al., 2006; Hutchinson, Laprade, Burnett, Moss and Terpstra, 1995):

- Lower limb: 31% to 67%
- Upper limb: 20% to 49%
- Trunk: 3% to 21%

The material used and playing surfaces

One of the aspects that impacts injuries the most in tennis is the material used and its provoked changes. Many tennis injuries are caused by repetitive microtrauma that causes an overload poorly tolerated by the athlete. Here is where the material becomes essential.

The material includes rackets and balls mainly. As in many sports, there are commercial interests in playing with a specific racket or balls. In addition, these vary depending on the competition.

There are multiple factors to consider regarding the racket:

- **The *grip* or grip type**: there are different types of grips. Those that stand out:

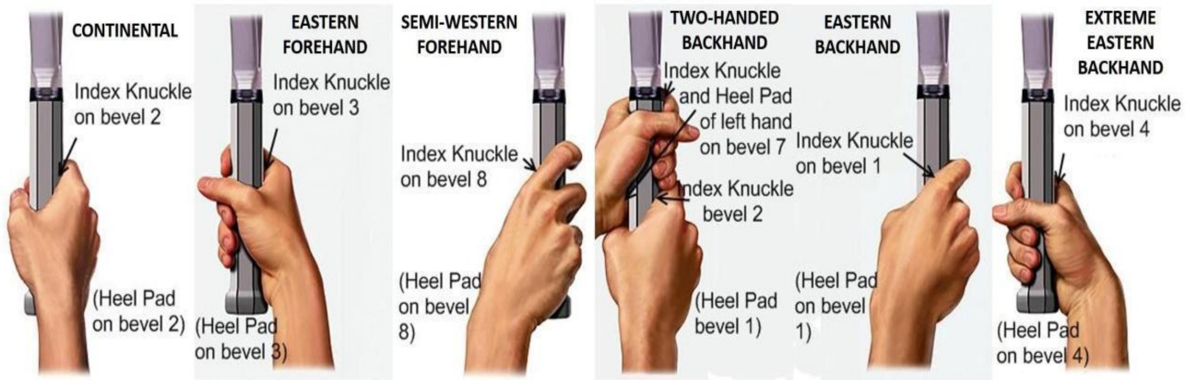
- *semi-western;*
- *full western;*
- *eastern;*
- continental (Figure 4).

● **The racket's weight**: some rackets weigh a few grams more than others to make more powerful or faster strokes.

● **The string's tension**: each player plays with a specific tension adapted to their type of play. As a rule, the higher the tension, the better the ball control. However, to make the ball keep the same speed, we need to strike harder. This tension can be varied when the coach or the player considers it convenient.

● **The way to hold the racket**: depending on the game type (and the tennis culture of the country where the player is from), the player can hold the racket in one way or another.

Figure 4: Types of *grip* in tennis



Source: [Untitled image on types of grips in tennis]. (sf). Retrieved from https://twitter.com/USPTA_Tennis/status/686627413711716352/photo/1

It is easy to think that any change in these components can cause the player's imbalance. For example, suppose a player has been playing with a specific type of grip and string tension for 9 years, and he makes a sudden change in tension and grip and continues with the same activity. In that case, this will generate an overload situation. In turn, this is likely to trigger an injury due to overuse.

This means that different injuries can be related depending, for example, on the type of *grip* used. Thus, players who use a *semi-western* or a *western* grip tend to suffer more injuries at the ulnar wrist level, while players who use an *eastern grip* tend to suffer more at the radial level (Tagliafico et al., 2009). The same happens with the balls and with the changes of the playing surface. The tennis circuit is played on different surfaces. The main ones, from least to most aggressive, are grass, clay, and hard courts.

In addition to the above, one of the main risk factors of injury for tennis players is training errors. The types of material used are also included in those errors.

Main injuries in tennis

We will address the primary injuries that affect the tennis player per anatomical region. In Table 1, which is a table modification by Dines, Bedi, Williams, Dodson, Ellenbecker, et al. (2015), we can summarize the main pathologies that affect the tennis player.

Among these injuries, some may be common to other sports, but others are tennis-specific. These are precisely the ones that we will discuss in this chapter:

- Suprascapular nerve injury or impingement.
- Ulna carpal joint pathology.
- Injury to the rectus abdominis muscles.
- Spondylolysis / listhesis.
- Femoroacetabular hip impingement.

Table 5: Main injuries in tennis

ANATOMIC REGION AND INJURY	MECHANISM
SHOULDER	
Internal impingement	Repeated movements above the plane of the head
SLAP lesions	Repeated movements above the plane of the head
Suprascapular nerve injury	Repeated movements above the plane of the head
ELBOW	
Lateral epicondylitis	Backhand stroke with a flexed wrist
Medial epicondylitis	Too open right blow and/or with little structured arm
WRIST	
Posterior ulnar tendinopathy	Ulnar deviation of the non-dominant arm in a two-handed backhand stroke
Posterior ulnar subluxation	Abrupt movement in forced ulnar flexion
Ulna-carpal impingement	Repeated microtrauma in ulnar deviation
ABDOMINAL WALL	
Rupture of the rectus abdominis	Forced eccentric contraction after a serve or smatch
LUMBAR REGION	

Lower back pain	Continued overload
Spondylolysis / listhesis	Constant overload, especially in teenagers
HIP	
Femoro-acetabular impingement	Forced and repeated movements of hip rotation with a load
LEG	
Injury of the medial head of the gastrocnemius	Eccentric contraction with a knee in extension and ankle in dorsal flexion

Source: adapted from Dines et al., 2015.

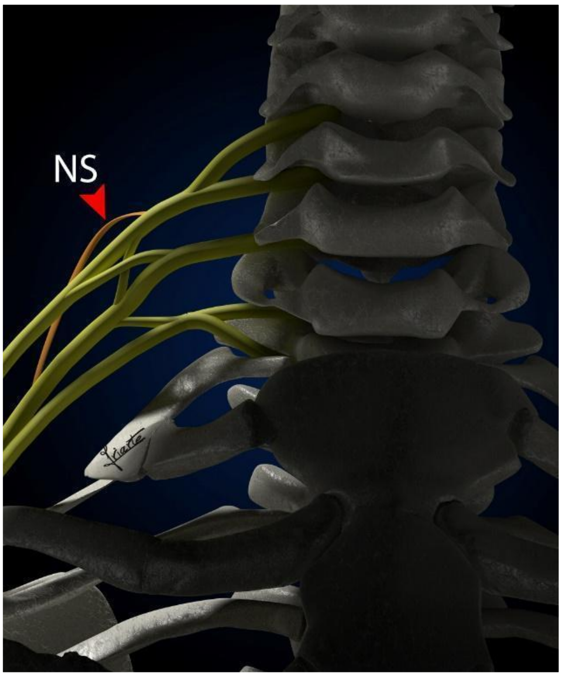
Suprascapular nerve injury/impingement.

Although it is not the most common injury in the anatomical region of the shoulder, it is one of the most typical injuries in tennis. If it is not suspected, its difficult diagnosis causes to be found at advanced stages of the pathology and, therefore, its treatment is more complicated.

The suprascapular nerve arises from the posterior roots of the upper primary trunk of C5 – C6 (Figure 5) and shows 2 points of conflict: one is in the coracoid notch and the other at the spine level of the scapula (Figure 6).

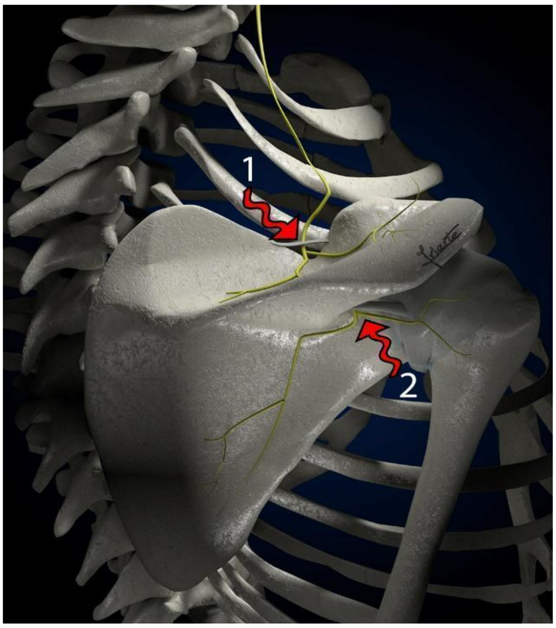
The injury consists of this nerve's entrapment at one of these points and the symptoms that derive from it.

Figure 5: Brachial plexus. The suprascapular nerve (NS) arising from the upper primary trunk formed by the C5 and C6 roots



Source: Authors' work.

Figure 6: Main points of conflict of the suprascapular nerve: in the coracoid notch (1) and the spinoglenoid (2)



Source: Authors' work.

Production mechanism

Anatomical factors are specific to each person that favour compressions in the recently discussed osteoligamentous structures.

There are dynamic factors, such as the repeated stretching of the scapula in each of the forehand strokes. There is a "sweeping" effect of the scapula itself on the rib cage.

The gestures that produce this injury in tennis are the following:

- The end of the forehand stroke (forced adduction + antepulsion).
- End of a serve (antepulsion + internal rotation).
- High one-handed backhand (wide horizontal retropulsion).
- Serving organisation (horizontal retropulsion).

Clinic and exploration

It is a pathology of difficult diagnosis because the pain can be of acute appearance or, more frequently, very progressive appearance. It is located at the armpit's posterior border level and in the scapula's infraspinous fossa, generally, with irradiation to the dorsal region and with nocturnal worsening.

In addition, the association with the pain of secondary subacromial origin is frequent, which further complicates the diagnosis.

There is suspicion of this pathology when the exam detects marked atrophy of the supraspinatus muscle and, especially, of the infraspinatus muscle (which, in addition, is painful on direct palpation) (Figure 7).

If the patient is asked to perform push-ups, this atrophy will show up even more. It is not uncommon for a winged scapula to be observed due to the association of a dysfunction of the long thoracic nerve that causes weakness of the anterior serratus (Figure 8).

Figure 7: Atrophy of the muscles of the right infraspinatus

Source: Authors' work.

Figure 8: Provocative maneuver with abduction and anteversion at 90°, which reveals a winged scapula (by alteration of the long thoracic nerve)

Source: Authors' work.

Diagnosis

Considering what we mentioned before, the critical tools for diagnosing suprascapular nerve involvement are clinical suspicion and exploration.

As for the complementary tests, the one that provides the most information is the rest and stress electromyogram. Experts must do it since it is not one of the most common nerve roots to explore.

Treatment

This compression of the suprascapular nerve is favoured, in most cases, by an imbalance between internal rotators and external rotators (very typical in the world of tennis). That is why the first therapeutic option consists of the decrease or complete cessation of sports activity and the start of physiotherapy exercises that contribute to the rebalancing of the shoulder girdle.

In those cases where the pain does not allow these exercises, echo-guided infiltrations on the scapular notch may be helpful.

Finally, in case of compression with a severe clinic, surgical treatment should be followed when there is a poor response to conservative treatment to achieve the nerve release.

Ulna carpal joint pathology.

Within the pathology at the ulna-carpal joint level, various types of injuries are included. In tennis, the main ones are *ulna-carpal* impingement, posterior ulnar tendon injuries, and triangular fibrocartilage complex injuries.

In all of them, the pain is in the ulnar recess. It is produced by repeated mechanisms of flexion and adduction of the wrist (Figure 9) that cause continuous micro traumatisms on this area.

Figure 9: Movement of forced ulnar deviation against resistance in the forehand stroke

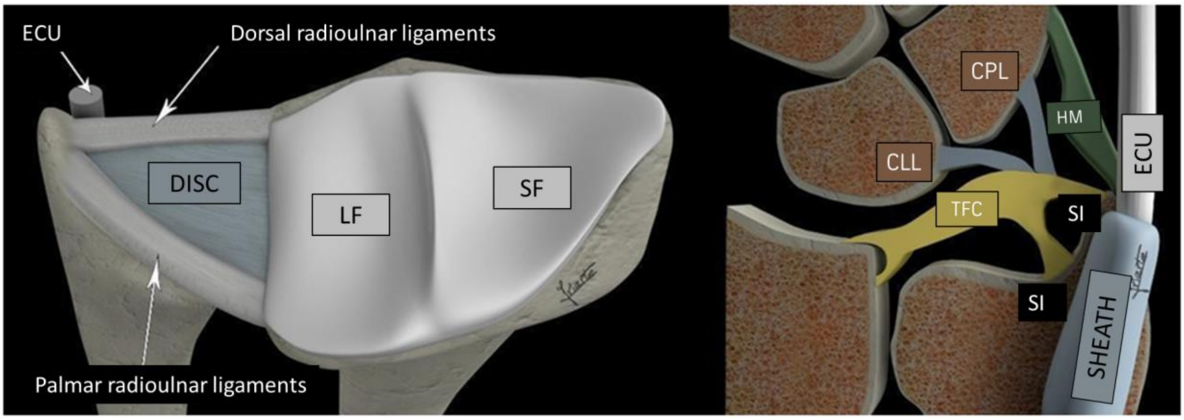
Source: [Untitled image on forced ulnar deviation movement against resistance in the forehand strike]. (sf). Retrieved from https://www.perfect-tennis.com/federer-starts-off-2016-with-win-against-kamke-in-brisbane/

The clinical exploration is also very similar in all entities since they are generally related to each other. The patient will report pain with palpation of the ulnar-carpal space, which increases when performing the ulnar deviation and passive prono-supination manoeuvres with an open hand.

Ulna-Carpal Impingement

The anatomy of the ulna-carpal space is complex. It is formed by the ulnar-carpal joint, the ulnar styloid, the lunate, the pyramidal, and the pisiform in bone margins. The homologous or meniscoid meniscus, the triangular fibrocartilage, the intra and extracapsular ligaments, and the posterior ulnar tendon, as soft elements (Figure 10).

Figure 10: Ulna-carpal space

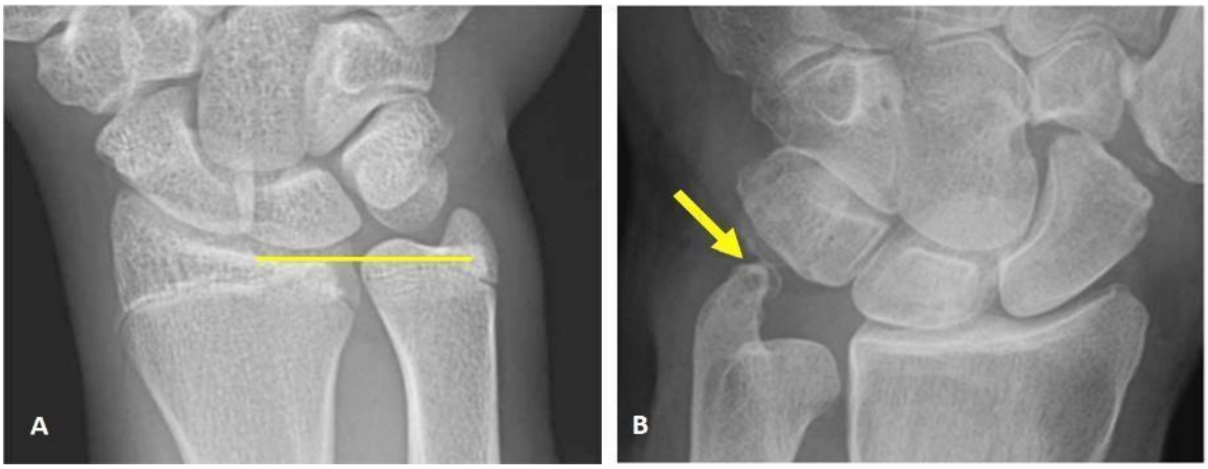


Source: Authors' work.

Figure 10: LF: lunate fovea; SF: scaphoid fovea; ECU, Extensor carpi ulnaris; CLL: cubito-lunate ligament; CPL: cubito-pyramidal ligament; SI: styloid insertion; HM: homologous meniscus.

The main risk factors for suffering an ulnar carpal impaction syndrome are the anatomical variant, known as ulna plus, or ulnar styloid magna (Figure 11). If repeated wrist flexion and adduction mechanisms are added to these anatomical characteristics, the tennis player will likely develop a syndrome of ulnacarpal impingement (Tagliafico et al., 2009; Vezeridis, Yoshioka, Han & Blazar, 2010). The type of racket grip used cannot be ignored either, since the more closed the movement, the more *impingement* is favoured.

Figure 11: Conventional radiograph showing a congenital ulna plus (A) and ulnar styloid magna (B): both condition the *ulna-carpal* impingement

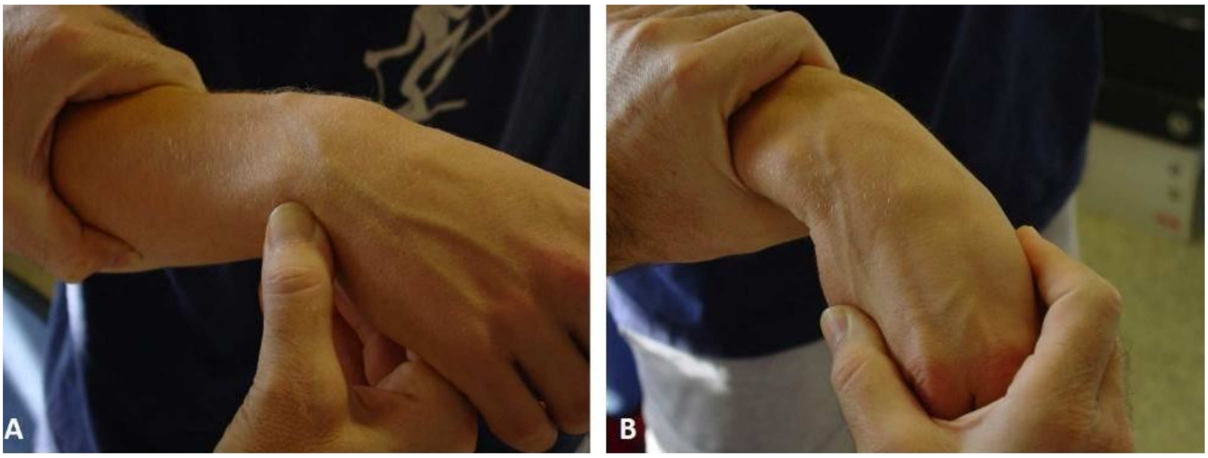


Source: Authors' work.

Diagnosis

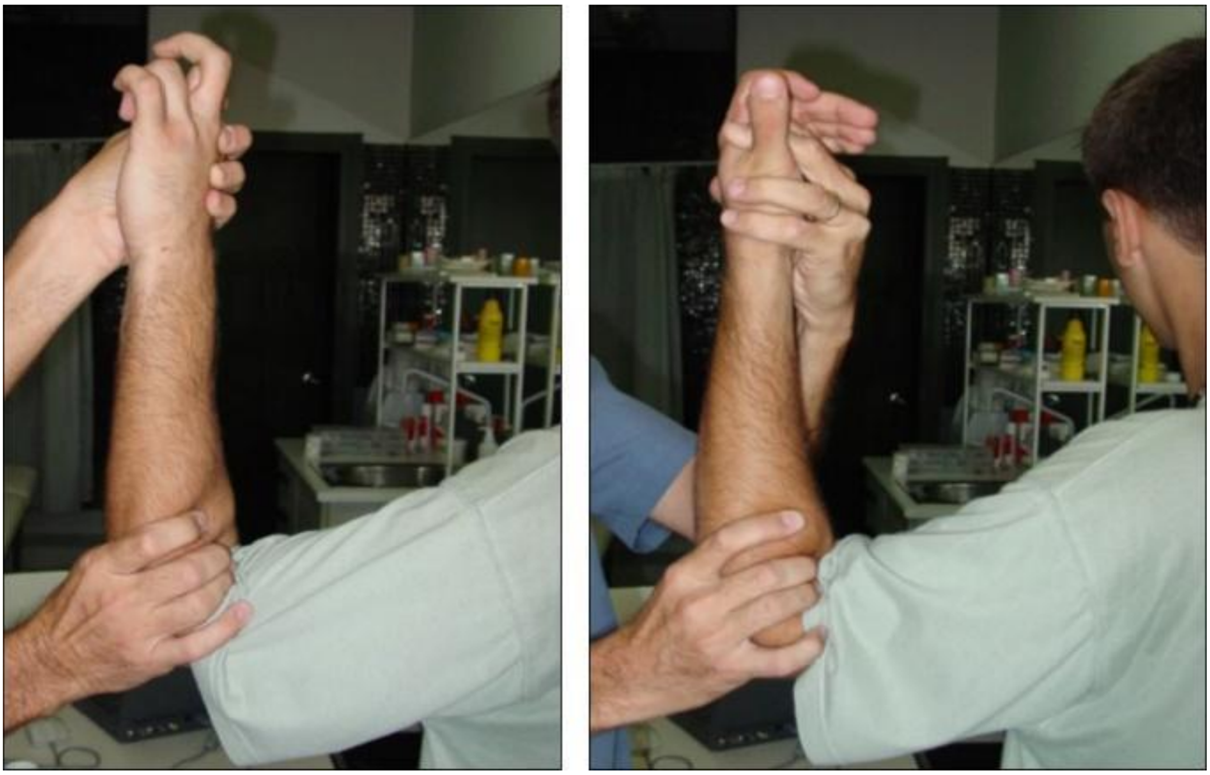
The initial diagnosis is by clinical suspicion and conventional radiography (Figures 12 and 13). Radiography is usually done in a neutral position and in forced radial and ulnar deviation to observe the behaviour of this space (Figure 12).

Figure 12: manoeuvres of clinical provocation of ulnar-carpal pain. Pain on infrastyloid palpation (A) and pain on forced ulnar deviation (B)



Source: Authors' work.

Figure 13: Passive pronation-supination manoeuvres



Source: Authors' work.

Figure 14: Images of conventional radiography projections to assess possible ulnar-carpal impingement, including radiography in ulnar deviation (A) and radial deviation (B)

Source: Authors' work.

Magnetic resonance imaging (MRI) is helpful in cases where an associated soft tissue lesion is suspected (quite common, especially in longstanding instances) or for early diagnosis. MRI can detect bone edema as an early sign of ulnar impaction before detecting changes on conventional radiography (Vezeridis et al., 2010).

In some doubtful cases, an anesthetic block used as a *test* in the ulna-carpal space can also be very useful in screening this pathology.

Treatment

The initial treatment is always conservative. The objective is to perform ulnar carpal stabilization using the muscular, ligamentous, and tendinous elements through physiotherapy exercise guidelines.

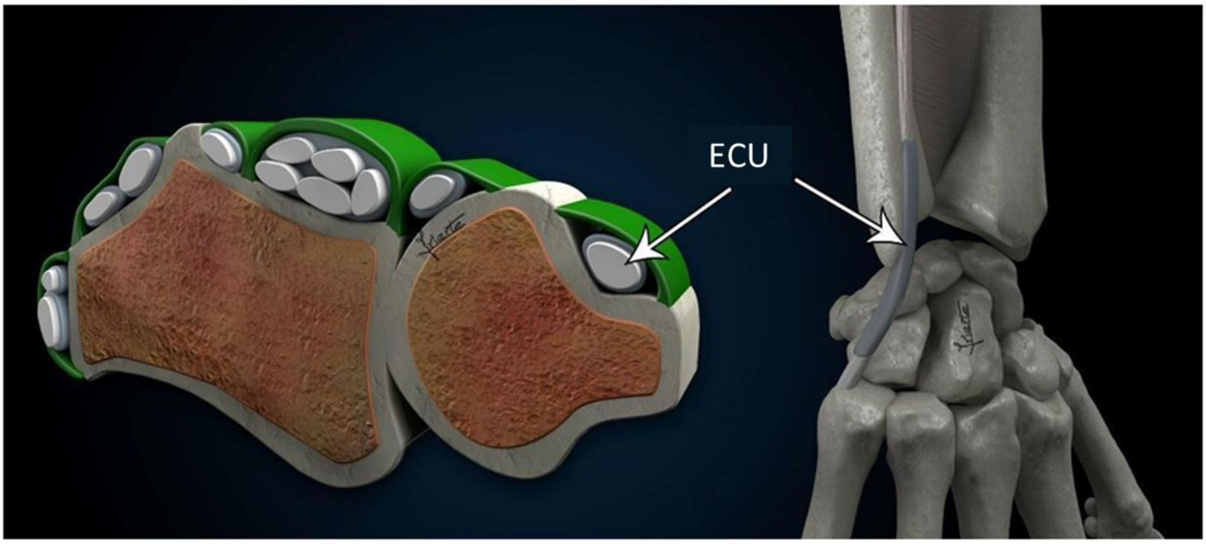
A rigid orthosis can be used in the first weeks to avoid forced movement in ulnar deviation.

In cases where the painful condition cannot be controlled by conservative treatment or when it returns when the activity is reintroduced, we should consider a surgical option to decompress this space or solve the existing lesions.

Pathology of the posterior ulnar tendon

The posterior ulnar muscle originates at the medial epicondyle level of the humerus. It inserts at the internal tubercle level at the fifth metacarpal base. At the wrist level, it forms the sixth compartment of the extensors, serves as the "ceiling" of the ulnar-carpal space, and is closely related to the triangular fibrocartilage and meniscoid of this space (Figures 10 and 15).

Figure 15: Anatomical diagrams of the Extensor Carpi Ulnaris (ECU) tendon

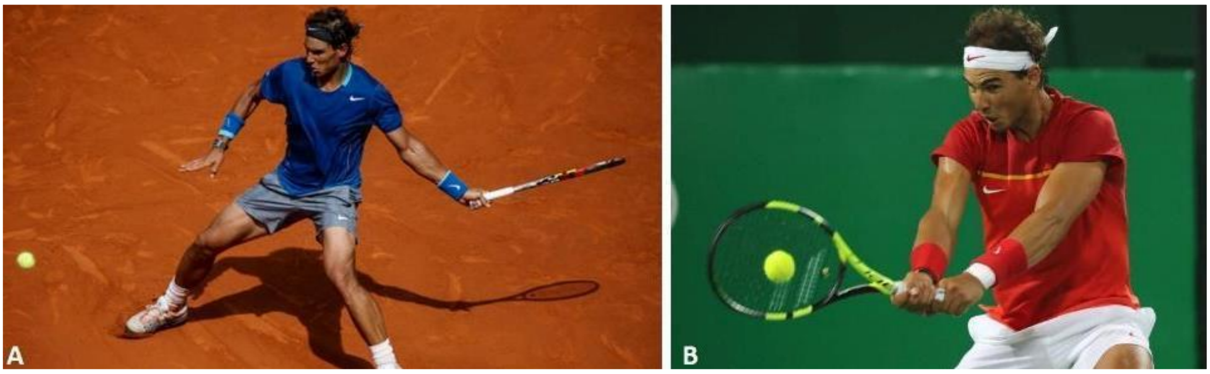


Source: Authors' work.

Its function is to carry out wrist extension and adduction and, in addition, to stabilize the distal radioulnar joint in pronation (the ligamentous system is distended in this position, and the posterior ulnar blocks the distal radioulnar). Therefore, this is a tendon that suffers constant aggression during tennis practice.

The mechanism of injury occurs when the wrist moves from a neutral position (dorsiflexion and slight radial tilt) to a forced position of volar flexion + ulnar tilt + pronation. In tennis, this occurs in the forehand *lift* and the backhand stroke (Figure 16).

Figure 16: Tennis strokes that irritate the posterior ulnar tendon. Forehand *topspin* stroke (A) and backhand stroke (B)



Source: Authors' work.

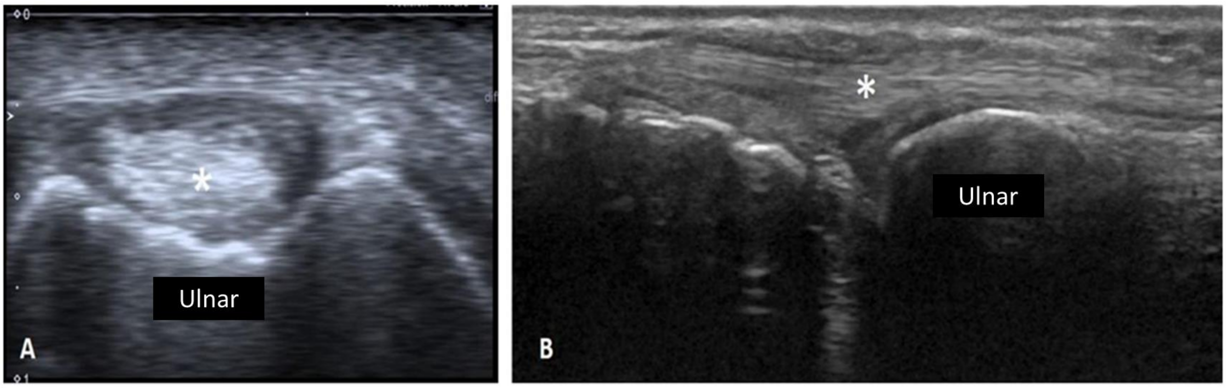
Diagnosis

The pain is sharp after a topspin forehand *stroke* or a backhand stroke. There may be slight swelling at the ulnar edge when there is an injury to the tendon itself.

The forced passive supination manoeuvre is very painful, passive pronation is painful, and isometric contraction is uncomfortable.

In posterior ulnar pathology, ultrasound is of great help. It is the imaging technique of choice. In cases of acute injury with tendinopathy or tenosynovitis and in cases of dislocations or subluxations (using dynamic maneuvers), ultrasound can give a reliable diagnosis (figures 17 and 18).

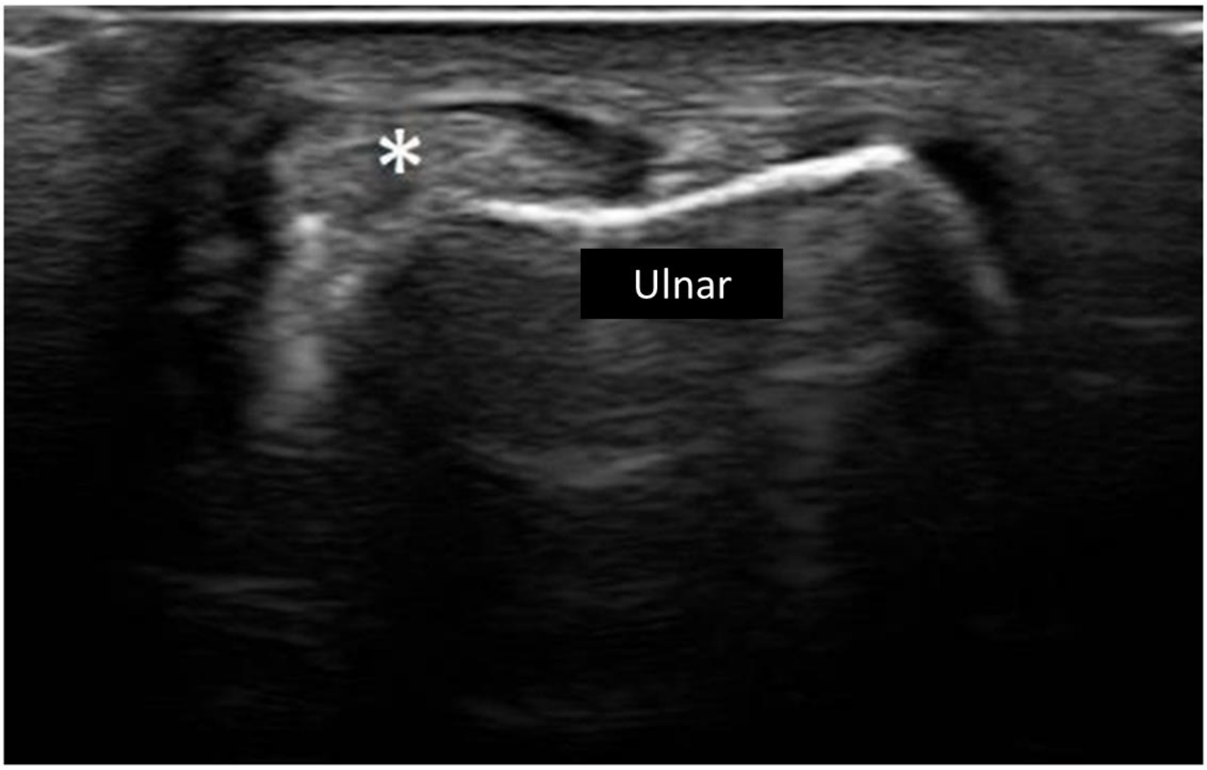
Figure 17: Short-axis ultrasound exploration of the posterior ulnar (A) and long-axis ultrasound exploration of the posterior ulnar (B)



Source: Authors' work.

In Figure 17, on the left (A), a circular hypoechoic image surrounds the posterior ulnar tendon (asterisk) that shows no alterations. This image corresponds to posterior ulnar tenosynovitis. Towards the right (B), an image of a discrete alteration is observed in the posterior ulnar ecotrama (asterisk). Image consistent with mild posterior ulnar tendinopathy

Figure 18: Posterior ulnar short-axis ultrasound exploration



Source: Authors' work.

In Figure 18, it can be seen how the posterior ulnar tendon (asterisk) is partially out of its compartment. Image compatible with posterior ulnar dislocation on dynamic exploration.

Treatment

In cases where there is tendinopathy or isolated posterior ulnar tenosynovitis, treatment will be conservative. It is about avoiding the injury mechanism and undergoing physiotherapy treatment. Immobilisation is saved for cases in which there is an injury to the tendon sheath.

When an acute sheath injury is detected, treatment is orthopaedic by immobilisation, approximately 4 weeks (in slight extension and ulnar inclination). Then the patient should start a rehabilitation treatment.

In the case of a chronic or old sheath lesion, the treatment is conservative by relative rest (avoid the injury mechanism), functional bandage of the wrist. If necessary, the treatment may be physiotherapy and, in some cases in which pain prevents the correct rehabilitation treatment, we should choose an ultrasound-guided infiltration.

In cases where ultrasound or MRI reveals a dynamic posterior ulnar tear or dislocation, we should choose restorative surgical treatment.

Triangular fibrocartilage complex injuries

Triangular fibrocartilage complex injuries include injury to the fibrocartilage itself or injury to the meniscoid.

The production mechanism and the clinic are the same that have been discussed so far in this section. Suppose this ulnar-carpal impingement and the forced movements of ulnar impaction are prolonged in time without showing symptoms previously. In that case, an injury of the meniscoid or the triangular fibrocartilage may occur. These are the components found in this ulna-carpal space together with the palmar and dorsal distal radioulnar ligaments, the ulnalunar ligament, the floor of the posterior ulnar's sheath, and the joint capsule (Esplugas and Aixalà, 2014).

Another possible production mechanism is the fall on the wrist in hyperextension with the forearm in pronation.

Diagnosis

The diagnosis of certainty of these lesions is, mainly, by MRI, or, even better, with arthro-MRI (with contrast injection), since it allows more precise visualisation of the involvement of the meniscoid, fibrocartilage, or even the sheath or posterior ulnar sub-sheath.

Conventional radiography or ultrasound may be helpful in the first place, but they do not allow diagnostic confirmation.

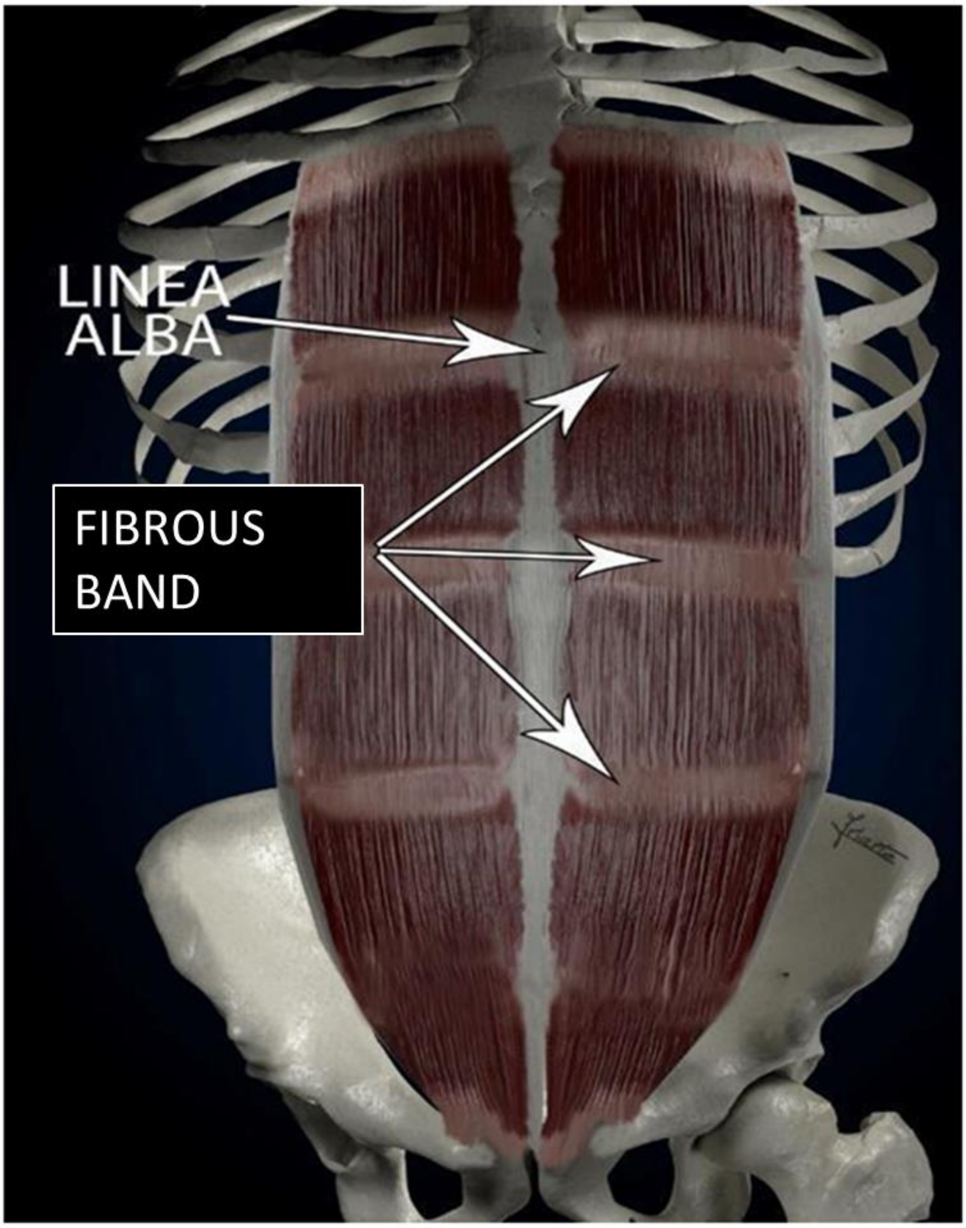
Treatment

Treatment of triangular fibrocartilage complex injuries will largely depend on the degree of injury and the structures affected. In a high-level tennis player (even if they are not professional players), the treatment must be surgical through repair arthroscopy.

Injury to the rectus abdominis muscles

The rectus abdominis (RA) musculature comprises pairs of muscles separated in the midline by the linea alba. Each group has two tendon origins: a medial head, which arises from the anterior surface of the pubic symphysis, and a more significant lateral portion, which originates from the upper edge of the ridge. Both join to insert into the fifth, sixth, and seventh costal cartilage. The muscle is partially interrupted by three fibrous bands or tendon intersections that blend inseparably with the anterior layer of the rectus sheath. These bands are found at the level of the umbilicus, the xiphoid process, and midway between the two (Figure 19).

Figure 19: Anatomical diagram of the rectus abdominis



Source: Authors' work.

In throwing and asymmetric sports, injuries at the RA level are typical. Therefore, they are injuries in a non-articular muscle (it is not usual), multilaminar and produced by eccentric contraction mechanism during precise sports gestures, such as the serve and the *smash* in tennis, or the spike in volleyball (Balius, Pedret, Pacheco, Gutiérrez, Vives et al., 2011).

The injury mechanism occurs after a hyperextension of the lumbar spine and stretching of the abdominal muscles with a contraction of the latter in the assembly phase of the serving arm. Next, a flexion movement of the spine is performed with significant contraction of the entire abdominal muscles. The gesture is always with twisting of the spine towards the side of the injury. In other words, it affects the contralateral side to the serving arm or *smash*.

Various studies have shown that professional tennis players have more significant muscle development, both in mass and volume, of the RA on the non-dominant side compared to the dominant side (Balius, Pedret, Galilea, Idoate and Ruiz Cotorro, 2012; Sanchis-Moysi, Idoate, Dorado, Alayón and Calbet, 2010). This adaptation occurs at a very early age and must be considered when assessing possible injuries at this level.

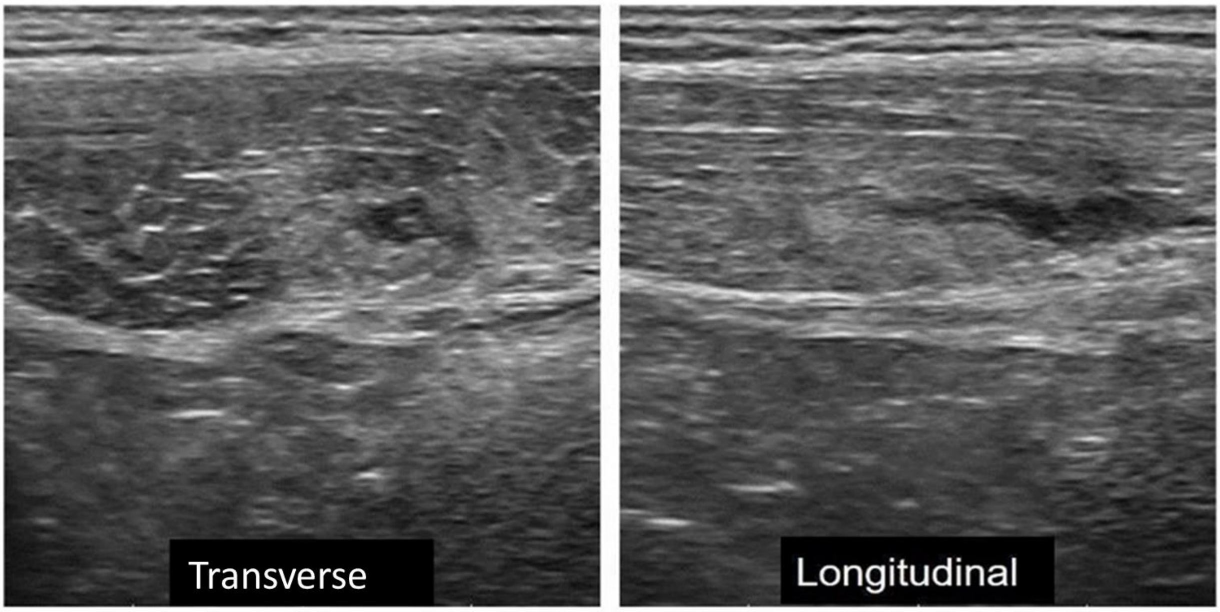
Muscle injuries due to the indirect mechanism of RA are myoconnective. In the cases of rupture in tennis players, the lesion is practically always attached to the posterior connective plane in the deep epimysium.

Diagnosis

After taking a serve or a smash, the tennis player reports acute and disabling pain and localises it to a fingertip area. This pain has mechanical characteristics and, generally, is located below the umbilicus level, that is, in the lower abdominal wall.

In these cases, as in most muscle injuries, the diagnostic test of choice is ultrasound. In the ultrasound image, a continuity solution is observed at the level of the fibrillar network located in the deep epimysium, which can sometimes be accompanied by a small liquid collection (Figure 20).

Figure 20: Transverse and longitudinal axis ultrasound exploration of an RA lesion



Source: Authors' work.

Note the discontinuity of the fibrillar pattern and the injury's location in the muscle's deepest area.

Treatment

Treatment is always conservative through physiotherapy. It begins with a relative rest of between 1 and 2 weeks with adjuvant rehabilitation treatment. Only the serve movement and *smash* are limited (the player can train without making these gestures). Advanced therapy of stretching is started when the pain has completely disappeared.

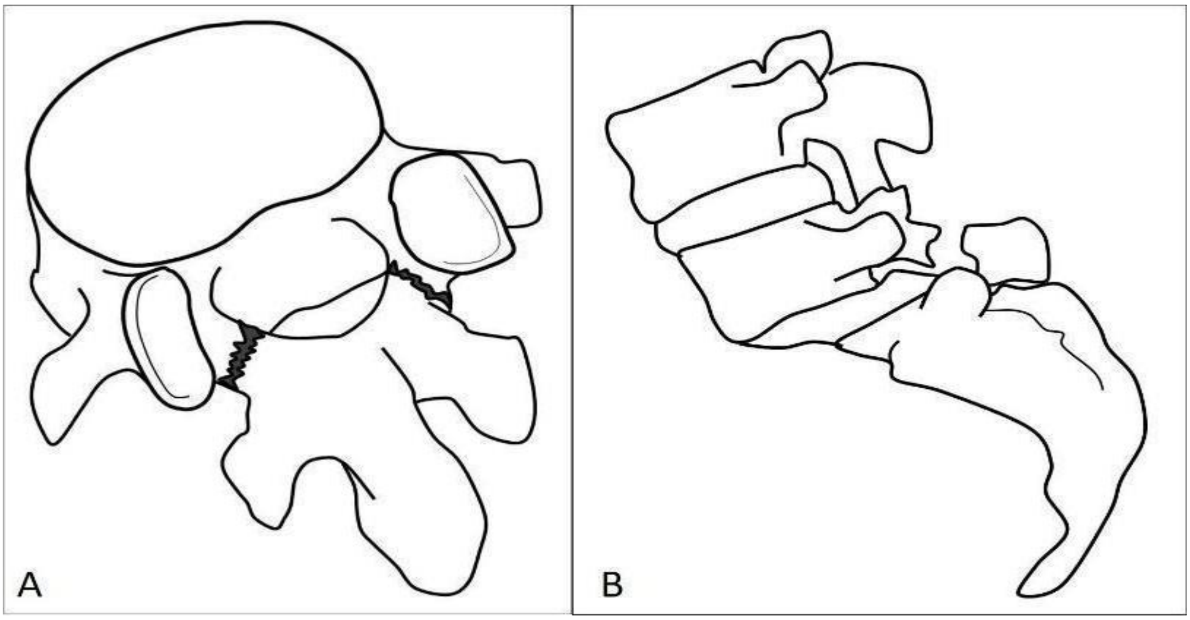
The main complication of this injury is a recurrence, prevalent because the injury mechanism is very aggressive and, sometimes, the time of *return to play* is too short.

Spondylolysis / listhesis

Spondylolysis is a bone defect at the level of the *pars interarticularis* of a vertebra (Figure 21, A). The *pars interarticularis* is a small isthmus located between the articular facets of the superior and inferior vertebrae. It usually occurs bilaterally and affects L5 (85-95%), and impact on the proximal lumbar vertebrae is uncommon (Ruiz-Cotorro, Balius Matas, Estruch Massana & Vilaro Angulo, 2006), in which case it is usually unilateral. Unilateral isthmic injury is observed in 14-30% of cases.

By *spondylolisthesis*, we understand the displacement of a vertebra on its immediate inferior (Figure 21, B). Such displacement will occur more frequently in the lumbosacral hinge.

Figure 21: Schematic image of spondylolysis (A) and spondylolisthesis (B)



Source: Authors' work.

In recent years, there has been a variation in the playing characteristics of tennis. Changing the materials of rackets, strings, courts, or even balls increase the speed and power of the strokes, which require an approach to the ball and a much faster exit after the stroke. This leads to a more abrupt lumbar rotation (with associated flexion-extension component) and a more powerful impact in both the forehand and backhand strokes.

It has been discussed whether this increase in rotational load on the spine is due more to the serving mechanism (where a forced lumbar hyperextension-flexion occurs with a greater or lesser rotation component depending on the serving used) or in the forehand or backhand strokes. In our experience with the Spanish federation, we believe that today, the forehand or backhand strokes are more aggressive for a possible injury in the form of spondylolysis than the serve.

These mechanisms and movements are typical of the game, together with a weakness of the abdominal muscles and an excessive rigidity of the hamstring muscles leading to the production of this stress reaction at the lumbar spine level with a higher percentage in the sports population.

The prevalence of isthmic injury in the sports population increases concerning the non-sports Caucasian population by 10-20%. Isthmic injury is observed in sports where flexion-extension predominates (gymnastics, butterfly swimming) associated, sometimes, with rotations (tennis, high jump) or sports with simultaneous loads, such as weightlifting, trampoline jumping, or taekwondo (Ruiz-Cotorro et al., 2006; McCleary and Congeni, 2007).

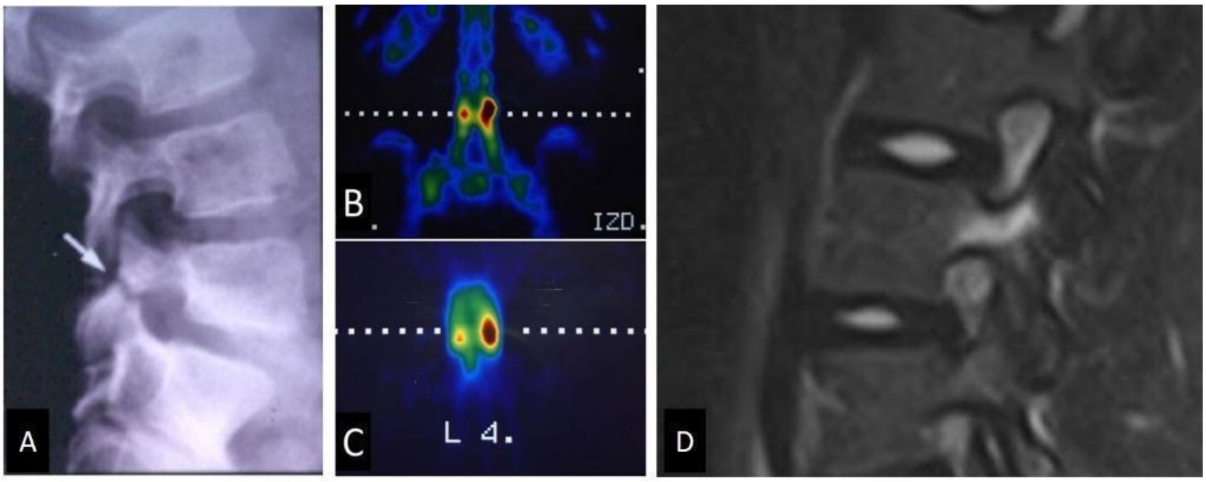
Diagnosis

The correct evolution of spondylolysis in adolescent athletes depends, to a great extent, on making an early diagnosis. For this reason, an athlete with acute low back pain or long-term evolution has greater or lesser radiculopathy, which increases with lumbar lateralisation and rotations. Spondylolysis should be discarded in the one-legged lumbar hyperextension test, accompanied by a decrease in flexibility of the hamstring muscles.

There are 4 complementary tests, each with different properties and characteristics. On all occasions, the combination of the clinical history with one or more of these tests will give us a particular idea of the injury's natural history moment.

The tests are plain radiography (especially lateral and oblique views), scintigraphy + SPECT, computed tomography (CT), and MRI. The combination of these is what provides the definitive diagnosis (Figure 22).

Figure 22: Imaging explorations applied to spondylolysis



Source: Authors' work.

About Figure 22:

- A: image of spondylolysis (lateral projection).
- B and C: scintigraphy images + SPECT, where increased uptake is observed, showing active spondylolysis.
- D: MRI image showing increased signal at the *pars interarticularis* compatible with bone edema at this level (stress reaction).

Treatment

Except in advanced cases and with associated complications, the treatment of spondylolysis in tennis players is conservative. Reconstruction of the *pars* can be achieved using different types of rigid or soft corsets (Ruiz-Cotorro et al., 2006) that exert an antilordotic action on the spine or limit lumbar extension (McCleary and Congeni, 2007).

There is a lot of discussions as regards the time that this corset should be worn. In this sense, some studies recommend two or three months of immobilisation or less, and others advise using the corset for up to six months. In addition, we should consider that, in many cases, an excellent clinical result is achieved without the reconstruction of the *pars*, which remains radiographically visible, if the isotopic or MRI tests do not show activity.

The treatment with a corset and sports rest must be associated with performing lumbar recovery exercises introduced very progressively from the third or fourth week of wearing the corset.

Femoroacetabular impingement.

In the last years, due to the change of materials and training methodology and game type, one of the pathologies that have increased more in tennis is the hip joint. It has become one of the most restraining and prevailing injuries in tennis now (Pluim, Staal, Windler and Jayanthi, 2006; Dines ET to., 2015).

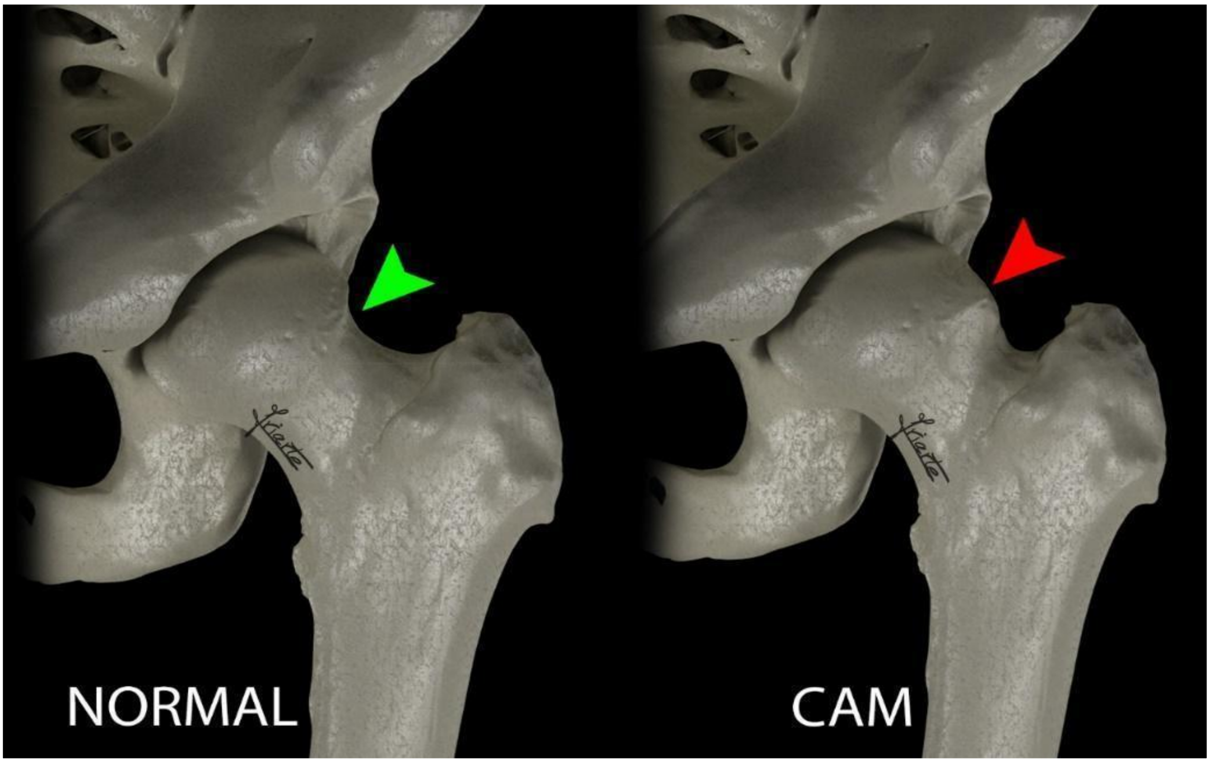
The femoroacetabular impingement (FAI) is commonly known, with all its associate variants.

The FAI has been defined recently as a dynamic clinical disorder related to the hip, including a triad of symptoms, clinical signs, and findings in images. It occurs through symptomatic shock between the femoral head and the acetabulum (Griffin, Dickenson, O'Donnell, Agricola, Awan et al., 2016). This dynamic concept of FAI, in recent years, has gained acceptance as one of the main causal factors related to hip pain and osteoarthritis.

This impingement can occur because of various conditions, as defined by Sankar, Nevitt, Parvizi, Felson, Agricola et al. (2013):

- Abnormal morphology of the femur (CAM type deformity) or of the acetabulum (PINCER type deformity) (Figure 23).
- Excessive contact between the femur and the acetabulum.
- Repeated movements in a supraphysiological range of motion result in abnormal contact between the femur and the acetabulum.
- Repeated microtrauma.
- Presence of soft tissue lesions.

Figure 23: Diagram of the typical morphology of the hip joint and diagram of CAM deformity as one of the leading causes of anterior femoroacetabular impingement



Source: Authors' work.

The production mechanism, in summary, would be that of repeated microtrauma and sudden movements in an athlete who already presents a CAM-type or PINCER-type deformity. This mechanism is prevalent in tennis due to the execution speed and the power required in strokes from the back of the tennis court. The abrupt rotation done with the trunk and the hip in the sequence of reaching the ball, hitting with force, and causing an abrupt exit to prepare the next stroke determines its high incidence in tennis players.

The FAI symptoms are usually progressive. The athlete begins with discomfort at the inguinal region but can also refer to the gluteal region, the front thigh, and even the lumbosacral area. Once established, it is accompanied by deep stabbing pain at the inguinal level with the forced hip flexion manoeuvre and, usually, limited internal and external rotation mobility.

We should note that chondral and hip labral lesions can frequently accompany advanced lesions in this anatomical region. The association of these lesions with FAI complicates the treatment and prognosis of this pathology.

Diagnosis

The diagnosis should always be by clinical, exploration, and imaging tests. At a clinical and exploration level, we have already mentioned what must be considered, so that this section will focus on imaging tests.

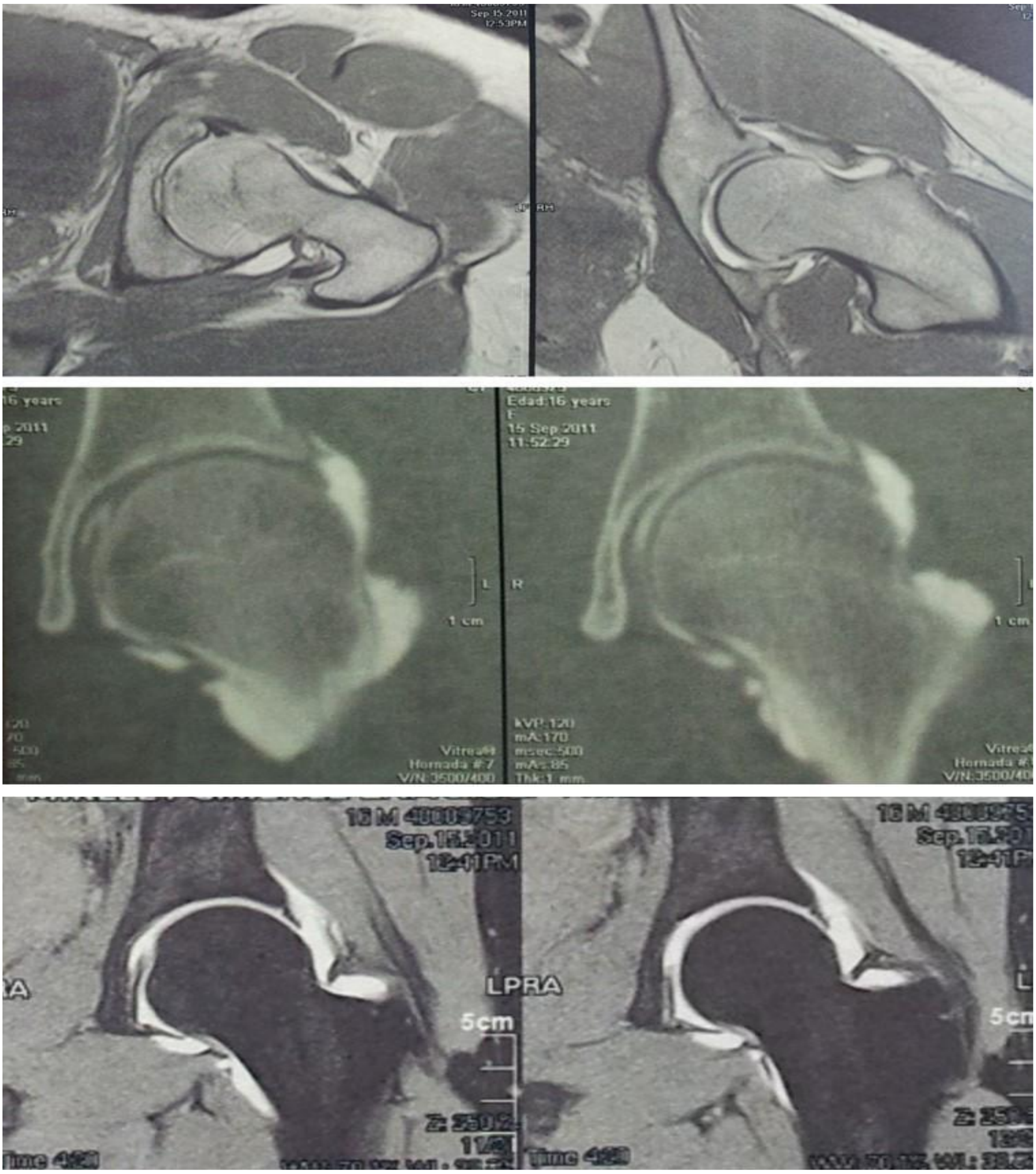
First, a conventional anteroposterior and oblique radiograph of both hips should be requested to observe the space between the femur and the acetabulum (Griffin et al., 2016).

In case of suspecting a joint lesion, either chondral or labrum, the test that provides more information is arthro-MRI with contrast. The leakage of this contrast will reveal a labral defect or joint capsule defect coxofemoral (figures 24 and 25).

Figure 24: Conventional radiography image of the left hip in AP (image on the left) and obliquely (image on the right) showing a mixed-type FAI (CAM + PINCER deformity)

Source: Authors' work.

Figure 25: Composition of MR-arthro images showing lesion of the anteroinferior labrum in the context of FAI syndrome



Source: Authors' work.

Treatment

The FAI syndrome can be treated conservatively or surgically (saving this for cases that conservative treatment cannot control). Conventional treatment consists, fundamentally, in the correction of the alterations of the mechanical axes of the lower extremities (if they exist), correction of alterations in the stepping and modification/correction of the activity, and the intensity of the athlete's load.

This change in the activity must be accompanied, from the beginning, with intensive physiotherapy treatment. This treatment aims to stabilize the lumbopelvic complex, improving neuromuscular control of strength, range of motion, and movement patterns.

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