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Residual Symptoms of Occult Pediatric Ankle Injuries: MRI-Diagnosed Bone Bruising

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Author's contribution

The only author performed the whole research work. Author NKS wrote the first draft of the paper. Author NKS read and approved the final manuscript.

Case Study

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ABSTRACT

Aims: To define the nature of non-radiographically evident injuries of the ankle and hindfoot in children who exhibited persistent pain, swelling and refusal to bear weight after 6 weeks of immobilisation.
Methods: Ten children (7 boys, 3 girls; age range 5 to10 years) were included in the study. They presented with normal plain radiographs after an acute traumatic ankle injury. They were all immobilised for 6 weeks. The detection of residual symptoms and signs indicated the need of a limited magnetic resonance imaging (MRI). It revealed bone bruising localized to the hindfoot in all cases. Bone bruises were classified according to anatomical location and whether they were solitary lesions or were combined with other soft tissue injuries.
Results: From a total of 10 cases, 6 were unifocal, 3 of them were localized to the talus and 3 to the calcaneus, while in 4 multifocal cases bone bruising involved all the bones of the hindfoot. All cases were associated with a varying degree of soft tissue injuries including signs of ankle and subtalar joint effusion, but there was no evidence of ligamentous injuries in our patients. The total period of immobilisation reached 3 months for unifocal bone bruises and 4 months for multifocal lesions. In all cases, a prolonged recovery period exceeding 2 months followed before return to normal activities including sports. The long-term follow-up ranged from 2 to 5 years. No complications were detected.
Conclusion: A limited MRI examination is indicated in children with residual symptoms following acute ankle injuries. Bone bruising localized to the hindfoot was the "occult"

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bone lesion diagnosed in all our cases. This study indicates that bone bruising or contusion should be classified as a distinct clinical entity best visualized on MRI with fat suppression.

Keywords: Residual symptoms; ankle injuries; children; magnetic resonance imaging; bone bruising.

1. INTRODUCTION

Ankle injuries are among the most common acute injuries in children. They are divided to fractures and ligamentous injuries (sprains). Athletes are more commonly involved than non-athletes. Physeal fractures of the distal fibula are the most common type of ankle fractures [1]. However, in less than 15% of lateral ankle injuries a fracture is diagnosed [2]. The vulnerability of the physeal plate to injury is greater than that of the ligaments [3], so injuries of the distal fibula without fractures visible on the radiographs are often diagnosed as Salter-Harris type I lesions. Recent reports using magnetic resonance imaging (MRI) revealed that the diagnosis of Salter-Harris type I distal fibular physeal fracture was not correct in a great majority of acute injuries and identified ligamentous sprains and/or bone bruising instead [4,5,6]. MRI examination of acute ankle sprains in children did not result in any significant information that could influence the treatment of such patients and, subsequently, it should not be considered as a first-line examination [7,8]. Bone bruising is an occult type of fracture that is best visualised by MRI with fat suppression. Bone bruising is not visible on conventional radiographs and CT scans. Another option for diagnosis might include bone scintigraphy but there are certain drawbacks for its application in children [9]. Bone bruising or contusion occurs due to focal edema and hemorrhage secondary to microfracture of the trabeculae of the affected region and it represents a new category of bone injury [3]. The value of MRI in children with normal radiographic imaging, whose recovery from injury was significantly prolonged, has only been examined in the distal forearm and wrist [10].

In the present study, a limited MRI was used in children without radiographic abnormalities after an acute ankle injury, who exhibited persistent pain, swelling and refusal to bear weight after an immobilisation period of 6 weeks. The MRI indicated the occult lesion of bone bruising in all our patients.

2. MATERIALS AND METHODS

A total number of 2195 children, younger than 14 years of age, were examined for ankle injuries between January 2006 and December 2009. The study group included ten of these children diagnosed and treated for bone bruising of the ankle and/or hindfoot during the same period. No patients in the study group had a history of infection, rheumatoid arthritis, steroid use or neoplasm. Their clinical and radiological data were, retrospectively, reviewed.

Each child in the study group presented swelling and pain on palpation, widespread over the anterior surface, as well as both sides of the ankle and hindfoot and refusal to bear weight on the injured lower extremity. Initial and follow-up radiographs revealed no evidence of a fracture line or signs of fracture healing including periosteal new bone formation and bone sclerosis. They were all considered to be suffering from possible occult fractures and, therefore, immobilised for 3 weeks in a below the knee cast. The persistence of significant residual symptoms and signs, including widespread swelling and pain on palpation of the

ankle and hindfoot, necessitated an additional 3 weeks time immobilisation in a below the knee cast. After a total of 6 weeks of immobilisation and because of significant prolonged residual clinical symptoms and signs, a limited MRI was performed.

MRI examination included coronal, sagittal and axial planes using a 1.0-Tesla MRI system. The following sequences were typically performed in the examination process: T1-weighted spin echo images and short tau inversion recovery (STIR) images or T2-weighted with fat suppression images. Diagnosis of bone bruising was based on the low signal-intensity on T1-weighted images and high signal-intensity areas on STIR or T2-weighted with fat suppression images.

The MRI findings were reviewed to establish characteristics and to subdivide bone bruises according to location and extent of injury. The children were evaluated with respect to mechanism of injury, correlation between physical examination and MRI findings and the duration of immobilisation required.

After the MRI scans, immobilisation was prolonged in a below the knee cast. The cast was changed to a removable splint when symptoms improved. Immobilisation was continued until significant clinical improvement was evident and was, then, followed by range-of-motion exercises and partial weight-bearing with crutches until complete resolution of the clinical symptoms and signs.

The control group included 10 patients younger than 14 years of age, with no history of an acute injury, who were evaluated by MRI for soft tissue lesions of the ankle and foot from 2005 to 2010.

3. RESULTS

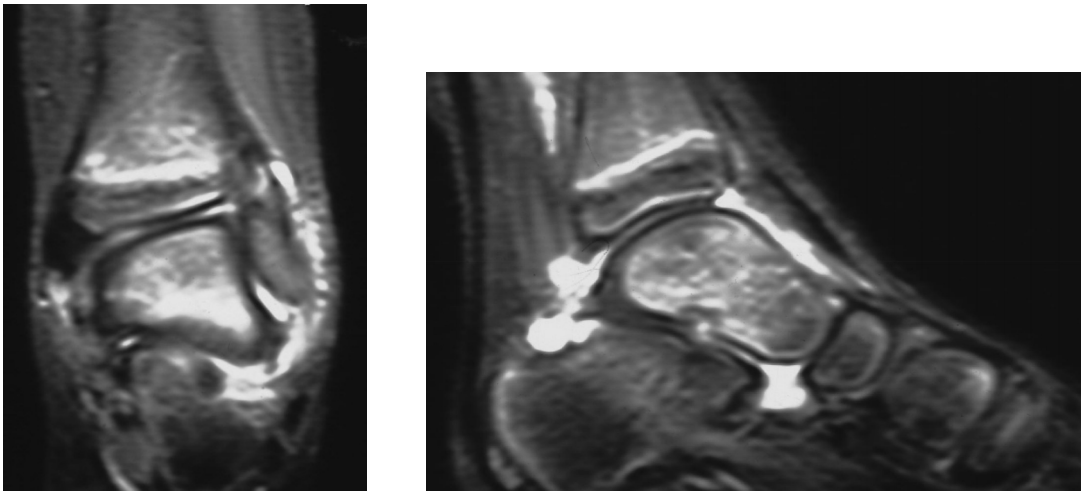
Of the 10 patients studied, 7 were male and 3 female with a median age of 7.5 years (range 5 to 10 years).

The mechanism of the recorded injuries was falling from a height (2 patients), fall from stairs at school (2 patients), sport-injuries caused by playing football (3 patients) or volleyball (1 patient), traffic accident with the foot being run over (1 patient) and home crush accident (1 patient).

Initial and follow-up radiographs were negative in all patients.

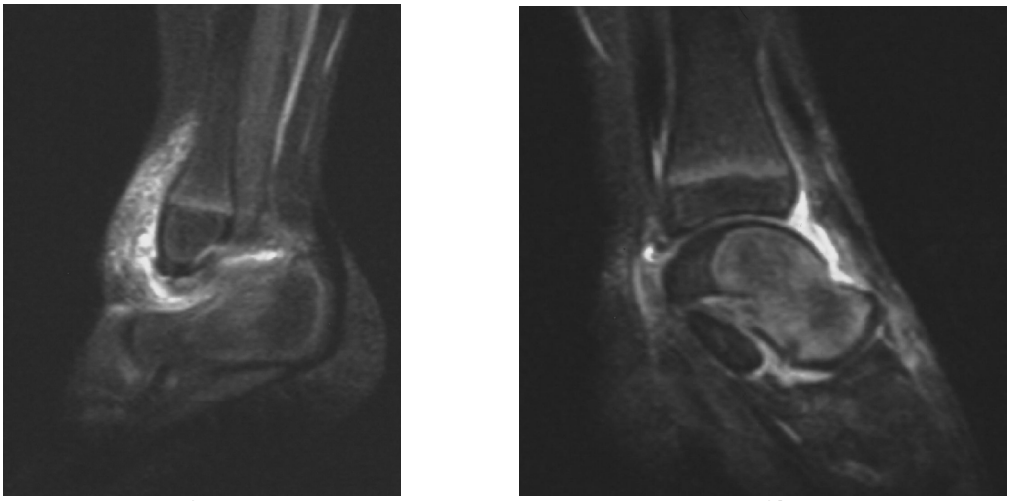
MRI revealed bone bruising localized to the hindfoot. Two types of bone bruising according to the location of bone lesions were identified. Unifocal bone bruising, involving a single bone, was evident in 6 children (60%), while multifocal bone bruising was diagnosed in 4 (40%). Unifocal lesions were located to the talus in 3 (Figs. 1a, b and 2a, b) and to the calcaneus in 3 other cases (Fig. 3 and Figs. 4a, b). Multifocal lesions were located to the hindfoot involving talus, calcaneus, navicular and cuboid in 4 cases (Figs. 5a, b).

There was evidence of neither a fracture line nor a ligamentous injury in the MRI findings of our patients. The distal tibia and fibula were not involved in any of the cases in the study group. There was evidence of soft tissue injury in 3 patients (Figs. 2a, 3 and 4a). A varying degree of effusion localized to the ankle and subtalar joints was evident in all cases (Figs. 1b, 2b, 4b and 5b).



1a 1b

Fig. 1. T2-weighted fat-suppressed images of a 6-year-old girl revealed bone bruising of the talus, evidence of soft tissue injury on the lateral side of the ankle joint (a) and pronounced fluid signal around the talus (b)



2a 2b

Fig. 2. Short tau inversion recovery images of a 7-year-old boy showed bone bruising of the talus, evidence of soft tissue injury on the lateral side of the ankle joint (a) and fluid signal around the talus (b)

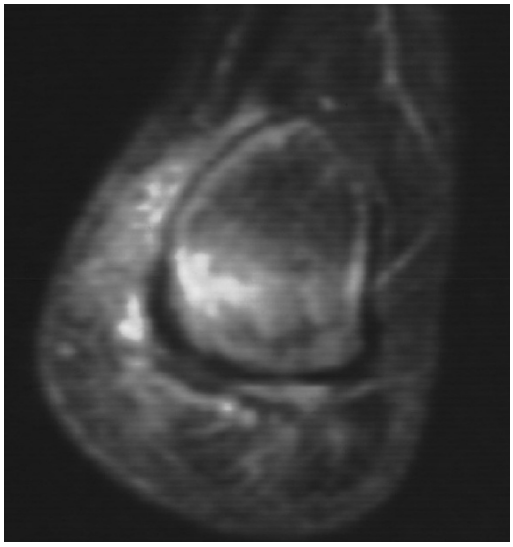
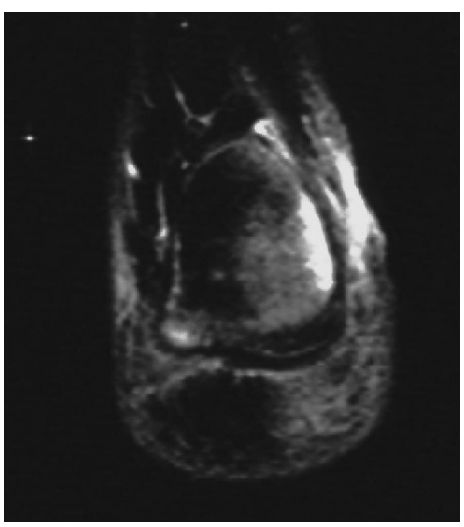
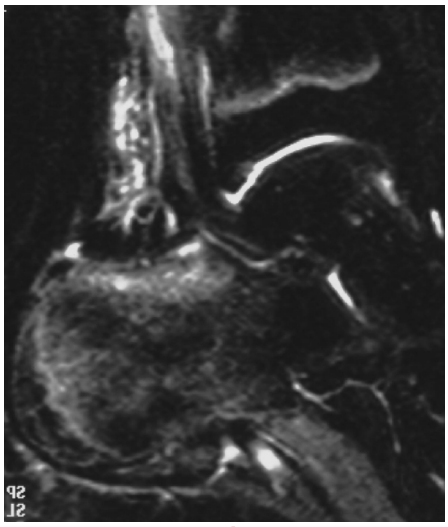


Fig. 3. Short tau inversion recovery image of a 9-year-old boy confirmed bone bruising of the posteromedial portion of the left calcaneus and evidence of injury to the adjacent soft tissues

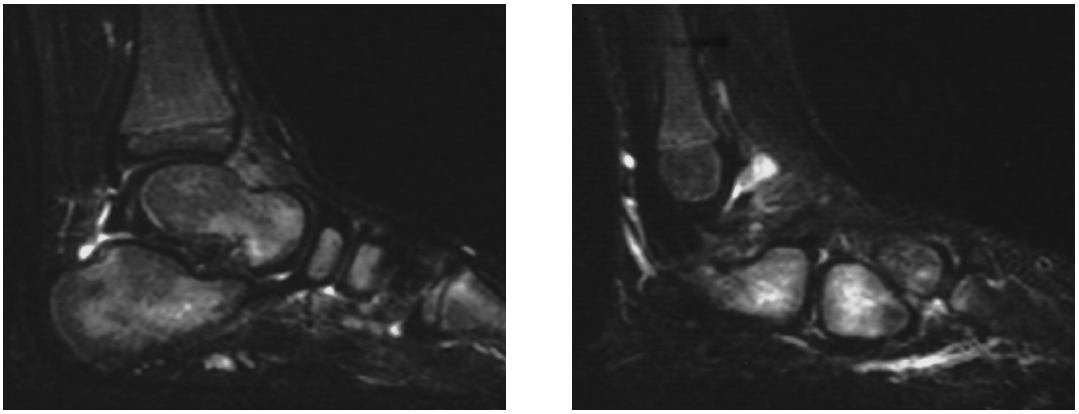


4a



4b

Fig. 4 Short tau inversion recovery images of a 10-year-old girl demonstrated bone bruising of the posteromedial portion of the right calcaneus, evidence of injury to the adjacent soft tissues (a) and fluid signal around the talus (b)



5a 5b

Fig. 5. Short tau inversion recovery images of a 5-year-old boy detected bone bruising involving all the bones of the hindfoot (a, b)

Detection of bone bruising by MRI modified the treatment protocol in all our cases. Both immobilisation and recovery period was dependant on the type and extent of the lesion. Immobilisation was continued until significant clinical improvement was evident. The total period of immobilisation reached 3 months for unifocal bruises and 4 months for multifocal lesions. In all cases, a prolonged recovery period exceeding 2 months followed before return to normal activities including sports. During that period range-of-motion exercises and partial weight-bearing with crutches was used until complete resolution of the clinical symptoms and signs. The MRI was not repeated for any patients during the follow-up. No complications were detected after a mean follow-up of 3 years (range 2 to 5 years).

In the control group, MRI showed no evidence of bone marrow oedema to the distal tibia, fibula and hindfoot of the examined children.

4. DISCUSSION

Ankle injuries are very common in the skeletally immature children and are more commonly localized on the lateral malleolus [1,11]. The value of clinical examination and the definition of clinical characteristics have already been emphasized to avoid unnecessary radiographic referrals [2,12]. Radiography is still the diagnostic cornerstone of pediatric ankle injuries. Although no complex ankle fractures were missed on radiographs, some obscure fractures in plain radiographs may be missed [8].

Occult fractures in children with acute ankle injuries may be diagnosed from the radiographic signs of bone healing, such as periosteal new bone formation and bone sclerosis, 3 to 5 weeks after injury [13,14]. Ultrasound is recommended for the detection of non-radiographically evident fractures of the pediatric ankle [15]. Computed tomography can also have a dominant role as a primary imaging technique in the diagnosis of occult fractures of the ankle and hindfoot [16].

MRI may also be useful to reveal fractures without radiographic abnormality [5,9]. However, MRI is an expensive study, which rarely adds information that influences the treatment of patients with acute ankle injuries [7,8]. The value of MRI has been assessed in the

recognition of ankle sprain as a clinical entity in children [4,5,7]. It has also been used to detect the incidence and distribution of bone bruises in cases of lateral ligamentous injuries of the ankle (ankle sprain) in children and adults [6,17]. Four types of bone bruising were described: type 1 involving the talar dome, type 2 the posteromedial aspect of the talus and the medial melleolus, type 3 the anteromedial aspect of the talus and type 4 presenting as a combination of types 2 and 3 [17].

Isolated subcortical trabecular fractures can occur in any region of the developing skeleton. With the advent of fat-suppression imaging, a new category of injury has been recognised: the bone bruise or contusion [18]. The nature of the high intra-osseous signal intensity on MRI using fat suppression is likely to represent focal edema and hemorrhage, following a microtrabecular injury of bone marrow without disruption of adjacent cortices or articular cartilage. The bruises usually disappear within 12–16 weeks. Appropriate immobilisation and restricted use of the involved limb is mandatory during trabecular healing to avoid insufficiency fractures [3,19].

Stress fracture and focal accelerated bone resorption in transient osteoporosis need to be differentiated. Differential diagnosis is based on clinical, radiographic and MRI findings [20,21,22,23].

The review of related literature indicates that MRI is useful and valuable in the detection of bone bruising in children with persistent symptoms following 5 weeks of immobilisation for an occult injury of the distal forearm and wrist [10]. In addition, the most challenging aspect of MRI-based diagnosis of occult lesions is the recognition of the very rare undisplaced Salter-Harris type I and the type V injuries [10,24]. However, patients with acute ankle injuries with subsequent pain, swelling and refusal to bear weight, where radiographic imaging remains normal and recovery is significantly prolonged, represent a true diagnostic dilemma. In adults, the use of limited MRI in cases with persistent ankle pain 6 weeks after an injury, despite normal findings on radiographs, resulted in the detection of bone bruising of the talar dome and, subsequently, cessation of physical therapy and prolonged casting [25]. However, similar reports have not been reported in children.

Traditionally, the appearance of a fracture line or signs of fracture healing on plain radiographs were needed to diagnose a fracture. Thus, children with a clinical diagnosis of ankle sprain but suffering from bone bruises might have been encouraged to use an injured extremity or to participate in sporting activities after an insufficient period of immobilisation.

This study highlights that bone bruising of the ankle or hindfoot may exhibit substantial variation in anatomical location and extent. Children with significant residual clinical symptoms and signs 6 weeks after an ankle injury, with no radiographic findings, should undergo a limited MRI to detect possible bone contusions. In such cases, an elongated immobilisation and recovery period is required for the complete resolution of the clinical symptoms and signs. Finally, it is evident that bone bruising represents a distinct clinical entity with “benign” characteristics, since no long-term morbidity occurred in any of our patients.

5. CONCLUSION

A limited MRI examination is indicated in children with non-radiographically evident injuries of the ankle and hindfoot who exhibit persistent pain, swelling and refusal to bear weight after 6 weeks of immobilisation. Bone bruising was diagnosed in all our cases. An elongated

immobilisation and recovery period is required until complete resolution of the clinical symptoms and signs. Bone bruising represents a distinct clinical entity with “benign” characteristics, since no long-term morbidity occurred in any of our patients.

CONSENT

Written informed consent was obtained from the patients (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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