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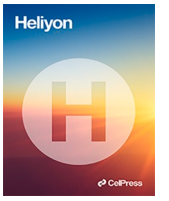

Case report

Point-of-care ultrasound detection of anterior inferior iliac spine avulsion fracture in an adolescent: A case report

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ABSTRACT

Purpose: This study presents a rare case of avulsion fracture of the anterior inferior iliac spine, typically occurring in adolescents engaged in physical activities. The purpose of this study is to emphasize the diagnostic challenges and conservative treatment options available for this condition.

Method: We describe the case of a 14-year-old healthy adolescent who suffered from an avulsion fracture following pelvic trauma after participating in a short-distance sprint. Initial physical examination and X-ray imaging were inconclusive, showing no apparent fractures. Due to parental refusal of a Computerized Tomography (CT) scan by concerns over the potential risks associated with radiation exposure, a diagnostic ultrasound was performed, which confirmed the presence of an avulsion fracture at the anterior inferior iliac spine.

Results: The ultrasound findings led to a conservative treatment approach, involving rest, and unloading of the affected limb. Follow-up assessments indicated significant pain relief within four weeks and enabled the resumption of partial physical activity after six months.

Conclusion: This case highlights the utility of ultrasound as an effective alternative diagnostic tool in situations where CT scans are not permissible. Additionally, it demonstrates that conservative management can be successful in treating avulsion fractures of the anterior inferior iliac spine in adolescents, leading to satisfactory recovery and return to activity.

1. Introduction

Pelvic apophyseal avulsion fractures (PAFs) are rare injuries commonly found in adolescents and young athletes [1]. As high-intensity athletic activities become increasingly popular, one uncommon injury seen in adolescent athletes is the avulsion fracture of the anterior inferior iliac spine (AIIS) [2]. Approximately 50 % of AIIS avulsion fractures are attributed to kicking actions during soccer and sprinting [3]. Despite its rarity, misdiagnosis of AIIS avulsion fracture is notably high in existing literature [4]., with orthopedic physicians often mistaking it for muscle strain [5]. While AIIS can be managed conservatively, lower limb activity before complete recovery or significant displacement of the fracture site can lead to poor outcomes, particularly in children and adolescents engaged in athletics [6].

Ultrasound is an alternative tool for detecting long bone fractures or tendon ruptures [7], but its use for detecting AIIS avulsion fractures in pediatric emergency medicine is not well documented. Here, we present a pediatric case of AIIS avulsion fracture detected

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using point-of-care ultrasound (POCUS). The patient and their parents provided informed consent for the publication of this case report.

2. Case presentation

The patient, a 14-year-old male, presented with left groin pain two days after participating in a short-distance sprint. He had a height of 175 cm and a weight of 51 kg, resulting in a Body Mass Index (BMI) of 16.6, which classifies him as underweight according to the World Health Organization's BMI categories for children and teens. The patient complained of intense pain in the "left hip" at the onset of running, making it unbearable, necessitating the cessation of the activity. Pain was relieved only when the hip joint was flexed and worsened with extension or abduction. The pain disrupted the patient's daily life and sleep, requiring the patient to flex the left hip during sleep for relief. There was no testicular or abdominal pain reported.

The patient was initially diagnosed with muscle injury and treated with oral non-steroidal anti-inflammatory drugs (NSAIDs) at another hospital. Two days later, pain persisted during ambulation but was relieved with rest, especially with hip flexion. Anteroposterior X-rays of the pelvis are routinely performed to assess for fractures. Regrettably, no fractures or suspicious artifacts were identified on this X-ray (Fig. 1). Despite the negative X-ray results, physical examinations were inconclusive in excluding the presence of fractures. Tenderness was evident in the lower left groin region, particularly in the area beneath the left AIIS. Consequently, a pelvic CT scan was recommended. However, due to parental concerns regarding the radiation dose exposure and its potential harm to adolescents, the CT examination was refused.

The PHILIPU EPIQ 7 ultrasound device, with a probe frequency set at 6.0–18.0 MHz and the probe mode selected as musculoskeletal mode, was used. The pediatric patient lay in the supine position with both lower limbs slightly externally rotated. During the examination, the patient was advised to relax, and the inguinal region was adequately exposed. During the scan, the probe was positioned over the AIIS on the affected side. Based on the anatomical location of the lesion, both longitudinal and transverse dynamic scans along the iliac bone were acquired. The morphology and internal echoes of the epiphyseal bone were specially observed, assessing the continuity between the epiphysis and the metaphysis, and evaluating any displacement of the epiphysis. The examination also included an assessment of the continuity and smoothness of the cortical bone surface and the presence of interrupted linear echoes. Localized depressions and bony protrusions were noted. The right AIIS was evaluated similarly and showed no fractures or hematomas. Ultrasound revealed a mixed echogenic and hypoechoic hematoma with no increased intravascular flow (Fig. 2). During the ultrasound examination, the anterior inferior iliac spines (AIIS) on both sides were compared. It was observed that the left AIIS displayed discontinuity in the bone cortex, with a clear "gully-like" image evident in the middle (Fig. 2a–b). Additionally, abnormalities in the periosteum were also noted on the left AIIS, where fluid appeared to be present (Fig. 2c–d). These abnormalities observed on the left side were marked in red on the ultrasound images.

At this point, ASIS is basically clear under ultrasound examination. We suggest that the patient and their parents undergo a CT scan to determine the volume of fracture fragments and the distance of fracture separation. The patient's parents agreed with our suggestion. A CT scan confirmed the fracture on the left AIIS, with a small hematoma (Fig. 3). Axial CT scan showing ASIS fracture with detached fragments (Fig. 3a–d); Coronal CT scan showing ASIS fracture with detached fragments (Fig. 3e–h); Sagittal CT scan showing ASIS fracture with detached fragments (Fig. 3i–l). Bed rest in a hip-flexed position was advised for four weeks. Follow-up X-ray images after three months indicated bony callus formation without ectopic ossification (Fig. 4). Physical examination revealed no significant pain or restricted movement, allowing for a gradual return to daily activities but recommending sports resumption after three months without discomfort.

3. Discussion

The avulsion fracture of the AIIS is categorized as a type of PAFs. According to Rossi et al. [3] it ranks second only to the ischial

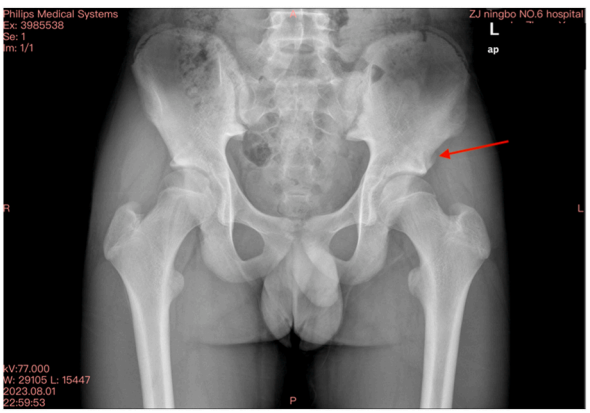

Fig. 1. Immediate post-traumatic anteroposterior pelvic X-ray indicating an iliac bone fracture and the AIIS injury is marked by a red arrow.

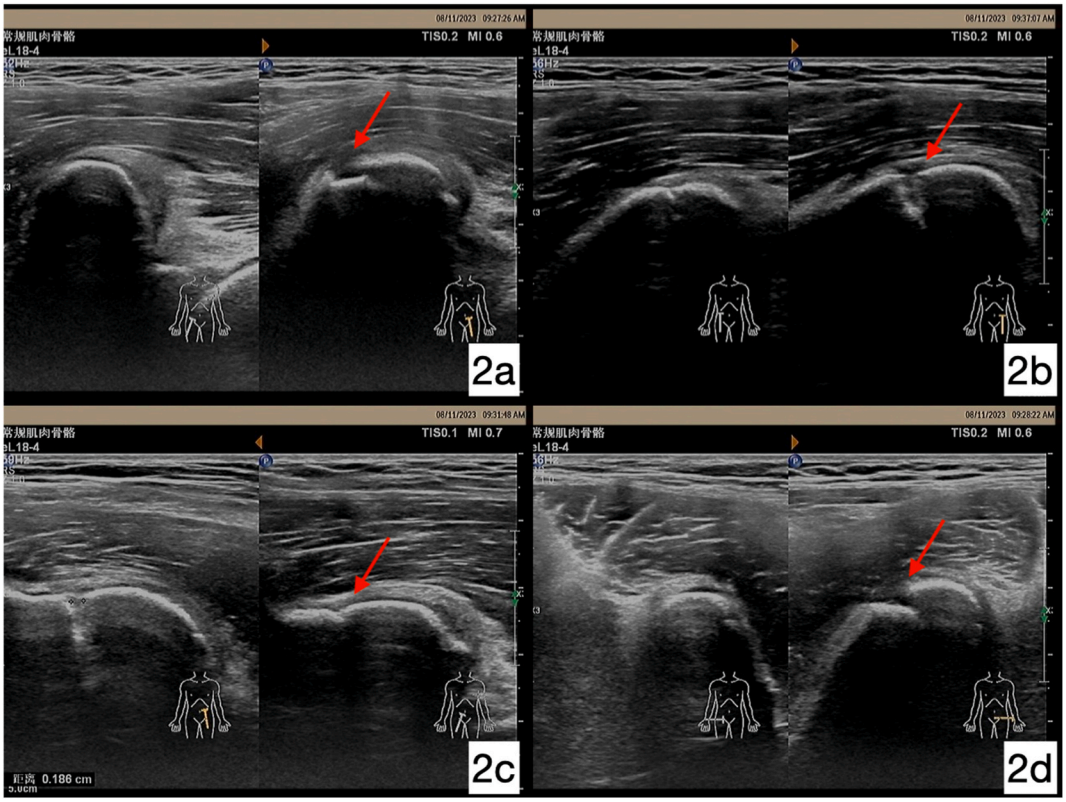

Fig. 2. Ultrasound showing the continuity and smoothness of the cortical bone surface and the presence of interrupted linear echoes. (a–d).

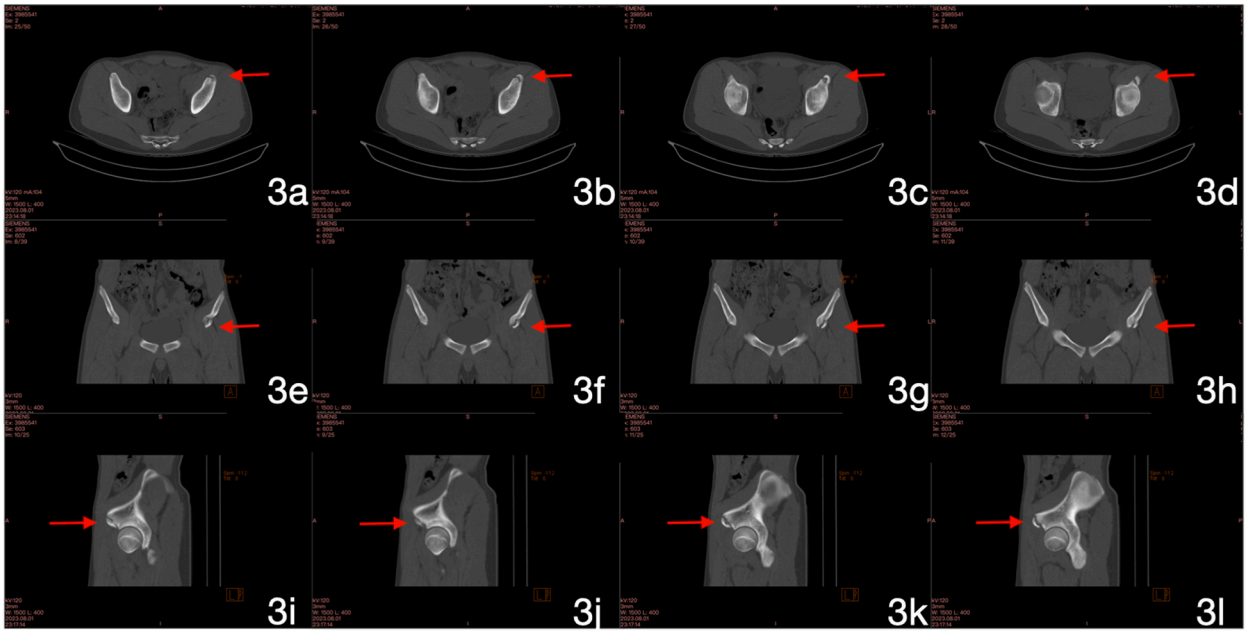

Fig. 3. Immediate post-traumatic CT examination, these abnormalities observed on the left side were marked in red on the ultrasound images and the AIIS injury is marked by a red arrow. a-d) Axial CT slices demonstrating fracture fragments located less than 1 cm from the ilium. e-i) Coronal CT slices showing the convergence of the anterior inferior iliac spine (AIIS) and anterior superior iliac spine (ASIS). h-l) Sagittal CT slices revealing the convergence of AIIS and ASIS.

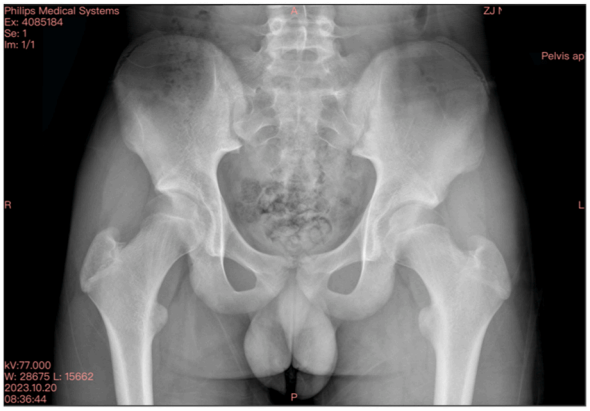

Fig. 4. X-Ray three months post-trauma, illustrating extensive callus formation and blurring of the fracture line.

tuberosity in prevalence among pelvic avulsion fractures. This injury is primarily observed in adolescents, typically around the age of 14, although rare cases have been reported in adults [8].

The mechanism of injury of AIIS avulsion involves significant hip joint extension and knee flexion, resulting from intense muscle contractions [7,9]. The AIIS bears high stress during the stretching of the rectus femoris muscle, often seen in high-intensity activities such as soccer, sprinting, and gymnastics [3]. Conservative treatment is typically effective, with most patients recovering satisfactorily in 4–6 weeks, unless significant displacement or ectopic ossification occurs, warranting surgical intervention [10–14].

Accurate history of the injury can be challenging to obtain from patients, making the determination of the exact time of injury difficult [15]. Fractures and potential displacement in standard pelvic plain X-ray images can help with the diagnosis [7]. However, if the bony protrusion has not ossified or has only undergone slight ossification, standard X-ray images may miss it. A Pelvic CT scan is an alternative diagnostic tool, offering clear visualization of fracture fragment volume and separation distance. Nevertheless, concerns about ionizing radiation may lead to CT refusal by patients and parents.

Current diagnostic methods for AIIS avulsion fracture rely on medical history and imaging. Standard pelvic X-ray images are commonly used for diagnosis [4], but early X-ray images often show overlapping bone structures and artifacts, making diagnosis difficult [9]. Delayed diagnosis due to unclear X-ray images can negatively impact the patient's daily life and athletic performance [7], and may even lead to medical treatment-related disputes [14]. Pelvic CT and magnetic resonance imaging (MRI) have higher diagnostic sensitivity compared to X-rays and are being increasingly used by orthopedic physicians for early AIIS fracture detection [9]. However, due to factors such as radiation exposure, examination costs, and time constraints, parents often refuse these examinations.

Furthermore, a few doctors recommend Magnetic Resonance Imaging (MRI) as an early diagnostic tool for AIIS injuries, as it can detect early bone damage and muscle hematoma [9]. However, MRI is limited in clinical application due to its high cost, long wait times, and lengthy examination duration, especially in children who may struggle to cooperate. Therefore, even in the absence of ossification centers, ultrasound examination presents an advantage during early detection, with Power Doppler ultrasound revealing acute congestion [2]. In 2022, Takaaki et al. [16] utilized emergency POCUS to diagnose an anterior superior iliac spine (ASIS) fracture in a 14-year-old. Hyperechoic areas were identified on the anterior and lateral sides of the pain site, which were confirmed as ASIS fractures via pelvic X-ray. Conservative treatment yielded satisfactory results. Their findings align with ours, demonstrating the diagnostic value of POCUS for ASIS. However, our study focused on an anterior inferior iliac spine (AIIS) injury. Unlike Takaaki et al., we employed POCUS for a definitive diagnosis when initial pelvic X-rays showed no fractures. We propose that POCUS may be more accurate than pelvic X-rays for ASIS injuries. In 2010, Chen et al. [17]. performed an X-ray examination on a 15-year-old with iliac pain. The initial X-ray showed no abnormalities, and the pain persisted despite rehabilitation. A re-examination suggested possible iliac fractures. Musculoskeletal sonography revealed left ASIS displacement, confirmed by CT. They recommended conservative treatment, but follow-up was not conducted. Our treatment approach mirrors Chen's, with POCUS detecting iliac fractures when X-rays are negative, and CT guiding treatment. The key difference in our report is the diagnosis of AIIS instead of ASIS. In our case, an ultrasound examination showed a hypoechoic area in the AIIS region, extending into the surrounding soft tissues, indicative of edema or hemorrhage. The healthy hypoechoic AIIS bone protrusion between the pubic bone and the iliac bone widened, signifying AIIS fracture and displacement. POCUS can dynamically indicate the displacement of fracture fragments [7]. Moreover, comparing the AIIS on the healthy side with that of the affected side can help identify any differences, making POCUS a technique with a shorter learning curve for physicians with musculoskeletal POCUS experience [9]. Additionally, POCUS is cost-effective, radiation-free, and avoids lengthy waiting times, making it more acceptable for patients.

Based on our experience, to further improve the diagnosis of suspected AIIS injuries, the first step involves a detailed patient history focusing on recent trauma, especially incidents related to sudden, intense activities such as sprinting, which are commonly associated with AIIS injuries. The nature of the pain—persistent, debilitating, and unresponsive to non-steroidal anti-inflammatory medications—particularly if it occurs suddenly during activity, warrants further investigation. Secondly, a meticulous physical examination is crucial. Typically, there may not be visible signs such as swelling or bruising over the area, but significant tenderness might be present in the groin area, particularly over the projected area of the AIIS. Pain usually subsides when the hip and knee joints are flexed

and intensifies upon extension. And most reported cases of AIIS avulsions occur in adolescents aged 12–17, a demographic detail that guides our suspicion and management strategies. While injuries in other age groups are not well-documented, our focus remains on this high-risk population. Lastly, given these specific symptoms and demographic data, we advocate for an initial ultrasound evaluation if AIIS injury is suspected, especially in settings where radiation exposure is a concern. If the ultrasound is inconclusive or if further detailed imaging is warranted based on clinical judgment, a CT scan may be considered to assess the extent of the injury and to plan appropriate management.

4. Conclusions

POCUS can assist clinicians in screening for muscle hematoma and hidden fractures in PAFs, especially in the case of AIIS fractures. It improves early diagnostic accuracy, reduces misdiagnosis rates, and helps select an appropriate.

Ethics approval and consent to participate

Ethical approval was obtained from the Ethical Commission of Ningbo NO.6 Hospital with approval no.2023-61(L) and the written informed consent of all participating subjects was obtained.

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Consent for publication

Not applicable.

Data availability

All data produced or analyzed in this investigation are contained in this article and its additional information files.

CRediT authorship contribution statement

Huaguo Zhao: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Licheng Ni:** Validation, Supervision, Software, Methodology. **Guanyi Liu:** Writing – review & editing, Supervision, Resources, Methodology. **Pingping Ye:** Validation, Supervision, Methodology. **Hongbo Duan:** Visualization, Validation, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] M. Reboli, A. Aprato, J. Vittori, M. Olivero, F. Bosco, A. Massè, Reevaluation of the surgical indications for anterior inferior iliac spine avulsion fractures in an acute setting – a narrative review of the current literature, Journal of Orthopaedics [Internet] 38 (2023) 20–24 [cited 2023 Aug 2], https://linkinghub.elsevier.com/retrieve/pii/S0972978X23000594.

[2] T. Mori, T. Ihara, O. Nomura, Avulsion fracture of the anterior superior iliac spine in a young athlete detected by point-of-care ultrasound, POCUS J [Internet] 7 (2022) 140–143 [cited 2023 Oct 4], https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9979938/.

[3] F. Rossi, S. Dragoni, Acute avulsion fractures of the pelvis in adolescent competitive athletes: prevalence, location and sports distribution of 203 cases collected, Skeletal Radiol [Internet] 30 (2001) 127–131 [cited 2024 Apr 7], http://link.springer.com/10.1007/s002560000319.

[4] R. Eberl, H. Wegmann, R. Marterer, T. Kraus, E. Sorantin, G. Singer, Diagnosis and treatment of apophyseal injuries of the pelvis in adolescents, Semin Musculoskelet Radiol [Internet] 18 (2014) 498–504 [cited 2024 Apr 7], http://www.thieme-connect.de/DOI/DOI?10.1055/s-0034-1389267.

[5] J.L. Moeller, Pelvic and hip apophyseal avulsion injuries in young athletes, Curr. Sports Med. Rep. 2 (2003) 110–115 [cited 2024 Apr 7], http://journals.lww.com/00149619-200304000-00011.

[6] D.J. Schuett, J.D. Bomar, A.T. Pennock, Pelvic apophyseal avulsion fractures, J Pediatr Orthoped [Internet] 35 (2015) 617–623 [cited 2024 Apr 7], https://journals.lww.com/01241398-201509000-00014.

[7] D. Lazović, U. Wegner, G. Peters, F. Gossé, Ultrasound for diagnosis of apophyseal injuries, Knee Surg. Sports Traumatol. Arthrosc. 3 (1996) 234–237 [cited 2024 Apr 8], http://xlink.rsc.org/?DOI=C8RA03629B.

[8] J.V. Soprano, Musculoskeletal injuries in the pediatric and adolescent athlete, Curr. Sports Med. Rep. 4 (2005) 329–334 [cited 2024 Apr 7], http://journals.lww.com/00149619-200512000-00009.

[9] R.M. Pisacano, T.T. Miller, R.M. Pisacano, T.T. Miller, Comparing sonography with MR imaging of apophyseal injuries of the pelvis in four boys, Am J Roentgenol [Internet] 181 (2003) 223–230 [cited 2024 Mar 26], https://www.ajronline.org/doi/10.2214/ajr.181.1.1810223.

[10] A. Volpi, C. Matzko, D. Feghhi, T. Matheney, S. Bharam, Conservative treatment of avulsion injuries of the lesser trochanter in adolescent athletes, Cureus 13 (2021) e15638 [cited 2023 Oct 4], https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8278968/.
[11] M. Uzun, B. Alpan, H. Özger, Avulsion fractures involving the straight and reflected heads of the rectus femoris, Hip Int [Internet] 24 (2014) 206–209 [cited 2024 Apr 7], http://journals.sagepub.com/doi/10.5301/hipint.5000110.
[12] M. El-Feky, Anterior inferior iliac spine avulsion fracture, Radiopaedia.org [Internet]. Radiopaedia.org (2020) [cited 2024 Apr 7], http://radiopaedia.org/cases/anterior-inferior-iliac-spine-avulsion-fracture-7.
[13] T. Ruffing, T. Rückauer, F. Bludau, A. Hofmann, M. Muhm, A.J. Suda, Avulsion fracture of the lesser trochanter in adolescents, Injury 49 (2018) 1278–1281 [cited 2024 Apr 7], https://linkinghub.elsevier.com/retrieve/pii/S0020138318302195.
[14] S. Serbest, H.B. Tosun, U. Tiftikçi, B. Oktas, E. Kesgin, Anterior inferior iliac spine avulsion fracture: a series of 5 cases, Medicine 94 (2015) e562 [cited 2023 Oct 5], https://journals.lww.com/00005792-201502030-00026.
[15] Pogliacomi F, Calderazzi F, Paterlini M, Ceccarelli F. Surgical Treatment of Anterior Iliac Spines Fractures: Our Experience.
[16] T. Mori, T. Ihara, O. Nomura, Avulsion fracture of the anterior superior iliac spine in a young athlete detected by point-of-care ultrasound, POCUS J [Internet] 7 (2022) 140–143 [cited 2023 Oct 4], https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9979938/.
[17] L.-W. Chen, W.-C. Yeh, Musculoskeletal sonography facilitates the diagnosis of adolescent anterior superior iliac spine avulsion fracture, J. Med. Ultrasound 18 (2010) 158–160 [cited 2023 Oct 6], http://linkinghub.elsevier.com/retrieve/pii/S0929644110000081.