Module 3. Joint pathology and osseous injury

Unit 3.1 Joint pathology

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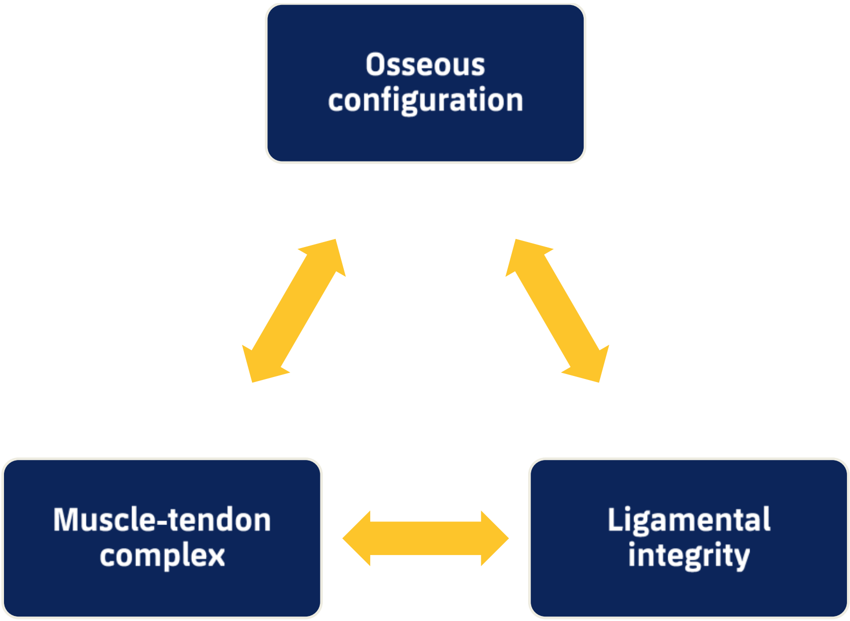
Joint: it is known as the place of union of the bone´s segments, which provide mobility to segments and is exposed to external loads. Main functions of joints are the following:

- To transmit loads.
- To ensure stability.
- To facilitate functional movement.
- To self repair the tissues that are part of it.
- To allow the spatial relation (posture, movement, throwing and approaching objects).

Joint stability depends on several factors:

Figure 1. Factors on which joint stability depend



Source: Own creation.

The bone group in the joint is the passive rigid stabilizer that is based on joint congruence and provides bigger stability, in relation to the cover's magnitude (for example, the shoulder or hip's joints).

Ligaments are passive stabilizers that are less rigid than the bone and they generally restrict movement when stretched. The ligament's disposition is the one that really determines which movement it can resist.

Muscle-tendon structures are dynamic stabilizers.

The joint movement is determined as follows:

- Functional axes.
- Movement range.
- Friction in superficial joints.

Joints main parts:

- Articular cartilage.
- Intraarticular synovial fluid, real lubricant.
- The synovial membrane that secretes synovial fluid.
- The joint capsule that connects bones and is reinforced by ligaments.

There are two types of cartilages:

- Hyaline cartilage: very hydrophilic, it covers the bone ends forming a highly polished surface and it can greatly resist the friction forces.
- Fibrocartilage: it is more fibrous and resistant to loads. It is usually found on locations like meniscus, rings on invertebral discs and pubic symphisis. It is a very hydrophilic tissue, with high innervation; it is avascular and it has a small repair capacity.

Sprain

It is a joint twisting or distention that can occur together with an incomplete or complete injury of the ligaments that are part of this joint. Here we have an example of classification of ankle sprain.

Table 1. Ankle sprain classification

GRADE	Structural injury	Edema/ecchymosis/pain	Anterior drawer test	Functional repercussion
I	Incomplete injury of the Anterior Talo-Fibular Ligament (ATFL)	Positive	Positive	No mechanical instability
II	Complete injury of the Anterior Talo-Fibular Ligament (ATFL) Incomplete injury of the Calcaneo-Fibular Ligament (CFL)	Positive	Moderate	Mechanical instability
III	Complete injury of the Anterior Talo-Fibular Ligament (ATFL) Complete injury of the Calcaneo-Fibular Ligament (CFL)	Positive	Variable	Mechanical instability

Source: Own creation

The recovery prediction and times for an ankle sprain are related to the syndesmosis involvement, it then would be interpreted as a high ankle sprain, which usually has an incidence of 5 to 18% in ankle ligament injuries.

Syndemosis is formed by 3 ligaments:

- The anterior tibiofibular ligament
- The interosseous ligament
- The posterior tibiofibular ligament

Diagnosis:

- Visual exploration.
- Ottawa ankle rules and metatarsal approximation maneuvers for dismissing osseous injuries.

Table 2. Ottawa rules

Ankle radiography if there is pain in the malleolar zone and some of the following symptoms:	Foot radiography if there is pain in the mid foot and some of the following symptoms:
Pain in palpation in the distal 6cm in the posterior edge or spike of the lateral malleolar. Pain in palpation in the distal 6 cm in the posterior edge or spike of the medial malleolar. Incapacity for supporting weight (taking 4 steps one after the other without help) immediately after trauma and in emergency	Pain in palpation in the 5th metatarsal base Pain in palpation in the navicular bone Incapacity for supporting weight (taking 4 steps one after the other without help) immediately after trauma and in emergency

Source: Own creation

Complementary tests:

- If any Ottawa rule is positive, an X-ray is required.
- If exploration is compatible with syndemosis injury, then an MRI is required.

Treatment

- In all cases the initial treatment is POLICE (Protection, Optimal Load, Ice, Compression and Elevation).
- In all cases, immobilization can be applied by using the following:
  - A plaster splint
  - Pressure bandage
  - Walker boot

A monitor of progress is recommended every 5-7 days.

Synovitis

It is an inflammation or irritation of the synovial membrane that covers joints. The most frequent cause in sports is trauma or overload.

Treatment:

- Modify loads
- Ice
- NSAID (non-steroidal antiinflammatory drug)

Luxations and subluxations

Luxation is a traumatic injury when the bone moves beyond its anatomic limits, after a relatively important trauma.

On subluxations the movement is incomplete.

They are very incapacitating injuries associated with almost total loss of function and with a very evident deformity. They can be associated with a rupture of stabilizing elements, of the capsule, of ligaments and osseous insertions. Occasionally, it can be associated with injury in close nervous and vascular structures.

Pain caused by luxation is a side effect of muscle contraction and of immediate inflammatory processes.

An expert assessment and treatment monitoring is urgently needed, as a way of reducing luxation without aggravating the existing injuries.

After luxation, athletes need immobilization treatment with sling during 2-3 weeks and physiotherapy after that.

Fibrocartilage injuries

Fibrocartilage structures are the meniscus, the rings on invertebral discs and the pubic symphisis.

The fibrocartilage injury mechanism is produced after an anomalous translation or rotation movement, which comprises it or pulls it, forcing it above its capsule resistance, provoking its rupture or disinsertion.

Treatment

- POLICE (Protection, Optimal Load, Ice, Compression and Elevation).
- The prediction is uncertain due to this tissue little repair capacity.

The functional repercussion will depend on the function of the injury itself or on the secondary sequelae to the surgical solution (extirpation or suture-reanchorage, when possible).

Joint injuries due to overload

Osteochondrosis

The osteochondrosis origin is unknown, but one of the hypotheses is that there is a circulatory disease that causes ischemia on bone tissues.

Another hypothesis is that repetitive microtraumas can cause lack of blood flow and this would trigger the disease.

It usually gets manifested on growth stages with the clinic pain symptoms, functional deficit and, in some cases, with joint inflammation.

Evolution for this pathology is uncertain, but young people usually return to their habitual levels of physical activity.

Treatment

- Modification of training loads or retirement from sports activity.
- Ice
- NSAID (non-steroidal antiinflammatory drug)

Traumatic arthritis

It is the inflammation in the joint and in the tissues that surround it. The traumatic arthritis main cause is the direct trauma or the repetitive microtrauma.

Repetitive microtraumas produce synovial thickening and thickening in the close bone and they appear with the clinic pain symptoms, with muscle spasm and joint crepitus.

Returning to intense sports activity will depend on the clinic symptoms, but it can be started before the full repair of periarticular soft tissues is completed, after an important injury.

Treatment

- POLICE (Protection, Optimal Load, Ice, Compression and Elevation).
- NSAID (non-steroidal antiinflammatory drug)

Bursitis

It is an inflammation of the small bags called bursas, which help to reduce any friction among bones, tendons or muscles.

Treatment

- Modification of training loads.
- Ice
- NSAID (non-steroidal antiinflammatory drug)

Capsulitis

It is the joint capsule inflammation that is generally caused by trauma, but it can also have a metabolic or rheumatologic cause.

Depending on the injury origin, an X-ray monitor is recommended for dismissing associated osseous injuries.

Treatment

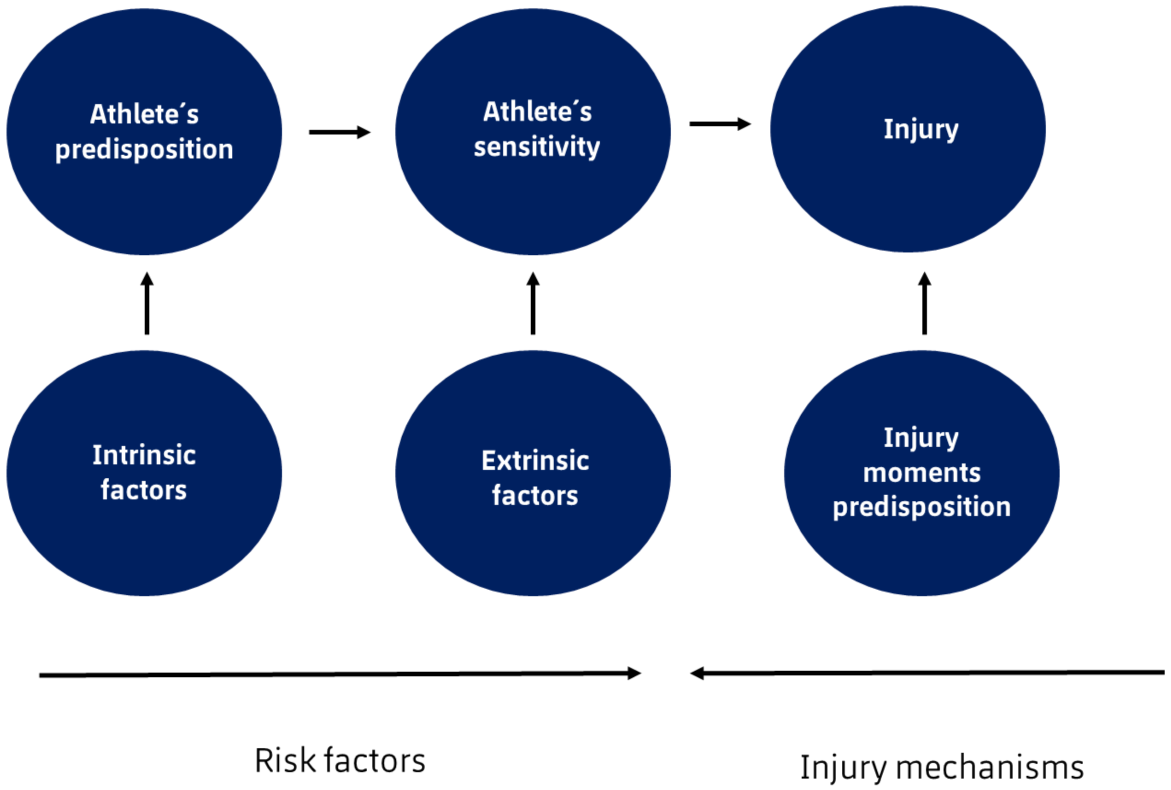
- In all cases the initial treatment is POLICE (Protection, Optimal Load, Ice, Compression and Elevation).
- Immobilization with orthosis
- NSAID (non-steroidal antiinflammatory drug)

Injury mechanisms

Risk factors

Even though many injuries are caused by accidents, there are several factors that can also predispose to injuries. An athlete can have a predisposition to suffer from one or another injury. For example, intrinsic factors like sex, age, physical condition or fatigue. Other risk factors can be extrinsic, like sports itself, humidity in the environment or the friction with the surface. It is proved that females face more risks of suffering from an ACL (anterior cruciate ligament) injury and it has been also proved that in handball, when the shoe-surface friction is high, there is more risk of an ACL injury. That is why, on a handball match where there is a high surface friction; females will be more vulnerable to suffer from a knee injury.

Figure 2. Intrinsic risk factors



Source: Own creation

Table 3. Injury risk factors

Intrinsic factors:	Extrinsic factors:	Injury moments:
Age Sex Body composition Previous injury events Physical condition Anatomic characteristics Sports level Psychological factors Fatigue	Sports factors (For example: rules and referees) Protection items (For example: helmets and gloves) Sports clothes (For example: shoes and socks) Environment (humidity, heat, friction with surface, etc.)	Game situation Player vs opponent General biomechanics Gesture biomechanics Action

Source: Own creation

Wrist injuries

Carpal instability

It is a non-traumatic injury that is secondary to congenital laxity, or a trauma that causes an incorrect bone alignment and it causes a persistent pain in the wrist, which, in general, gets worse with force.

The imaging tests like the MRI do not provide much information, because they highly depend on the staff and the radiologist.

Patients will precise an X-ray study in both wrists:

- Posteroanterior and profile projection;
- Posterior projection with fist.

At the beginning, the treatment is generally physiotherapy with specific exercises for reinforcing wrist muscles.

For preventing this type of injury, it is very important to start with muscle activation, before starting with the physical activity.

Injuries in the triangular fibrocartilage complex

It is a specialized three-dimensional structure and it is located between the radius, the ulna and the first carpal line, which allows a soft rotational movement of the carp as well as the forearm.

The main functions are the following:

- To stabilize the distal radioulnar articulation.
- To stabilize the ulnar carpal articulation.
- To distribute forces between the ulna and the carpus.

Clinic symptoms:

- Pain in the ulnar side of the carpus.
- “Click” in the ulnocarpal zone.
- Possible pain sensation with active pronosupination.
- Increase of the tuberosity in the distal ulnarepyphisis.

Clinic symptoms usually start after a fall on the wrist in hyperextensionts, or after a sudden mechanism of the forearm pronosupination.

The pain is generally manifested on the ulnocarpal side of the joint capsule when the forearm is on a maximum supination. Pain usually increases with the forced passive pronosupination in the forearm and with the active resistance pronosupination. Sometimes pronosupination can be associated with and audible “click”.

Patients will precise an X-ray study in both wrists:

- Posteroanterior and profile projection.
- Posterior projection with fist.

The MRI arthrogram increases sensitivity and specificity of the topographic diagnosis.

At the beginning, the treatment is generally physiotherapy with specific exercises for reinforcing wrist muscles. The treatment can be reinforced with PRP infiltrations. And in the case that traditional treatments fail, surgery is recommended.

For preventing this type of injury, it is very important to start with muscle activation, before starting with the physical activity.

Elbow impingement

It is an unusual injury in sports, but it can sometimes be found in sports like tennis, baseball and in a football or handball´s goalkeeper.

The diagnosis for this injury is clinic symptoms. There is an objectification of the alteration in the articular movement with limitation on the last grades of extension and pain with hyperextension.

The complementary tests, like the X-rays study, can objectify the presence of osteophytes in the olecranon and an MRI will provide us with more information on the cartilage state and in the osteochondral injuries.

At the beginning, the treatment is traditional with FST and it can also be associated with infiltration of corticoids, hyaluronic acid or PRP.

Later, it will be necessary to value a surgical procedure.

In order to prevent this type of injuries, it is very important to control the sports gesture and to have an adequate muscle tone.

Scapulohumeral luxation

The shoulder is an extremely mobile joint and a very stable one. Its stability depends on structures that are not rigid.

The luxation mechanism is produced when the normal movement amplitude is exceeded, with the arm in abduction and mainly in external rotation, by being forced backwards, it projects the head of humerus outside the cavity and it moves under the coracoid process. Example: fall

It clinically presents a serious functional deficit with joint deformity. It is usually associated with labrum´s injuries.

Management:

- It needs immediate reduction and immobilization. The immobilization time will depend on whether the labrum is injured or not.
- X-rays before and after the reduction.
- MRI for dismissing labrum´s injury.
- The recommendation is to consider deferred repair.

The initial treatment is physiotherapy, but there are studies that confirm a 90% relapse risk in young athletes with a first luxation event.

In order to prevent this type of injury, it is very important to have an adequate physical condition and to start with an initial activation of the shoulder´s muscles before the physical activity.

The pathology prevention consists of the following actions:

- Working on muscle compensation.
- Make humeral rotators stronger.
- Make scapular fixation stronger.

Acromioclavicular luxation

This injury is usually produced after a fall on the shoulder´s stump (motorcycle, bike fall, among others).

There are different types of classification by grades, from capsular distension to the coracoclavicular ligaments´ rupture.

The types of acromioclavicular luxations according to Rookwood´s classification are the following:

Table 4. Types of acromioclavicular luxations according to Rookwood´s classification

STRUCTURES	I	II	III	IV	V	VI
Acromioclavicular ligament	Distended	Complete rupture	Complete rupture	Complete rupture	Complete rupture	Complete rupture
Acromioclavicular joint	Intact	Disorganized, widened	Luxation and superior displacement of clavicle	Luxation and posterior displacement of clavicle	Luxation and greatly marked displacement of clavicle	Luxation and inferior displacement of clavicle
Coracoclavicular ligament	Intact	Distended and edematous	Complete rupture with edema	Partial or complete rupture with edema	Complete rupture with edema	Intact
Deltoid and trapezius	Intact	Possible partial detachment	Possible partial detachment of the distal clavicle	Possible partial detachment of the distal clavicle	Possible partial detachment of the distal clavicle	Possible partial detachment of the distal clavicle

Source: Own creation

Treatment:

- POLICE (Protection, Optimal Load, Ice, Compression and Elevation).
- Type I and II luxations are given a traditional treatment applying immobilization with Gilchrist sling during 2 weeks, and later, the recommendation is to avoid extreme weights and loads during 8 weeks.
- Grade III, IV, V, VI luxations will need surgical procedure.

The pathology prevention consists of the following actions:

- Working on muscle compensation.
- Making humeral rotators stronger.
- Making scapular fixation stronger.

Hip injuries

The inguinal pain in athletes is many times related to a hip injury. In general, it does not hurt during the exercise practice, but later. Pain is usually referred at the inguinal level or in the trochanter and in the gluteal region. They are usually sports with kicks or anterior flexion.

The femoroacetabular impingement is one of the causes of early osteoarthritis of the hip, especially in the group of young and active patients. The estimated prevalence is 10-15%.

In exploration, patients present a limited mobility range, especially in flexion and internal rotation. When it is about the anterior impingement, the exploration is positive when the patient experiences pain with hip flexion maneuvers and the internal rotation with forced abduction. And in the posterior impingement, if pain is experienced with the maneuver for external rotation in complete extension of the hip.

There are three types of impingements (Pincer, Cam and a mixed type Pincer-Cam):

- The Pincer impingement is generally produced by an increase of the acetabulum overcoverage.
- The Cam type impingement is caused by an overgrowth in the sphericity in the area between the neck and head of the femur, when this section impacts in the acetabulum.
- The mixed type impingement where we will find an increase of the acetabulum overcoverage and an increase of the thickness in the neck of the femur

A non-diagnosed impingement can cause an acetabular labrum injury. It is the first structure that is usually injured in all types of impingements. The labrum injury, in most cases, is usually located in the acetabulum´s anterior and superior zone. The labrum preservation is very important for the hip stability and for the protection of the articular cartilage.

For the femoroacetabular impingement diagnosis we will use a simple radiography with anteroposterior pelvis projections, a Dunn axial projection and a lateral projection. The MRI will provide us more information and the arthro-MRI detects labral injuries or chondral injuries in the anterosuperior zone.

Currently, there is no effective traditional treatment that could improve the mechanical defect. The treatment is a surgical procedure and it should be followed as soon as possible.

Knee injuries

Knee injuries occur as follows:

Table 5. Possible mechanisms of knee injury

MECHANISM	POSSIBLE INJURY
Knee in semiflexion + forced valgus + tibial external rotation	ACL, ILL and IM injury
Knee in slight flexion + forced varus + tibial internal rotation	ACL, ELL, IM and EM injury
Knee in extension + forced valgus	ILL, ACL or PCL injury
Knee in extension + forced varus	ELL, PCL or ACL injury
Sudden hyperextension or a direct blow on the anterior side of the knee.	PCL injury and posterior capsule distention

Source: Own creation

Knee ligaments injuries

Incidence: from 4 to 7% of sports injuries.

The sports activities with more incidences are the ones that suppose a sudden change in support (sports played in halls, football, and ski).

Absence due to sports injuries is generally variable and it depends on severity.

They are caused by multiple factors.

Possible ligament injuries in the knee:

- Internal collateral ligament
- External collateral ligament
- Anterior cruciate ligament
- Posterior cruciate ligament
- Injuries in the knee capsule

Also, inside the group of knee fibrocartilage injuries, we can include the meniscus as follows:

- Internal meniscus
- External meniscus

Diagnosis:

In the injury initial manifestation, it is very important to assess on the knee instability and the hemarthrosis.

Maneuvers for testing the knee instability:

- Articular movement
- Lachman (grading ACL injury)
- Anterior drawer (grading ACL injury)
- Posterior drawer (grading PCL injury)
- Forced valgus (grading an injury in the MCL)
- Forced varus (grading an injury in the LCL)

MRI: elected imaging test that will allow the confirmation or dismissal of a possible injury.

Treatments

Mild sprain of the MCL:

- Orthosis use
- Ice
- Rest
- NSAID (non-steroidal antiinflammatory drug)
- Physiotherapy

In case of complete injury of the MCL, the LCL or the ACL, the treatment will be surgery.

Surgical procedure´s goals:

- Pain control
- Edema prevention
- To restore the joint mobility (mainly extension).
- To restore the muscle strength.
- To restore the proprioception.
- To restore the joint function.

- To respect the ligamentization period.
- To protect the load ligament.

Physiotherapy starts the day of the injury until the activity (mobility, run or sports activity) is total; this process consists in restoring the following:

- Articular movement
- Muscle tone
- Proprioception
- Specific training for the athlete´s activity

Meniscus injuries (tears)

Meniscus is located between the femoral condyle and the tibial plateau. The internal meniscus has a "C" form and the external has an "O" form.

There are more IM tears than EM´s tears. In sports like football, athletics and ski, meniscus tears are more frequent.

Symptoms for a torn meniscus:

- Pain in the articular interline
- Mobility limitation or complete block in the joint.
- Click sound
- Sensation of instability
- Intraarticular effusion

Types of meniscus tears:

We first classify them in complete and incomplete tears.

Then as follows:

- Vertical tear
  - Longitudinal (simple and bucket-handle) tear
  - Transversal or radial tear
  - Oblique tear

- Horizontal tear
  - Fish mouth tear

- Complex or mixed tear
  - Parrot beak tear on external meniscus

- Tear with an horizontal pedicle
- Tear with a vertical pedicle
- Double bucket-handle or multiple tear

Some of the maneuvers in meniscus exploration:

- Steinman I: in the dorsal decubitus or sedestation position with the knee in 90°, an internal and external tibial rotation is applied, observing pain in the palpation on the affected meniscus interline.
- Steinman II: in the dorsal decubitus or sedestation position with the knee in 90°, an internal and external tibial rotation with flexoextension is applied, observing pain's posterior displacement with flexion, and, with extension, pain is displaced towards anterior.
- Bragard: in the dorsal decubitus position with the knee in 90°, an internal and external tibial rotation with extension will be applied, observing fluctuating pain in the palpation on the affected meniscus interline.
- Epley: in the prone position with the knee in 90°, an internal or external tibial rotation with axial compression will be applied on heel and, that way, we will observe pain in the affected meniscus interline.

For diagnosis, the elected imaging study is the MRI, which can determine the site and the type of meniscus tear.

The election of the treatment depends on the type of tear, site, sports and the athlete's individual characteristics.

- Traditional treatment, in case of an asymptomatic injury.
- Surgical procedure with arthroscopy (meniscus suture, partial meniscectomy, meniscal transplant, collagen meniscus implant).

Ankle ligaments injuries:

The acute ankle sprain is the most frequent pathology and its relapse is habitual.

In the United States, 23 thousand sprains occur every day.

From 15 to 40% of injuries are in sports activities.

It is more frequent in sports that suppose sudden changes in support (basketball, handball, volleyball, etc.).

Most sprains occur with ankle forced inversion and affecting the ELL.

Less frequent, but more important are the ILL injuries and syndesmosis.

Individuals that suffer from several ankle sprains show functional instability, chronic instability and residual instability.

It is the most stable mobile joint that exists.

Ankle stabilizers structures:

- External lateral ligament:
  - Anterior talofibular ligament (tension on plantar flexion)
  - Calcaneofibular ligament (tension on inversion)
  - Posterior talofibular ligament (low probability of injury)

- Internal lateral ligament:
  - Deltoid ligament
    - It provides internal stability.
    - It needs a great amount of energy for getting injured.
    - Osseous structures get injured before.

- Syndesmosis (posterior and inferior tibiofibular membrane)

Ankle stabilizers:

- Intrinsic:
  - Articular disposition
  - Ligaments

- Extrinsic:
  - Muscles

- Neuromotor coordination

Ankle sprain

Injury mechanisms

- Inversion in plantar flexion: sequential injury (ATFL-PCL-PTFL) due to stretching of one or more fascicles of the external lateral ligament.
- Anterolateral or posteromedial contusion: osteochondral injury.
- Dorsiflexion in external rotation: distension of the syndesmosis.

GRADE I

- ATFL or PCL distension
- Mild pain
- Mild edema
- No functional loss
- No mechanical instability

GRADE II

- ATFL or PCL partial rupture
- Moderate edema and ecchymosis
- Intense pain on injured structures
- Functional loss and incapacity for variable load
- Slight instability

GRADE III

- Complete rupture
- Variable pain
- Important edema and ecchymosis
- Functional loss and incapacity for variable load
- Plain instability

Diagnostic methods

- Anamnesis
- Symptoms exploration
- Simple and forced radiography
- Simple and dynamic echography
- MRI

Diagnosis

- Injury medical history: mechanism, situation and previous events.
- Exploration:
    - Examination: deformity and edema
    - Palpation: Ottawa signs (malleolus crest syndesmosis, 5 ° metatarsal base, scaphoids, neck of the fibula, interline, squeeze test). It can reduce unnecessary radiographies in a 28%.
    - Loads capacity
    - Laxity exploration (anterior drawer, varus)

- Radiography: they provide 100% sensitivity on malleolar fractures and in midfoot fractures.

Treatment:

The treatment main goals are the following:

- To prevent edema.
- To keep an optimal mobility range.

Orthopedic:

- On the first days, depending on the jury grade, the recommendation is rigid immobilization with pressure bandage or with Walker orthosis during some days or weeks.
- In case of grade II-III sprains, the recommendation is rigid immobilization with Walker boot from 2 to 4 weeks.
- In case of sprains with partial injury of syndesmosis, the recommendation is rigid immobilization with Walker boot from 4 to 6 weeks.

Surgical procedure:

- In case of sprains with injuries linked to them, like complete rupture of syndesmosis or malleolus fractures.

Assessment indications by traumatologist:

Table 6: Assessment indications by traumatologist

Fracture or luxation	Neurovascular compromise	Tendinous rupture or subluxation
Deep open joint wounds	Complete syndesmosis rupture	Joint block

Source: Own creation

Treatment´s goals:

- Pain control
- To prevent a big edema.
- To restore joint mobility.
- To restore muscle strength.
- To train proprioception.
- To restore joint functionality.
- To respect the healing period.
- To protect the load ligaments.

Initial treatment indication:

- REST (immobilization)
- ICE immediately for 10´ every 1-2 h
- COMPRESSION
- ELEVATION (15 cm above heart)

Indication for following treatment:

- Immobilization against pain Immobilization time will depend on the injury grade.
- Crutches in the initial period.
- Aids in the initial period.
- Pain killers or NSAID if it is necessary in the initial period.
- Physiotherapy (the treatment will start depending on the injury grade and the need of immobilization, but it can always be started by treating the edema).

Physiotherapy:

- Edema control during the first days.
- Articular movement
- Muscle tone
- Proprioception
- Specific training for the athlete´s activity

Unit 3.2 Osseous injury

Osseous injuries can be classified as follows:

Table 7. Osseous injuries classification

Acute injuries	Injuries caused by overuse
Fractures	Stress fractures
Periosteal contusion	Osteitis
	Periostitis
	Apophysitis
	Enthesopathy

Source: Own creation

Fractures:

They are defined as loss of osseous continuity.

Clinic symptoms:

- Localized deformity
- Limited mobility
- Crepitus
- Localized pain
- Edema
- Ecchymosis
- Lacerations and visible wounds (open fractures)

The treatment's main goal is to allow for the consolidation of the fracture in an anatomic position, for performing an adequate mechanical function. If the fracture is displaced, it is necessary to align the fragments. A badly aligned fracture can cause complications in the future like osteoarthritis.

Monitoring for possible complications must not be forgotten:

- Infection
- Non-union
- Compartment syndrome
- Vascular or nervous damage
- Deep vein thrombosis/pulmonary embolism (in fractures of long bones)
- **Adjacent soft tissue injury (ligaments, muscles)**

Trauma fractures

Definition and classification

The fracture due to trauma is the rupture of a non-pathological bone, due to the application of acute load that exceeds the periosteum endurance capacity. According to the application of force and the fracture focus, we can divide fractures into direct trauma, when the fracture occurs directly where the force is applied, and indirect trauma, when the fracture are distant from the actual application of force. In this case, they are caused by the bone torsion or angulation.

We can classify them according to the site of the fracture, the type of fracture, the displacement of fragments and whether there is exposition.

Table 8. Classification of fractures

According to site:

Affected bone
Epiphysis, diaphysis, metaphysis, physis, tubercle, epicondyle, etcetera

According to type of fracture:

Complete fracture: it crosses the whole bone length.
- Transversal: fracture trace that is perpendicular to the bone axis.
- Oblique: oblique fracture trace
- Spiral: helicoidal fracture trace
- Comminuted: when there are more than two fragments.

Incomplete fracture: it does not cross the whole bone length.
- Due to torsion
- Green stick: the bone is broken, on one side and on the other is hunched (only in children).

According to exposition:

Open: when in the fracture focus there is a wound that communicates with the exterior of the wound. There is possibility of infection.

Closed: when there is no wound, or if there is, there is no communication with the fracture's focus.

According to displacement: traslation, angulation, rotation and distraction length.

Source: Own creation

Most frequent fractures

Trauma fractures can occur on any bone, but they are a lot more frequent on inferior limbs bones than on superior limbs (Table 9: Most frequent trauma fractures).

Table 9. Most frequent trauma fractures

Superior limb	Inferior limb
• Clavicle • Humerus tubercle (or majus tubercle). • Radius neck and head • Olecranon • 5th metacarpal • Fingers phalanges	• 5th metatarsal • Medium and lateral malleolus • Radius head

Source: Own creation

Inferior limb:

- 5th metatarsal: it can occur because of an avulsion when performing an ankle sprain, a Jones fracture or a metaphyseal fracture (Figure 3).

Figure 3. 5th metatarsal

Source: Own creation

- Medial and lateral malleolus: it is generally a consequence of an ankle sprain (Figure 4).

Figure 4. Medium and lateral malleolus

Source: Own creation

- Fibular head: they are fractures due to indirect trauma in the ankle.

Superior limb:

- Clavicle: due to direct or indirect trauma. Usually a fracture on the medium third. Consolidation time: 4-6 weeks. Using bandage in 8 helps the fracture alignment and the correct consolidation.
- Humerus tubercle (or majus tubercle): due to fall on arms in extension or on the lateral side of the shoulder. Clinic symptoms are similar to the ones in the rotator cuff injury.
- Radius neck and head and olecranon: they can occur after direct trauma, after fall on the extended arm or after arm´s torsion (Figure 5).

Figure 5. **Radius neck and head and olecranon**

Source: Own creation

- 5th metacarpal: they can occur after direct trauma (Figure 6).

Figure 6. **5th metacarpal**

Source: Own creation

- Fingers´ phalanges (Figure 7).

Figure 7. **Fingers´ phalanges**

Source: Own creation

Clinic symptoms

Fractures usually get manifested with pain, functional impotence and deformity on most occasions. They can also show crepitus.

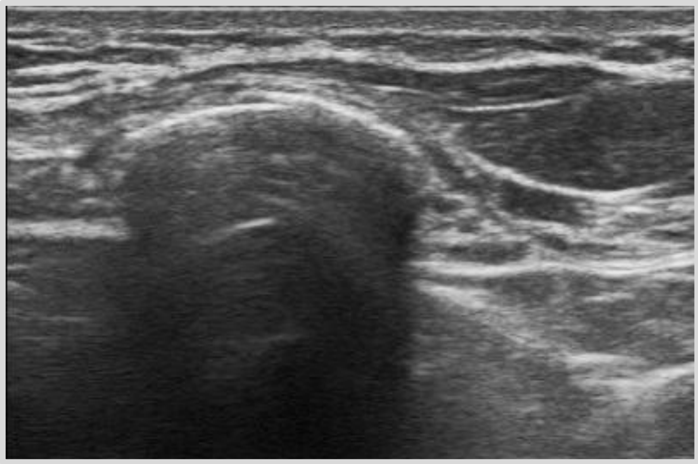
Some types of fractures, mainly the incomplete ones, can only manifest a bit of pain, enough for causing discomfort, but it does not prevent players from continue training. For these fractures not to go unnoticed and when an athlete feels a recurrent pain with traumatic antecedents, the fracture must be dismissed. An example of them is the greenstick fractures in kids, some metatarsal diaphyseal fractures and sacral incomplete fractures.

Diagnosis

The diagnosis will be established with the clinical suspicion and the X-ray, always asking two projections for being able to clearly determine the type of fracture and if there is displacement or not (see above). For most fractures, we do not need other complementary tests for making a diagnosis.

The musculoskeletal ultrasound is also useful for superficial bones. With it, we can only observe whether the periosteum is affected or not, but in experienced hands, the immediacy and the dynamic exploration the ultrasound offers can be very useful for a first diagnosis orientation. An example of its utility is for rib fractures, since there are incomplete fractures of costal arches that could not be diagnosed with radiography (Figure 8).

Figure 8. **Musculoskeletal ultrasound of a costal fracture**



Source: Own creation

Other complementary tests are Computerized Tomography (CT) and the MRI, to which we can resort to if we cannot establish a reliable diagnosis with the X-ray and if we have high suspicion of fracture. They are useful, for example, for spondylolysis. The MRI, besides, offers us information about the existence of osseous edema (trabecular fractures) and it gives us images about soft tissues that surround the bone.

Treatment

Fractures treatments are mainly based on aligning and immobilizing.

These steps will depend on the type of fracture and its site, although the displacement grade must be also taken into account. This is the moment when a decision has to be made on whether the fracture should undergo a surgical procedure or not. In some cases in which the surgical procedure is not clear, we should firstly immobilize and wait for the natural evolution for the fracture. We can also find fractures that, once reduced, are unstable; that is why, the decision will be that they undergo surgical procedure. If the fracture is on an inferior limb, the fracture will be aided for avoiding its displacement.

We should not forget that fractures are painful and that is why we should administer painkillers or antiinflammatories.

Subtypes of fractures

We differentiate two types of fractures:

Table 10. Subtypes of fractures

Pathological fractures	***Fragility fractures***
They occur without trauma or due to a trauma that should not cause a fracture, on bones that are weakened by any reason, whether benign or malignant; the injury is focal, such as a metastasis, benign osseous cysts, malignant bone tumors, osteolytic tumors or diseases that cause osseous fragility, like the imperfect osteogenesis, the fibrous dysplasia, the osteoporosis, the osteomalacia, the Paget´s disease and osteitis (Figure 9).	They are the result of normal activities, like a jump or a fall. The most common sites are the vertebral bodies, the neck of the femur and the Colles fracture of the wrist.

Source: Own creation

Figure 9. Pathological fracture

Source: Own creation

Nasal fractures

Clinic symptoms: Pain, epistaxis, edema, crepitus, deformity.

Treatment: hemorrhage control

- Nondisplaced fractures: pain and edema control
- Displaced fractures: reduction

Stress fractures

Definition

When we talk about stress fractures, we refer to bone fractures caused by instability between the force of the bone itself and the chronic mechanical stress exerted on it or, in other words, when the bone cannot absorb repetitive loads.

We can divide them according to the bone status and the applied load:

Table 11. Fractures due to fatigue and insufficiency structures

Fatigue fractures:	Insufficiency fractures:
Caused by an increase in the applied load on a normal bone (For example: high volume of stress exercises).	Caused by normal loads on weakened bones (For example: osteoporosis, osteomalacia).

Source: Own creation

Injury mechanisms

The bone is a dynamic living tissue which is in constant remodeling and restructuring. This remodeling function is coordinately performed by osteoblasts and osteoclasts. A complete cycle of bone turnover, remodeling and mineralization needs a period of three to four months.

The bone receives repetitive forces of tension, compression and impact and it responds by changing shape for absorbing these forces to go back to normality later. The moment these forces exceed the bone elasticity range is when the microfractures occur and as they cannot be remodeled quickly enough, they end up provoking stress fractures.

Since stress fractures are the result of a repetitive load, there is a consideration that training factors, such as volume, intensity and surface are important. And at the same time, there are also other risk factors like the type of sports, low levels of Vitamin D, the muscle fatigue, the osteopenia, the female sex, the hormonal factors like late menarche, the oligo or the amenorrhea or a body mass index (BMI) <19 (Table 12: Risk factors for stress fracture).

Table 12. Risk factors for stress fracture

EXTRINSIC	INTRINSIC
	1. Low osseous density
1. High training volume and intensity	2. Lack of physical activity
2. Hard training surface	3. Female sex
3. Inadequate or worn-out shoes	4. Low osseous density
4. Type of sports: running>swimming	5. Decrease on muscle strength
5. Low Vitamin D levels	6. Menstrual alteration
6. Alcohol	7. BMI<19.
7. Tobacco	8. Diet alterations
	9. Thyroid malfunction

Source: Own creation

Most frequent fractures

Stress fractures can theoretically occur on any bone, but they are a lot more frequent on inferior limbs bones than on superior limb ones.

We classify them into high-risk and low-risk injuries according to their probability of curing without complications with a traditional treatment.

Table 13. High-risk injuries and low-risk injuries

High risk
Calcaneus posterior tubercle
Talus neck
Neck of the 2nd to 4th metatarsals
5th metatarsal base
Scaphoid tarsal
Medial malleolar
Anterior diaphysis of the tibia
Sesamoid bones
Femur
Spondylolysis
Patella transverse fracture

Low risk
Diaphysis of the 2nd to the 4th metatarsals
Sacrum
Posteromedial tibial diaphysis
Ribs
Ischiopubic ramus of the pelvis
Fibula
Longitudinal fracture in the patella

Source: Own creation

High risk: fractures in sites where there is higher risk of lack of junction, displacement or progression to a complete fracture. These cases require long and specialized treatments.

They are the following:

- Calcaneus posterior tubercle
- Talus neck
- Neck of the 2nd and 4th metatarsals
- 5th metatarsal base: the riskiest zone is the lateral plantar zone, since it is the zone where there is the biggest concentration of traction forces. It is the most frequent fracture in football players (Figure 10).

Figure 10. 5th metatarsal fracture

Source: Own creation

- Scaphoid tarsal bone: most fractures occur in the medium third, since it is the zone with less vascularization. They are difficult to diagnose and treat.
- Medial malleolus: they are not frequent, but they can cause a significant morbidity.
- Anterior diaphysis of the tibia: the second in frequency. If aid is not extended in time, there is a risk of consolidation delay and even a failure in this consolidation (Figure 11).

Figure 11. Fracture in the anterior diaphysis of the tibia

Source: Own creation

- Sesamoid bones: they are very rare.
- Femur: they can be located in the femoral neck, intertrochanteric/subtrochanteric or in the femoral diaphysis.
- Spondylolysis: the most affected zone is the pars interarticularis and most frequently on level L5 (Figure 12).

Figure 12. Spondylosis

Source: Own creation

- Patella transverse fracture

Low risk: those fractures which, due to site, heal correctly and tend not to progress to complete fracture. Their treatment will be simple and even modeling the intensity and volume loads; the athlete can continue training and competing. They are the following:

- Diaphysis of the 2nd and 4th metatarsal: they are called “march fracture”.
- Sacrum
- Posteromedial tibial diaphysis: they are frequent.
- Ribs
- Ischiopubic ramus of the pelvis
- Fibula
- Longitudinal fracture in the patella

Clinic symptoms

Stress fractures usually manifest a progressive and insidious pain in the fracture zone without any traumatic antecedent. Pain appears with activity, whether training of competition and it disappears with rest. When the athlete returns to activity, pain reappears on the same site. There is often an antecedent of increase in load or an important change in the type or duration of the usual training.

During exploration, we can spot an intense localized sensitivity on a certain location or a diffuse pain on a whole zone; both can occur with an edema in the zone. Pain can be constant or nocturnal or it can appear only with certain movements or loads. That pain increases throughout time, if the trigger factors remain. In this case, the injury progresses and it will go on limiting the sports gesture. Kaeding y Miller (2013) made a classification of stress fractures based on the presence of pain and on the findings on images (Table 14).

Table 14. Kaeding–Miller classification system for stress fractures

Grade	Pain	Image			
		X-ray	BS	CT	MRI
I	NO	Without fracture line and sclerosis	↑ Of uptake	Sclerosis	Bone marrow edema
II	YES	Without fracture line and sclerosis	↑ Of uptake	Sclerosis	Bone marrow edema
III	YES	Nondisplaced fracture			
IV	YES	Displaced fracture			
V	YES	Non-union fracture			

Source: Kaeding, C. C., and Miller, T. (2013). The Comprehensive Description of Stress Fractures: A New Classification System. *Journal of Bone and Joint Surgery*, *95*(13), 1214–1220. https://doi.org/10.2106/jbjs.l.00890

Diagnosis

The stress fracture diagnosis is basically a suspicion diagnosis based on the clinical and sports history (changes in types of training). But imaging tests are essential for certifying our suspicion. These complementary tests, used by order of diagnostic utility, are the ones detailed on table 15.

Table 15. Radiology rating of stress fractures

	X-ray	BS	MRI	TREATMENT
Grade I	Normal	Increased uptake areas, wrongly defined	Positive STIR Negative T1 and T2	Rest 3 weeks
Grade II	Normal	More intense uptake, but non defined	Positive STIR and T2 Negative T1	Rest 3-6 weeks
Grade III	Slightly noticeable lines Incipient periosteal reaction	Well defines uptake lines with well contrasted margins	Positive T1 and T2 without cortical rupture	Rest 12-16 weeks
Grade IV	Fracture or periosteal reaction	Intense transcortical uptake	Positive T1 and T2 with fracture line	Rest more than 16 weeks

Source: Berger, F., De Jonge, M., Smithuis, R., and Maas, M. (2007, May 23rd). *Stress fractures*. Radiology Assistant. https://radiologyassistant.nl/musculoskeletal/unsorted/stress-fractures

a) Simple radiography (Rx): it is the initial exploration, due to its easy access and its low cost. Stress fractures might not appear on Rx during the first 2-4 weeks after the injury, that is why we say that it has high rate of false negatives. It can delay diagnosis. The first radiographic finding could be a localized periosteal reaction or a cortical thickening, which are the signs that show that the body us trying to form a bone callus.

b) Nuclear magnetic resonance (MRI): it is recommended as 2nd line in imaging diagnosis. It has high sensitivity and specificity. It allows differentiating the muscle damage from the cortical damage, the endosteal and the periosteal damage, allowing for the ranking in injuries in relation to its gravity and prediction. There are two types of known sequences like fat suppression sequences, called STIR (Short Time Inversion Recovery) and FAT, SAT or SPIR (Spectral Presaturation with Inversion Recovery), which allow for suppressing the signal in certain elements or tissues specifically, especially fat.

c) Bone scan (Scintigraphy) (BS): high sensitivity and low specificity. They show fracture evidence few days after the beginning of symptoms. It gets manifested as a focal point of higher radioisotope activity ("hot spot"), due to the increase in the osseous renovation in the new bone formation site. Nevertheless, most uptakes can also occur because of osteomyelitis, osseous tumors or avascular necrosis.

d) Axial Computerized Tomography (CT): it is very similar to Rx. It detects areas of osseous remodeling, microfractures of the trabecular bone, periosteal reaction and callus bone formation. It is useful for differentiating osseous tumors and osteomyelitis. The TC-

SPECT (Single Photon Emission Computed Tomography) is useful in the diagnosis of dorsal spine stress fractures, spondylolysis specifically.

Treatment

Treatment will depend on the stress fracture zone and on the possibility of performing rehabilitation. In general terms, we should decrease overload in the affected site, administer painkillers or antiinflammatories for pain control, administer bisphosphonates for inhibiting osseous reabsorption and perform physiotherapy rehabilitation.

Low risk fractures usually need a traditional treatment, together with medication, load decrease and modification of activities that cause pain.

If we are in the presence of a high risk fracture, we may have to immobilize the affected zone, that is why we will have to take into account this immobilization harmful effect on muscles, tendons, ligaments and joints for defining a parallel adapted rehabilitation program.

Faced with any stress fracture, we should make regular control visits and establish a program for keeping flexibility, strength and physical cardiovascular conditioning.

High risk fractures in a high percent can evolve towards the bone non consolidation and the surgical procedure becomes necessary for stabilizing the fracture.

Recently, the treatment with platelet rich plasma (PRP) is being used mainly in surgical procedures, since it accelerates and improves recovery.

A complication we may find is the delay in consolidation. It is those fractures that exceed the usual consolidation period without the appearance, in complementary tests (Rx), of signs of consolidation start, like the localized periosteal reaction. In these cases, we will increase the initially established measures in an appropriate period. With low risk fractures, we will be more considerate than with the high risk ones, with which a delay in consolidation can most frequently be interpreted as a non-consolidation; in that case, the definitive treatment will be the surgical procedure.

Prevention

In order to adequately prevent stress fractures, we should identify the risk factors that lead to the disease. For that purpose, we will start assessing the affected zone anatomy and biomechanics; we will search for hormonal and muscle strength alterations and we will identify if there is a low cardiovascular condition. All that will orient us to a possible cause. Once that is established, we will correct sports movements, we will change training places that might be favoring the osseous load, we will change diet habits and we will modify the type of shoes for every sports practice.

References

Anguita Martínez, G., Vega González, M. A, Cobos Huerga, C., y Moreno Casado, M. J. G. (2011). Fracturas de estrés de los metatarsianos. *Revista Internacional de Ciencias Podológicas*, *5*(2), 47–54.

Astur, D. C., Zanatta, F., Arliani, G. G., Moraes, E. R., De Castro Pochini, A., and Ejnisman, B. (2016). Stress fractures: definition, diagnosis and treatment. *Revista Brasileira de Ortopedia (English Edition)*, *51*(1), 3–10. https://doi.org/10.1016/j.rboe.2015.12.008

Bahr, R., and Krosshaug, T. (2005). Understanding injury mechanisms: a key component of preventing injuries in sport. *British Journal of Sports Medicine*, *39*(6), 324–329. https://doi.org/10.1136/bjsm.2005.018341

Banerjee, P., and McLean, C. R. (2011). Femoroacetabular impingement: a review of diagnosis and management. *Current Reviews in Musculoskeletal Medicine*, *4*(1), 23–32. https://doi.org/10.1007/s12178-011-9073-z

Berger, F., De Jonge, M., Smithuis, R., and Maas, M. (2007, 23 mayo). *Stress fractures*. Radiology Assistant. https://radiologyassistant.nl/musculoskeletal/unsorted/stress-fractures

Cain Jr, E. L., Dugas, J. R., Wolf, R. S., and Andrews, J. R. (2003). Elbow Injuries in Throwing Athletes: A Current Concepts Review. *The American Journal of Sports Medicine*, *31*(4), 621–635. https://doi.org/10.1177/03635465030310042601

Chen, N. C., Jupiter, J. B., and Jebson, P. J. L. (2009). Sports-Related Wrist Injuries in Adults. *Sports Health: A Multidisciplinary Approach*, *1*(6), 469–477. https://doi.org/10.1177/1941738109347981

Chung, K. C., and Lark, M. E. (2017). Upper Extremity Injuries in Tennis Players. *Hand Clinics*, *33*(1), 175–186. https://doi.org/10.1016/j.hcl.2016.08.009

Daffner, R. H., and Pavlov, H. (1992). Stress Fractures: Current Concepts. *American Journal of Roentgenology*, 159 (2), 245-252. https://doi.org/10.2214/ajr.159.2.1632335

Davies, G. J., Wallace, L. A., and Malone, T. (1980). Mechanisms of Selected Knee Injuries. *Physical Therapy*, *60*(12), 1590–1595. https://doi.org/10.1093/ptj/60.12.1590

Denay, K. L. (2017). Stress Fractures. *Current Sports Medicine Reports*, *16*(1), 7–8. https://doi.org/10.1249/jsr.0000000000000320

Dhillon, M. S., Ekstrand, J., Mann, G., and Sharma, S. (2016). Stress Fractures in Football. *Journal of ISAKOS: Joint Disorders & Orthopaedic Sports Medicine*, *1*(4), 229-238.

Dugas, J. R., and Cain Jr, E. L. (2005). *Elbow injuries in Sport. Orthopedic Sport Medicine Board Review Manual*.

Edouard, P., Degache, F., Oullion, R., Plessis, J. Y., Gleizes-Cervera, S., and Calmels, P. (2013). Shoulder Strength Imbalances as Injury Risk in Handball. *International Journal of Sports Medicine*, *34*(07), 654–660. https://doi.org/10.1055/s-0032-1312587

Esplugas, M., y Aixalà Llovet, V. (2014). Lesiones del complejo del fibrocartílago triangular. Tipos de reparación. *Revista Española de Artroscopia y Cirugía Articular*, *21*(1), 14–27. https://doi.org/10.1016/s2386-3129(14)70004-0

Ferran, N. A., and Maffulli, N. (2006). Epidemiology of Sprains of the Lateral Ankle Ligament Complex. *Foot and Ankle Clinics*, *11*(3), 659–662. https://doi.org/10.1016/j.fcl.2006.07.002

Gorbaty, J. D., Hsu, J. E., and Gee, A. O. (2017). Classifications in Brief: Rockwood Classification of Acromioclavicular Joint Separations. *Clinical Orthopaedics & Related Research*, *475*(1), 283–287. https://doi.org/10.1007/s11999-016-5079-6

Haddad, S. F., and Cory, M. C. (2020, 9 marzo). *Stress Fractures*. Medscape.

Jones, J., Rasuli, B., et al. (n. d.). *Pathological fracture*. Radiopaedia.

Jowett, A. (n. d.). *Stress Fractures*. FIFA Medical Platform. https://www.fifamedicinediploma.com/courses/stress-fractures/

Kaeding, C. C., and Miller, T. (2013). The Comprehensive Description of Stress Fractures: A New Classification System. *Journal of Bone and Joint Surgery*, *95*(13), 1214–1220. https://doi.org/10.2106/jbjs.l.00890

Minoves Font, M. (2001). La gammagrafía ósea en el diagnóstico y valoración de las lesiones deportivas. *Revista Española de Medicina Nuclear e Imagen Molecular*, *20*(2), 132-152.

Patel, D. R., Yamasaki, A., and Brown, K. (2017). Epidemiology of sports-related musculoskeletal injuries in young athletes in United States. *Translational Pediatrics*, *6*(3), 160–166. https://doi.org/10.21037/tp.2017.04.08

Polzer, H., Kanz, K. G., Prall, W. C., Haasters, F., Ockert, B., Mutschler, W., and Grote, S. (2011). Diagnosis and treatment of acute ankle injuries: development of an evidence-based algorithm. *Orthopedic Reviews*, *4*(1), e5. https://doi.org/10.4081/or.2012.e5

Rockwood Jr, C. A. (1984). Fractures and dislocations of the shoulder. En C. A. Rockwood Jr y D. P. Green (Eds.), *Fractures in Adults* (pp. 860–910). Lippincott.

Standring, S. (Editor-in-Chief) (2015). *Gray's Anatomy. The Anatomical Basis of Clinical Practice* (41ª Ed.). Elsevier.

Taimela, S., Kujala, U. M., and Osterman, K. (1990). Intrinsic Risk Factors and Athletic Injuries. *Sports Medicine*, *9*(4), 205–215. https://doi.org/10.2165/00007256-199009040-00002

Tannast, M., Siebenrock, K. A., and Anderson, S. E. (2008). Femoroacetabular impingement: radiographic diagnosis-what the radiologist should know [Article in Spanish]. *Radiología*, *50*(4), 271–284. https://doi.org/10.1016/s0033-8338(08)71986-6

White, T. O., Mackenzie, S. P., and Gray, A. J. (2016). *McRae. Traumatología. Tratamiento de las fracturas en urgencias* (3.a ed.). Elsevier.

Willems, T. M., Witvrouw, E., Delbaere, K., Mahieu, N., De Bourdeaudhuij, I., and De Clercq, D. (2005). Intrinsic Risk Factors for Inversion Ankle Sprains in Male Subjects: A Prospective Study. *The American Journal of Sports Medicine*, *33*(3), 415–423. https://doi.org/10.1177/0363546504268137