Are ankle sprains always benign?

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Introduction

Epidemiology

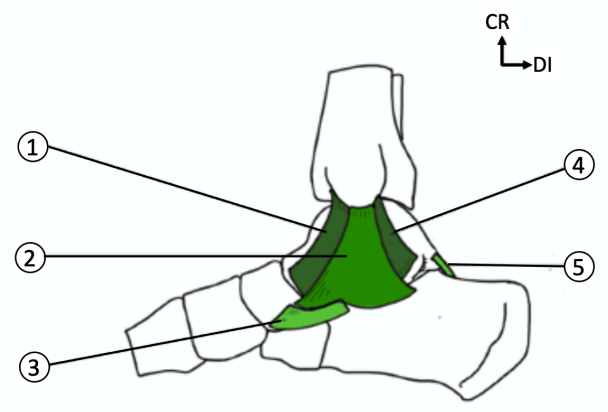
Ankle trauma is one of the most frequent reasons for consultation in the emergency department, especially in pediatrics. They are increasingly frequent in children, especially in overweight and obese patients – the incidence of which is also increasing in the pediatric population – and athletic children and adolescents (1-4). Around 6,000 daily consultations for ankle sprain have been recorded in France. According to the l'Assurance Maladie (AMELI), isolated sprains of the lateral ligaments of the ankle represent up to 90% of all ankle sprains (5). In the pediatric population, ankle sprains are mostly benign (6). Nevertheless, these injuries can vary from simple contusions to tears, ligamentous avulsions or epiphysial separations, also including a simple stretching of the ligaments. As such, these injuries should not be neglected and complications secondary to insufficient management in the case of a missed severe sprain should be rules out. Furthermore, differential diagnoses that can mimic an ankle sprain must also be kept in mind.

It is difficult to estimate the exact prevalence of these types of injuries. For example, the number of patients presenting to the emergency department of the Morvan hospital in Brest and who required ankle immobilization was around 1100 patients, a number based on the number of times the Classification Commune des Actes Médicaux (CCAM) code for ankle immobilization was submitted for the year 2019, as well as around 400 at the Nantes University Hospital. These numbers probably underestimate the true incidence of ankle trauma, especially since there are many ankle sprains that are treated in private clinics.

Clinical presentation and diagnosis

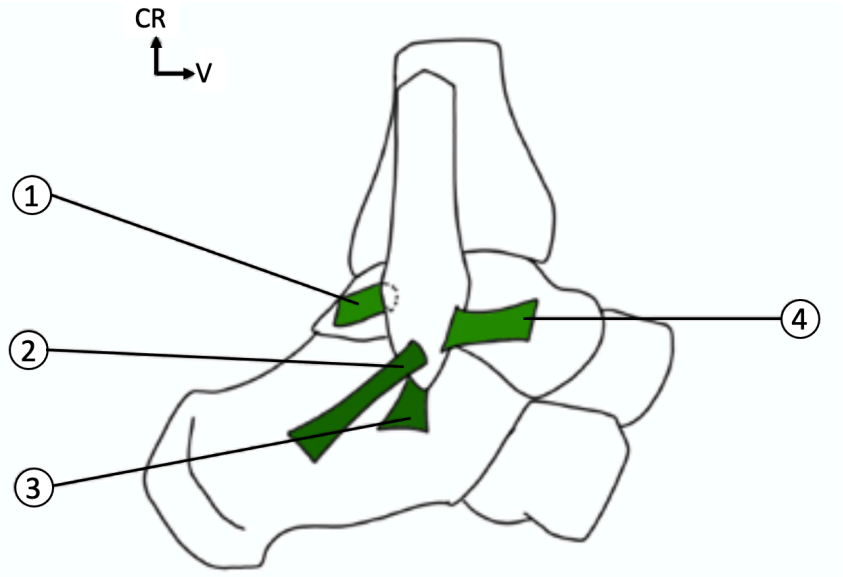
Anatomy recap

The ankle consists of the ankle mortise and the talus, as well as their surrounding ligaments including the medial and lateral collateral ligaments, the accessory syndesmoses which allow the stabilization of the ankle in the coronal and sagittal planes, and the joint capsule



1- Anterior tibiotalar ligament (Anterior bundle of the deltoid ligament)
2- Tibicalcaneal ligament (Middle bundle of the deltoid ligament)
3- Calcaneonavicular ligament (Spring ligament)
4- Posterior tibiotalar ligament (Posterior bundle of the deltoid ligament)
5- Posterior talocalcaneal ligament

Ligamentous complex of the ankle, medial view



1- Posterior talofibular ligament (Posterior bundle of the lateral ligamentous complex)
2- Calcaneofibular ligament (Middle bundle of the lateral ligamentous complex)
3- Talocalcaneal ligament
4- Anterior talofibular ligament (Anterior bundle of the lateral ligamentous complex)

Ligamentous complex of the ankle, lateral view

The lateral ligamentous complex is comprised of three bundles. The anterior talofibular ligament (ATFL), suspended between the anterior border of the distal fibular epiphysis and the neck of the talus, its main role is the stabilization of the foot and prevention of anterior translation of the ankle join in plantar flexion. It is considered the most fragile ligament and is thus the most

frequently injured during trauma in inversion. The calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL) are less commonly injured.

In this chapter, benign sprains of the lateral ligamentous complex of the ankle will be discussed.

Pathophysiology

Diagnosis:

Ankle sprains are capsular and ligamentous injuries, ranging from a simple stretching of the ligament to actual ruptures (more frequently seen in post-pubertal children and adults) or avulsion fractures of either the osteochondral attachment or the bone (more frequent in pre-pubertal children).

The mechanism of injury is usually forced inversion, i.e., plantar flexion, adduction, and supination of the ankle.

Eversion corresponds to dorsiflexion-abduction-pronation of the ankle.

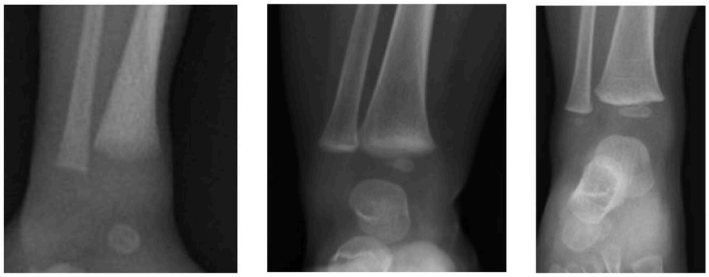
No correlations have been found between the severity of pain, severity of injury, and the mechanism of injury. However, there seems to be a relationship between local clinical findings, such as edema or a visible hematoma, and anatomical lesions (7). Although taking a thorough history is important, the exact mechanism of injury is often unknown, making interrogation often of little value in young children.

Since the physis are more fragile than capsular-ligamentous structures, ankle trauma usually leads to fractures and epiphyseal separations of variable severity, usually classified according to the Salter-Harris classification as types 1 or 2.

Nevertheless, ligamentous injuries are still more common than fractures in children.

Growth of the ankle

The ankle joint in children is composed of a cartilaginous matrix which ossifies progressively, including open physis at the tibia and the fibula, with ossification centers that appear at varying ages.



(1) (2) (3)

(1) Radiographic aspect of the ankle in a newborn
(2) Radiographic aspect of the ankle in a 6-month-old child
(3) Radiographic aspect of the ankle in a 2-year-old child

(4) (5) (6)

(4) Radiographic aspect of the ankle in a 6-year-old child
(5) Radiographic aspect of the ankle in a 11-year-old child
(6) Radiographic aspect of the ankle in a 16-year-old child

Interpreting images of the ankle should therefore be done according to the child's age. The type of Injury is also variable depending on the child's stage of growth.

When is a sprain considered benign?

Clinical exam:

Diagnosing ankle sprains requires ruling out other diagnoses in patients with ankle trauma.

Therefore, a minute clinical exam is of paramount importance, although said exam in the acute setting is often limited by impaired mobility. The location of the pain should be noted, and edema and hematoma assessed.

Owing to the fragility of the physis compared to the ligamentous structures, and therefore the high prevalence of epiphyseal separation (or articular fractures), radiographs should be obtained in all patients with ankle trauma in the pediatric population, even though not all fractures are visible on standard radiographs. In contrast to the adult population, there are no actual guidelines on the management of ankle trauma in children.

Terms such as mild, moderate, and severe have also not been well established in children, contrary to adults.

Medical imaging:

Radiographs:

Indications to obtain radiographs are as of yet ill-defined. Practically, they are obtained almost systematically in all skeletally immature children presenting with trauma due to fears of missing a fracture, to an incomplete physical exam, or to parental pressure.

Validated clinical tools may be useful, but their diagnostic value remains insufficient, and their sensitivity is low when faced with little or non-displaced fractures (Ottawa ankle rules, Malleolar zone, Low risk ankle rule, etc…) (8-10).

At least two different views of the ankle (Anteroposterior and lateral) while clearing the base of the fifth metatarsal should be obtained. A fracture has been found in less than 15% of children presenting with ankle trauma. Although a small proportion of patients present occult fractures, most are readily diagnosed.

Limiting the indications for radiographs to decrease unnecessary exposure to radiation should be a public health initiative.

Ultrasonography:

Ultrasonography aids in evaluating the lateral and medial ligamentous structures, arriving at the diagnosis, assessing the topography of the lesion, and visualizing signs of occult fracture.

It is highly sensitive and specific (11) but remains scarcely utilized in practice.

MRI:

The MRI is the most powerful imaging modality but is practically difficult to obtain in the emergency department or in the follow-up of classic cases. It may bring to light occult fractures or bony contusions. Recent studies have shown the predominance of ligamentous injuries (80%) and bony contusions (22%) compared to physeal injuries, which are more rarely encountered (12).

CT-scan:

CT-scanning is useful in the diagnosis of articular fractures, the evaluation of their displacement, and the confirmation of fractures extending to the physis, when in doubt. It is of little value in the diagnosis and evaluation of sprains.

Complementary imaging:

Stress radiographs and ultrasonography: These tests allow the identification of instability or laxity. They are not frequently obtained in the practical setting.

CT-arthrogram: It allows the identification of a bony foreign body or an osteochondral lesion. It is often reserved for the preoperative assessment of painful and chronic ankle instability dating back 6 months (1). It is the preferred medical exam for the confirmation of ligamentous lesions, but also of articular cartilage (4).

Signs of severe sprains: According to the literature, avulsion fractures of the tip of the fibula are found in 6-28% of patients (13). It is at high risk of instability and over one third of these children present with recurring sprains (14). Avulsion fractures of the lateral aspect of the talus are rather rare.

(1) *(2)* *(3)*

Stress radiograph in forced varus showing an avulsion fracture of the tip of the fibula with an associated os subfibulare

(1) Anteroposterior radiograph of the same ankle in neutral position
(2) Postoperative radiograph after osteosynthesis using an anchor

Treatment

The management of ankle trauma in children with an immature skeleton is not well established (15-16). Protocols often differ from center to center (Aircast® or SoftCAST™ braces with RICE protocols, vs. casting).

Nevertheless, it is imperative to rapidly relieve the child's pain by temporarily immobilizing the ankle with a splint, and then to reassure them and their family.

Treatment strategies may generally be categorized into two: Functional treatment vs. orthopedic treatment with strict immobilization, along with medical treatment, painkillers, and NSAIDs.

Surgery is not indicated in the acute setting, except in case of a fracture.

Practically, in many centers, even though no fracture is visible on the radiograph, if the patient is unable to bear weight in the emergency department, rigid immobilization is utilized with a plaster cast or fiberglass boot for 3 to 6 weeks, without bearing weight.

Therapeutic strategies found in the literature in children presenting with mild trauma of the ankle are numerous with relatively comparable efficiency (17).

The long-term functional benefit of return to normal activity and ambulation seems to be in favor of functional rather than rigid immobilization (17).

Functional treatment

Rest, Icing, Contention – either with a simple strap, removable semi-rigid orthoses with lateral stabilization, or a laced ankle brace – and Elevation (RICE), along with physiotherapy after pain relief has been achieved in patients with more severe or "real" recurrent sprains, is indicated.

Orthopedic treatment with immobilization

Twenty years ago, a rigorous orthopedic treatment was applied: application of a plaster splint for 8 days which is then transformed into a plaster cast boot for another 15 days without bearing weight. Owing to the prolonged immobilization, rehabilitation was indicated along with, when necessary, podiatric corrections for architectural disorders of the foot with the use of orthoses (1).

This "wise solution" is actually variable depending on the center and based on the clinical findings. Immobilization is usually between 3 to 6 weeks. It consists of immobilization with a plaster cast or fiberglass boot, with or without weightbearing, or with a soft fiberglass ankle brace or a small soft boot allowing a certain amount of mobility.

Thromboembolism prophylaxis is usually not necessary in premenstrual girls and before the development of secondary sexual characteristics in boys.

Surgery

Surgery is usually reserved for patients with chronic recurrent sprains. The principle of surgical treatment is to regain articular stability through capsulorrhaphy and by reinforcing the capsuloligamentous complex with either a periosteal flap in young children (1) or by arthroscopic reconstruction of the ligaments with the Broström technique in adolescents (18).

Differential and little-known diagnoses

Of a sprain in the acute phase

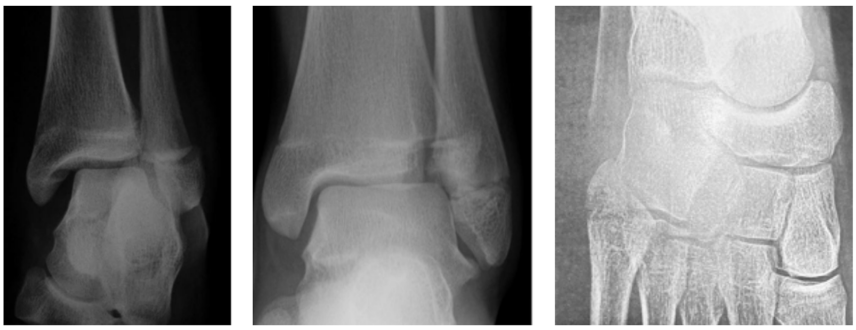
Fractures and epiphyseal separations

Non-displaced Salter I and II fractures of the distal fibula are considered low-grade fractures which, owing to the thicker periosteum than in the adult population, are at lower risk of interval

displacement and usually present a favorable outcome with a good functional prognosis, no matter the treatment strategy employed.

Epiphyseal separations are rare compared to ligamentous injuries. They are found in 0 to 3% of ankle trauma according to a recent meta-analysis (13).

The clinician must officially rule out a high-grade fracture, especially a Tillaux fracture (which is sometimes difficult to observe on radiographs), a fracture of the base of the 5th metatarsal (which should be distinguished from a secondary ossification center), a fracture of the tarsal bones, injuries to the tibiofibular syndesmosis, or a diastasis. These lesions are at high risk of destabilizing the ankle joint if treatment is inadequate.



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(1) Radiographic aspect of a displaced Salter I fracture of the fibula
(2) Radiographic aspect of a Tillaux fracture
(3) Radiographic aspect of a fracture of the base of the 5th metatarsal

In these cases, management of the patient may remain conservative with a stricter follow-up or become surgical.

Inadequate or insufficient treatment may lead to chronic pain, instability, delayed return to activity, growth disturbance, and early osteoarthritis.

Osteochondral lesions

The most common osteochondral lesion is the osteochondral lesion of the dome of the talus (OLT). Clinically, patients generally present with mechanical pain and cracking sensations.

Diagnosis is usually obtained on radiographs and is completed by a CT scan, which may give information on the stability of the lesion. Treatment is surgical (fragment fixation, removal of loose bodies, debridement and microfracturing, and mosaicplasty) (4).

Recurrent sprains vs chronic pain

Up to 40% of patients present residual symptoms after sustaining a sprain in inversion (19). If symptoms persist past the usual timeframe of a supposed simple sprain, the clinician should consider alternative diagnoses, which are often simplified as “recurrent sprains”. Patients generally present either with pain or ankle instability, which may or may not be painful. These signs and symptoms should be assessed during clinical examination, which may be more contributive after the acute phase has abated.

Synostoses (calcaneonavicular and talocalcaneal) and a Too Long Calcaneal Process (TLAP)

These entities are part of a group of pathologies known as tarsal coalition, where there is congenital bony or cartilaginous fusion of the tarsal bones. This is translated clinically as chronic, painful pes planovalgus. Patients present with episodic painful bouts that are often misdiagnosed as recurrent sprains.

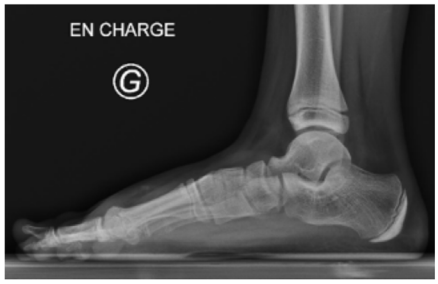
As the child grows, the tarsal coalition ossifies, and the foot becomes rigid with pains that most often appear after 10 years of age (20). In contrast with a real sprain, there is often no history of trauma in inversion and, clinically, there is no hematoma, although there may be some mild edema.

This entity should be considered when faced with recurrent sprains that are always monolateral and are due to minimal trauma.

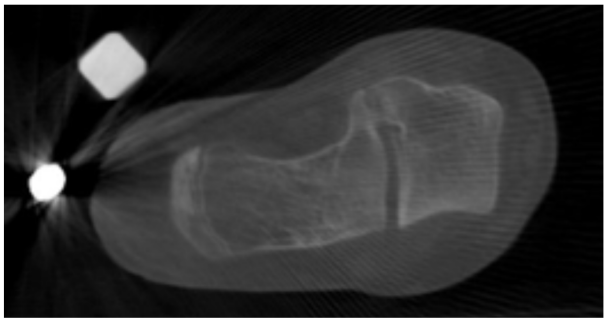
The child may also be asked to walk on the tip of their toes where a fixed calcaneus would evoke synostosis of the tarsals. 50% of tarsal coalitions are bilateral (20).

Calcaneonavicular coalitions may be seen on radiographs, especially on anteroposterior radiographs of the foot with external oblique views, whereas talocalcaneal coalitions are more easily seen on CT-scans and MRI, if there is doubt on the presence of a “C-sign” on the lateral views.

Management is initially conservative with surgery being reserved for failure of initial treatment and involves either open or arthroscopic resection of the coalition (21).



Radiographic aspect of a talocalcaneal synostosis, with visualization of a « C-sign » on a weight-bearing lateral radiograph of the foot



CT aspect of a Talocalcaneal synostosis as seen on an axial slice

Pre- and postoperative aspect of a calcaneonavicular synostosis

The TLAP is also part of the same pathophysiological entity as the synostoses. It is a developmental deformity of the hindfoot that leads to a rigid and often painful pes planus, such as in tarsal coalition, but without bony fusion, causing calcaneonavicular impingement. Diagnosis is radiographic, particularly on oblique views or on CT-scans. Treatment is usually conservative.

Osteochondrosis or osteochondritis dissecans (OCD) of the talus

This is a rare entity, with the ankle being the third most frequent location after the knee and elbow. It is most frequently found in girls aged 12 to 15 years old (22). Patients usually present with a painful ankle with swelling and limited range of motion. A crescent sign or bony erosions are often found on radiographs. The lesion can also be visualized on an MRI.

The primary differential diagnosis includes a post-traumatic osteochondral fracture. Management depends on the stage of the lesion, as would be classified according to the 4 stages of Berndt and Harty (23).

Radiographic aspect of an osteochondral lesion of the talus

Complex regional pain syndrome (CRPS)

Although CRPS is more rarely encountered than in the adult population, it should still be ruled out. This diagnostic entity requires a global pain management strategy along with a soft physiotherapy program.

Rare cases

Some authors have reported that, in 4% of children who had previously presented severe ankle trauma, there was formation of perineural fibrosis of the dorsal intermediate cutaneous branch of the superficial fibular nerve. Pain and paresthesia are often triggered inversion of the ankle. This entity requires neurolysis of the entrapped nerve along with surgical stabilization of the ankle (24).

More frequently encountered and presenting with a different clinical picture, the posterior ankle impingement syndrome (PAIS) is a very frequently missed etiology of posterior ankle pain. This entity was originally described in ballet dancers and football (soccer) players. It is caused by posterior mechanical impingement of bony structures (os trigonum or a posterior talar process) or soft tissues during extreme plantarflexion of the ankle (25).

Consequences and complications

Ankle sprains in the pediatric population are most often benign. When presenting with chronic pain, certain diagnoses should be ruled out, such as chronic instability – which may sometimes be secondary to an avulsion of the enthesis (tip of the lateral malleolus) – or the rare impingement syndrome, but also differential diagnoses for ankle sprains, especially tarsal coalition.

Recurrent sprains, or rather ankle instability, are not always secondary to the initial trauma. They may be due to a variety of causes and are not always sprains.

These entities should be differentiated from ankle instability, which is clinically seen by testing the ankle in forced varus (testing the CFL) and searching for an anterior drawer sign (testing the ATFL).

Chronic lateral instability is estimated between 5-20% with an increased risk of long-term subtalar osteoarthritis after ligamentous distension or rupture (4). The ATFL is frequently injured, with injuries to the CFL and the tibiofibular syndesmosis being less common (26). A recent meta-analysis did not show any relation between the occurrence of instability and the number of injured ligaments. However, patients with a higher number of injured ligaments had more severe sprains, which lead to delayed return to activity (27).

Another less-well known pathophysiological entity that should be considered when faced with painful ankle instability with swelling is the impingement syndrome (or anterolateral impingement), which is due to incorrect healing of the lateral ligamentous complex with synovial hypertrophy intruding between the talus and the tibia (28).

Conclusion and Take Home Messages:

Considered as benign, ankle sprains are complex entities with multiple diagnoses requiring special attention during management.

In patients presenting with ankle sprains:

- Other diagnoses should promptly be ruled out
- A minute physical examination should be undertaken
- Radiographs should be obtained with views specific to the preliminary diagnosis based on the physical exam findings and based on diagnostic tests such as the Low-Risk Ankle Rule, all the while keeping in mind that such tools have not been validated in children.
- The different tarsal and ankle bones should be assessed on imaging
- Keeping in mind that the epiphyseal separation is less frequent than actual sprains and avulsions
- Multiple pathophysiological entities may mimic a sprain and should be considered if the pain becomes chronic
- In conclusion, benign sprains are those that do not become complicated

References:

1. Masson E. Entorses de la cheville de l'enfant et de l'adolescent. EM-Consulte. Disponible sur: https:// www.em-consulte.com/article/24718/entorses-de- la-cheville-de-l-enfant-et-de-l-adolescent

2. Masson E. Entorses de la cheville de l'enfant et de l'adolescent. EM-Consulte. Disponible sur: https:// www.em-consulte.com/article/1355997/entorses- de-la-cheville-de-l-enfant-et-de-l-adolescent

3. Wier L, Miller A, Steiner C. Sports Injuries in Children Requiring Hospital Emergency Care, 2006: Statistical Brief #75. In: Healthcare Cost and Utilization Project (HCUP) Statistical Briefs [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2006. Disponible sur: http://www.ncbi.nlm.nih.gov/ books/NBK53975/

4. Entorses de la cheville de l'enfant et de l'adolescent - ClinicalKey Student. Disponible sur: https://www- clinicalkey-com.scd-proxy.univ-brest.fr/student/ content/emc/51-s2.0-S0292062X2042433X

5. Reconnaître une entorse de la cheville. Disponible sur: https://www.ameli.fr/assure/sante/themes/ entorse-cheville/reconnaitre-entorse-cheville

6. Masson E. Traumatisme de la cheville : épidémiologie et évaluation clinique. EM-Consulte. Disponible sur: https://www.em-consulte.com/article/739862/ traumatisme-de-la-cheville-epidemiologie-et- evaluation

7. Masson E. Traumatismes de la cheville sans fracture chez l'enfant. Étude prospective par résonance magnétique de 116 patients. EM-Consulte. Disponible sur: https://www.em-consulte.com/article/182152/ traumatismes-de-la-cheville-sans-fracture-chez-len

8. Dohin B, Lubanziado D. Validation of the ottawa ankle rules for varus ankle trauma in children: a prospective study of 160 cases. Orthop Proc. 1 janv 2004;86-B(SUPP_I):20-20.

9. Boutis K, Komar L, Jaramillo D, Babyn P, Alman B, Snyder B, et al. Sensitivity of a clinical examination to predict need for radiography in children with ankle injuries: a prospective study. Lancet Lond Engl. 22 déc 2001;358(9299):2118-21.

10. Tormey P, Callender O, Fitzpatrick P, Okafor I, McNamara R, Kandamany N. Introduction of the low risk ankle rule to a paediatric emergency department. Injury. mars 2020;51(3):633-5.

11. Cao S, Wang C, Ma X, Wang X, Huang J, Zhang C. Imaging diagnosis for chronic lateral ankle ligament injury: a systemic review with meta-analysis. J Orthop Surg. 22 mai 2018;13(1):122.

12. Boutis K, Plint A, Stimec J, Miller E, Babyn P, Schuh S, et al. Radiograph-Negative Lateral Ankle Injuries in Children: Occult Growth Plate Fracture or Sprain? JAMA Pediatr. janv 2016;170(1):e154114.

13. Rougereau G, Noailles T, Khoury GE, Bauer T, Langlais T, Hardy A. Is lateral ankle sprain of the child and adolescent a myth or a reality? A systematic review of the literature. Foot Ankle Surg Off J Eur Soc Foot Ankle Surg. 1 mai 2021;S1268-7731(21)00088-6.

14. Yamaguchi S, Akagi R, Kimura S, Sadamasu A, Nakagawa R, Sato Y, et al. Avulsion fracture of the distal fibula is associated with recurrent sprain after ankle sprain in children. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. sept 2019;27(9):2774-80.

15. Marson BA, Ng J, Myint Y, Grindlay D, Ollivere BJ. Management of « low-risk » ankle fractures in children: a systematic review. Ann R Coll Surg Engl. nov 2019;101(8):539-45.

16. Voizard P, Moore J, Leduc S, Nault M-L. The heterogeneous management of pediatric ankle traumas: A retrospective descriptive study. Medicine (Baltimore). juin 2018;97(24):e11020.

17. Boutis K, Willan AR, Babyn P, Narayanan UG, Alman B, Schuh S. A randomized, controlled trial of a removable brace versus casting in children with low-risk ankle fractures. Pediatrics. juin 2007;119(6):e1256-1263.

18. Kocher MS, Fabricant PD, Nasreddine AY, Stenquist N, Kramer DE, Lee JT. Efficacy of the Modified Broström Procedure for Adolescent Patients With Chronic Lateral Ankle Instability. J Pediatr Orthop. déc 2017;37(8):537-42.

19. Staples OS. Result study of ruptures of lateral ligaments of the ankle. Clin Orthop. 1972;85:50-8.

20. Bohne WH. Tarsal coalition. Curr Opin Pediatr. févr 2001;13(1):29-35.

21. Masson E. Arthroscopie chez l'enfant [Internet]. EM-Consulte. [cité 31 déc 2021]. Disponible sur: https://www.em-consulte.com/article/254014/ arthroscopie-chez-lenfant

22. Mendeszoon MJ, Iosue HE. Pediatric Osteochondritis Dissecans of the Talus. Clin Podiatr Med Surg. 1 janv 2022;39(1):105-11.

23. Berndt AL, Harty M. Transchondral fractures (osteochondritis dissecans) of the talus. J Bone Joint Surg Am. sept 1959;41-A:988-1020.

24. Falciglia F, Basiglini L, Aulisa AG, Toniolo RM. Superficial peroneal nerve entrapment in ankle sprain in childhood and adolescence. Sci Rep. 23 juill 2021;11:15123.

25. Kushare I, Kastan K, Allahabadi S. Posterior ankle impingement–an underdiagnosed cause of ankle pain in pediatric patients. World J Orthop. 18 oct 2019;10(10):364-70.

26. Gruskay JA, Brusalis CM, Heath MR, Fabricant PD. Pediatric and adolescent ankle instability: diagnosis and treatment options. Curr Opin Pediatr. févr 2019;31(1):69-78.

27. Pacheco J, Guerra-Pinto F, Araújo L, Flora M, Alçada R, Rocha T, et al. Chronic ankle instability has no correlation with the number of ruptured ligaments in severe anterolateral sprain: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. nov 2021;29(11):3512-24.

28. Liu SH, Nuccion SL, Finerman G. Diagnosis of anterolateral ankle impingement. Comparison between magnetic resonance imaging and clinical examination. Am J Sports Med. juin 1997;25(3):389-93.