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Review

Is lateral ankle sprain of the child and adolescent a myth or a reality? A systematic review of the literature

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ABSTRACT

Background: Ankle trauma in children and adolescents is the most common orthopedic injury encountered in pediatric trauma. It has long been recognized that a lateral ankle injury in this population is often a Salter and Harris type I fracture of the distal fibula (SH1). The purpose of this study is to confirm the existence of a lateral ankle sprain and to report the incidence of each pathology of the lateral ankle compartment: SH1 fracture, ATFL injury, and osteochondral avulsions.
Methods: A systematic review of the literature is done using the database provided by PubMed and Embase. All articles reporting the incidence of imaging modality-confirmed lateral ankle injury (SH1, ATFL injury, osteochondral avulsion) in children and adolescents were included. Exclusion criteria were the following: case reports or articles with less than ten subjects, unspecified imaging modality and articles unrelated to lateral ankle lesions. Thus, 237 titles and abstracts were selected, 25 were analyzed thoroughly, and 11 articles were included for final analysis.
Results: SH1 fractures were found in 0–57.5% of the cases in all series and 0–3% in the most recent series. A diagnosis of an ATFL injury was found in 3.2–80% and an osteochondral avulsion of the distal fibula in 6–28.1%. The most recent series report 76–80% and 62% for ATFL injury and osteochondral avulsion respectively.
Conclusions: There is a non-negligible incidence of ATFL sprains and fibular tip avulsions in patients with a suspected SH1 fracture of the distal fibula. According to recent evidence and MRI examinations, the most common injuries of the pediatric ankle are ATFL sprain and osteochondral avulsions. This should be taken into consideration in daily practice when ordering radiological examination and deciding on treatment modalities

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1. Introduction

Ankle trauma is the most common paediatric injury [1–4]. It is contributing to 30% of sports-related injuries [5,6]. It has long been acknowledged that a lateral ankle injury in this population with an inversion type mechanism is usually a fracture line through the distal fibular physis [7] rather than a lateral ankle sprain [8,9], and treated accordingly as a Salter and Harris type I fracture (SH1). Treatment varied in the literature and could consist of six weeks of immobilization in a short leg cast, removable splinting [10], or functional treatment [11].

However, recent studies go against such a diagnostic rationale and treatment modality [12–15]. Indeed, if the fracture is obvious on X-ray, there is no diagnostic or therapeutic concern. The complexity of management is to be able to differentiate an SH1 fracture from an anterior talofibular ligament (ATFL) sprain in children with external ankle injury with a normal X-ray. A lateral ankle sprain is a differential diagnosis that exists in the traumatic paediatric ankle with a sprain found in the anterior talofibular ligament.

This study aims to determine the existence of lateral ankle sprain, i.e. the avulsion or rupture of the ATFL in the paediatric population and to define the incidence of different types of lateral ankle injuries in children. The second objective was to analyze the usefulness of the different imaging modalities (X-rays, ultrasound and MRI) in reporting the incidence of lateral ankle lesions.

2. Material and method

2.1. Study protocol

This research was done according to PRISMA guidelines for systematic review and meta-analysis [16,17]. All articles reporting a confirmed diagnostic lesion of the lateral ankle injury in children and adolescents through imaging modalities were included regardless of the timeframe. The imaging modality had to be defined (conventional radiography, ultrasound and MRI). Other inclusion criteria were French or English articles, abstracts that were available online, and children below 16 years old. Indeed, closure of the distal fibular growth plate occurs at 17 years old regardless of gender [18]. Exclusion criteria were the following: case reports or articles with less than ten subjects, unspecified imaging modality and articles unrelated to lateral ankle lesions (distal fibular fracture SH1, distal fibular osteochondral avulsion or ATFL injury).

2.2. Research databases

A systematic review of the literature of all articles published up to November 2020 was done using the database provided by PubMed and Embase. MeSH terms were: “lateral ankle sprain”, “lateral ligament injuries”, “children”, “pediatrics”, “lateral ankle fracture”, “salter and harris”, and “fibular fracture” used alone or in an association.

2.3. Articles selection

Two independent authors reviewed the articles. A first selection was performed based on the articles’ titles and abstracts. Then, the selected articles were thoroughly analyzed and therefore retained or dismissed based on the inclusion and exclusion criteria mentioned above. Finally, the authors analyzed the indexed references of the selected articles and retained any pertinent finding. If an author selected an article but not by the other, a mutual agreement was found between all authors on whether or not to include it in the study.

2.4. Data extraction

The two independent authors proceeded to data extraction from the selected studies. The gathered information included: type of imaging modality, the time between ankle trauma and diagnosis, demographic data, definitive diagnosis of a particular ankle lesion (SH1 fracture of the distal fibula, ATFL sprain, osteochondral avulsion) and finally, level of evidence of the study. According to the Cochrane recommendations, all authors independently evaluated the methodology used in each selected study while adjusting for confounding factors (Preferred Reporting Items for Systematic Reviews and Meta-Analysis, PRISMA) [16,17].

2.5. Method of analysis

Since a high heterogeneity was found between selected studies, results were presented as means, minimum-maximum and percentages. No test for homogeneity was used.

3. Results

3.1. Selected articles

Five hundred eighty-six articles were found using the MeSH terms mentioned above, and two hundred thirty-seven articles were screened. A total of eleven articles published between 1996 and 2019 were finally selected to review this study. The evidence level was II for five articles, III for one article and IV for five articles. The algorithm of selection is presented in Fig. 1.

3.2. Global incidence (Table 1)

The incidence of SH1 fractures of the distal fibula varied significantly according to their date of issue, from 0 to 57.5%. The two least recent series issued before 2000 found 50 and 57.5% of SH1 fractures [19,20]. Three series published between 2001 and 2012 evaluated the incidence of SH1 fractures to vary from 10 to 18% [21–23]. Finally, five series issued between 2008 and 2016 reported 0 to 3% [12–15].

The diagnosis of distal fibular chondral avulsion was not mentioned in the series until 2010. An estimated incidence ranging

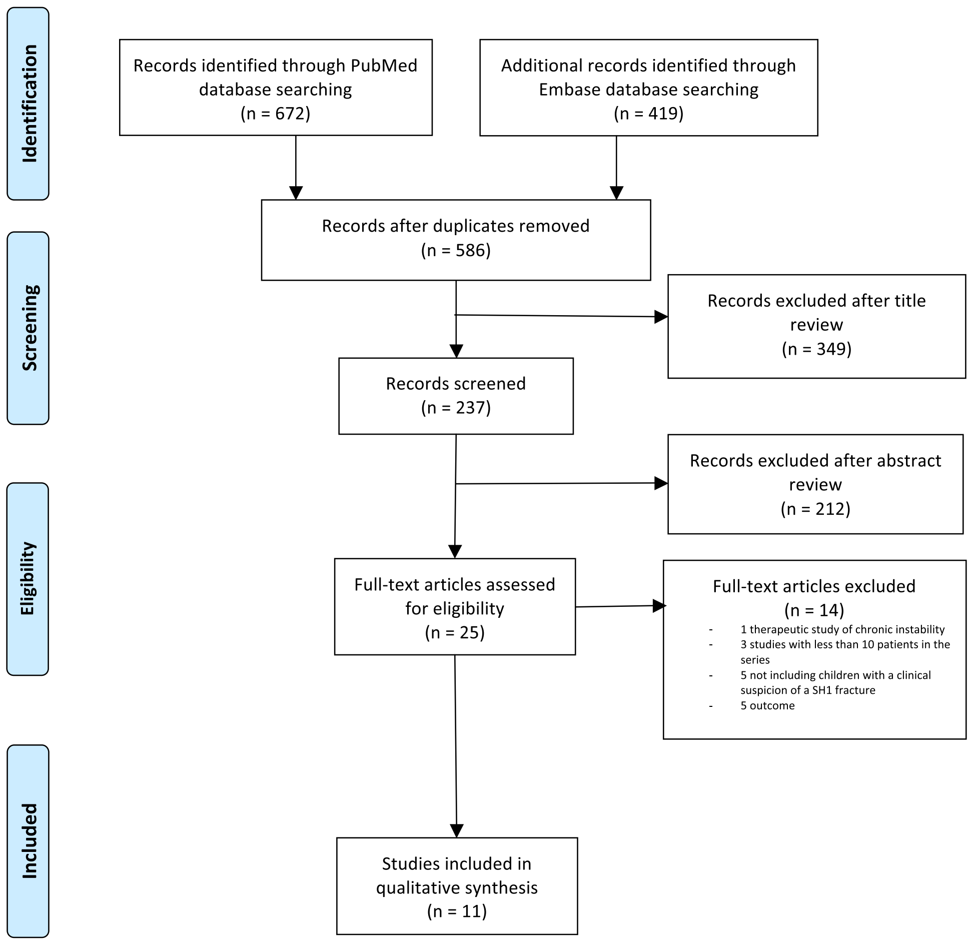

Fig. 1. Flowchart illustrating the article selection process.

from 6 to 28.1% was reported [13,14]. Recently, Yamaguchi et al. reported 62% of avulsions following the first episode of ankle sprain [24].

The incidence of ATFL sprain diagnosis ranged between 19.6 and 45.4% in the series published between 1998 and 2008 [12,19,21]. It increased significantly in three series published after 2010, with incidences ranging from 76 to 80% [13,14,23]. However, Hofsli et al. in 2016 reported an incidence of 3.2% of ATFL sprain [15].

3.3. Incidence according to the imaging modality

When using conventional radiography and, more specifically, follow up X-rays, the incidence of SH1 fracture was 18% in cases where the physical exam was suggestive of a distal fibular fracture [22]. But the main contribution of follow up X-rays was identifying distal fibular osteochondral avulsions evaluated to range from 26% in the series published by Kwak et al. [25] to 62% by Yamaguchi et al. [24]. They used specific views to visualize the insertion of the ATFL and the calcaneofibular ligament.

The use of ultrasound has identified a subperiosteal hematoma on the distal fibula at the growth plate level in SH1 fractures, with an estimated ultrasound incidence of 57.5% by Gleeson [20]. However, Farley identified 18% of SH1 fractures in his study, of which 45.4% had a concomitant ATFL lesion [21].

The recent use of the MRI seemed to yield more precise information: 0 to 3% SH1 fractures [12–15], 6 to 28.1% osteochondral avulsions [13,14,23] and 76 to 80% ATFL sprains [13,14,23]. Hoflsi et al. [15] and Launay et al. [12] found lower incidences of ATFL sprain 3.2% and 19.6%, respectively. Endele et al. found 10% of the cases having a SH1 fracture [23]. The only study to yield contradicting results was to use an MRI done by Stuart et al. in 1998, showing 30% ATFL sprain and 50% SH1 fractures [19].

4. Discussion

This study's main result confirms that ATFL sprains exist and that distal epiphyseal fractures of the fibula are over-diagnosed. However, even if many studies have shown ATFL sprain in the pediatric and adolescent population, its frequency and clinical manifestation remain unknown, thus resulting in unclear management [13,14,26,27]. Indeed, even after 20 years of proving otherwise, the symbolic saying “the child does not get sprains” [3] is still very present in the minds of orthopedic surgeons, pediatricians or traumatologists [28] (referring to the mechanism of failure in children whose periosteum and ligamentous attachments are more substantial than the epiphysis). The fibula's distal epiphyseal fracture is also believed to be the most common fracture around the ankle in children and adolescents [29]. The growth plate is weaker than cancellous bone, periosteum or ligamentous attachments and thus fails first. Children having a lateral ankle trauma with an inversion type mechanism associated with standard radiography have been treated for a suspected SH1 fracture of the distal fibula for nearly 50 years [8,30,31]. No study in this review reported a possible impact of age, weight or gender on the incidence of the different lateral ankle injuries. However, in addition to certain intrinsic factors of hyperlaxity or connective

Table 1
Data from selected studies, and estimated incidences of SH1 fractures, ATFL sprains, and osteochondral avulsions.

Authors	Year of Publication	Level of Evidence	Study Type	Main Objective	Number of Patients	Age	Follow-up (Months)	Incidence of ATFL Sprain (%)	Incidence of Avulsion (%)	Incidence of SH1 Fractures (%)
Gleeson et al. [18]	1996	IV	Prospective	Confirmation of SH1 fracture by ultrasound	40	9 (3–14)	1	–	–	23 (575%)
Stuart et al. [17]	1998	IV	Prospective	MRI performed one week after a clinical suspicion of SH1	10	11	–	3 (30%)	–	5 (50%)
Farley et al. [19]	2001	II	Prospective	Confirmation of SH1 fracture by ultrasound	11	9.6 (5–13)		5 (45,4%)	–	2 (18%)
Sankar et al. [20]	2008	IV	Retrospective	Followed by x-rays at three weeks of suspected SH1	37	8.5 (1.3–15)	–	–	–	7 (18%)
Launay et al. [10]	2008	II	Prospective	MRI performed for any ankle trauma without fracture identified on the x-ray	102[a]	8–15	–	20 (19.6%)	–	2 (1.9%)
Boutis et al. [11]	2010	II	Prospective	MRI performed one week after a clinical suspicion of SH1	18	8.7 (5–12)	–	14 (78%)	1 (6%)	0 (0%)
Endele et al. [21]	2012	IV	Retrospective	MRI scans performed within three days of a sprained ankle	30	11.2 (7–15)	3–8	23 (76%)	3 (10%)	3 (10%)
Kwak et al. [23]	2015	IV	Retrospective	X-rays taken one month after an external ankle sprain	78	9.8 (4.75–15.1)	5.5	–	20 (26%)	–
Boutis et al. [12]	2016	II	Prospective	MRI performed one week after a clinical suspicion of SH1	135	9.2 (5–12)	1–3	108 (80%)	38 (281%)	4 (3%)
Hofsli et al. [13]	2016	II	Prospective	MRI performed one week after a clinical suspicion of SH1	31	10 (5–15)	–	1 (3,2%)	–	0 (0%)
Yamaguchi et al. [22]	2019	III	Prospective	Radiographic follow-up after a first episode of ankle sprain	143	9 (6–12)	2–24	–	89 (62%)	–

[a] 116 included patients, but 102 analyzable MRI.

tissue disorders, risk factors for trauma to the external ankle compartment in children have been identified in the literature. They include a history of ankle sprain [32–34], increased height [35,36], balance disorders [37–39] and obesity defined by an increased body mass index [32,33,35,40]. Overweight children would even be at risk of persisting symptoms (weakness, swelling, pain, etc.) six months after the traumatic episode [41].

The overall incidence of SH1 fractures and ATFL sprains shows a discrepancy in findings between the different case series, with variation in results reported over time and depending on the diagnostic means used. Sankar et al. reviewed the follow-up X-rays at three weeks of children suspected of having a SH1 fracture of the distal fibula, with only 18% of the cases showing a periosteal reaction suggestive of an initial physeal fracture [22]. Ultrasound has demonstrated its utility in assessing a specific diagnosis. Gleeson et al. reported 57.5% of SH1 fractures in children with a clinical suspicion of a fracture caused by a traumatic incident within the previous three days based on the presence of a subperiosteal hematoma on ultrasonography [20]. Farley et al. found five ATFL sprains (45.4%), and two SH1 fractures (18%) in a series of eleven children [21]. Ultrasound was used to define the ATFL sprain's grade and differentiate it from an osteochondral or a periosteal avulsion. It also provides information regarding the presence of joint effusion [20,21], lesion over the peroneus longus tendon [20], disruption of the interosseous membrane [21], of the calcaneofibular ligament [21], or a metaphyseal fracture of the distal fibula [20,42,43]. They thus make it possible to provide a specific assessment at an early stage, unlike follow-up X-rays.

The first reported MRI study for confirmation of SH1 fractures was performed by Stuart et al. [19], reporting 50% of proven SH1 fractures and 30% of ATFL sprains. These results showed a marked discrepancy with those of subsequent studies. Lohman et al. showed that all suspected SH1 fractures in their series were reclassified as ligament sprain by MRI [44]. Launay et al. found 19.6% ATFL sprain and 1.9% of external malleolar fracture [12]. Endele et al. found 10% of SH1 fractures, 10% of avulsions and 76% of ATFL sprains [23]. Boutis et al. reported in their first MRI study in 2010 no SH1 fractures, 78% ATFL sprains and 6% of osteochondral avulsions in 18 patients clinically suspected of having a SH1 fracture [13]. They confirmed these previous results with another prospective study of 135 patients [14] (3% SH1 fractures, 28.1% avulsions and 80% ATFL sprains). All patients who presented a SH1 fracture had an associated ligamentous injury. These results on SH1 fractures were confirmed by Hofsli et al. the same year (0% SH1 fracture), but they found a single ATFL sprain in 31 patients (3.2%) [15]. It is striking to note that these results vary over the decades from one case series to another. The precision of MRI machines and the better knowledge of the lesions in pediatric ankles may be elements that could explain such changes in results over time.

X-ray and ultrasound are valid during initial workup for a suspected fracture but can be found lacking [45]. Lohman et al. showed that the radiographs were insufficient: 18% false negatives and 13% false positives for diagnosing SH1 fracture of the distal fibula confirmed by MRI [44]. Ultrasound is less technically demanding than MRI for children under five and is easier to obtain since ankle trauma is a frequent presentation [46]. Nevertheless, MRI remains the most precise examination [14].

Avulsions are more common in children than in adolescents or young adults [47] and should not be overlooked [48]. Specific radiographic views have been described to increase diagnostic sensitivity, as the identification of avulsions may be lacking on conventional views [49]. In fact, up to 62% of sprains were undetected avulsions [24], with only 30% union at three months [25], and a recurrent risk of sprain of 44% at two years [24]. This incidence may appear high in comparison with MRI results and could, according to the authors, be explained by the fact that small avulsions can go undetected on MRI and be falsely classified as isolated bone contusions [24]. Some authors have described accessory subfibular ossifications called os subfibulare [50,51]. Others have reported cases of children prone to episodes of pain or instability with a subfibular bone associated with a history of ankle trauma, suggesting that this ossification is a sign of an old avulsion that went undetected [52,53]. Pill et al. suggested the resection of this subfibular bone associated with a reconstruction of the ATFL at an average of 3.2 years after the initial ankle sprain in children complaining of chronic pain and recurrent sprains [54]. Recently, Kim et al. showed that a large fragment, the presence of fluid interposition between the fibula and the avulsion, or the presence of oedema in this subfibular bone were predictive factors of instability and chronic pain [55].

We recognize several limitations to our study. First, it is a systematic review dealing with heterogeneous articles using different imaging modalities. Secondly, scarce data is confirming a clinical suspicion of SH1 fractures. They cover a period spanning twenty years with fluctuating results over time. One might wonder whether the older reports were overestimating SH1 fractures because of older MRI machines and our lack of knowledge of specific views to identify avulsions. Besides, it would have been interesting to compare two age groups: 5–10 years old on the one hand, and 11–16 years old on the other. Children have different bone and ligament strength according to each age group. The differential diagnosis in this anatomical region in adolescence is Tillaux's fracture, the management of which differs in every way from the sprain. However, since most studies included all age groups up to 14 or 15 years old, we couldn't compare childhood and adolescence. Finally, the level of evidence of most studies remains low. Carrying out higher-level research and focusing more precisely on distinguishing children by age group is necessary to answer the question exactly.

5. Conclusion

There is a non-negligible incidence of ATFL sprains and fibular tip avulsions in patients with a suspected SH1 fracture of the distal fibula. The most recent studies and the use of MRI in studies of a higher level of evidence are starting to question the estimated high incidence of SH1 fractures and prove the apparent predominance of ATFL sprains and fibular tip osteochondral avulsions. This should be taken into consideration in daily practice when ordering radiological examination and deciding on treatment modalities

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Conflict of interest disclosure

GR, TN, GEK, and TL have nothing to disclose. AH is occasional educational consultant for Medacta outside the scope of this work. TB is occasional educational consultant for Arthrex, and associated editor of OTSR-RCOT, outside the scope of this work.

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