Case Report

Gymnast's wrist in a 12-year-old female with MRI correlation

Zachary R. Ashwell*, Michael L. Richardson

University of Washington, Department of Radiology, Musculoskeletal Radiology Division, UW Medical Center – Roosevelt, 4245 Roosevelt Way NE Box 354755, Seattle, WA 98109, USA

ARTICLE INFO

ABSTRACT

We describe a case of chronic overuse injury of the distal radial physis (gymnast's wrist). While the radiographic appearance of this entity has been reported, there are limited studies highlighting the MR appearance of this entity. This lesion is being seen with increasing frequency in young, elite gymnasts. If this injury goes unrecognized, there is potential for abnormal osseous development, with premature physeal fusion, abnormal joint inclination and even Madelung deformity.

© 2018 Published by Elsevier Inc. on behalf of University of Washington.
This is an open access article under the CC BY-NC-ND license.
(http://creativecommons.org/licenses/by-nc-nd/4.0/)

Introduction

Acute physeal injuries are commonly encountered in the pediatric population. However, injuries to the distal radial epiphysis, related to chronic overuse or repetitive microtrauma are reported much less commonly. Over the past 20 years there has been a surge in high-level adolescent athletes participating in sports with unusually high loading of the wrist, such as ice hockey, volleyball, and gymnastics. The high demands of these sports can result in overuse injury to the developing physis, termed distal radial epiphysitis, or gymnast's wrist. While discussed briefly in various texts, clear examples have been infrequently documented in the radiologic literature. We report one such case and present a review of the relevant literature.

Case report

A 12-year-old female gymnast competing at a national level in events such as Yurchenko pike and back handspring presented with a 2-year history of intermittent pain of the right wrist, which steadily worsened. Her pain was focused about the radiocarpal joint on exam. There was no report of an acute injury. She had been taking approximately 200 mg of Ibuprofen PO for her symptoms as needed. On physical exam, initial inspection revealed no apparent abnormality. There was pain in the wrist with full flexion. Extension was limited by approximately 10° with increasing pain at extreme range of motion. No snuffbox pain was reported. There was focal tenderness over the distal radial physis. The ulnar side of her wrist was nontender. A normal grip strength was reported and there were no neurovascular deficits.

Fig. 1 – Frontal radiograph demonstrating widening of the physis along the radial margin. Mild ulnar inclination of the distal radial epiphysis. No abnormal sclerosis.

Initial radiographs including standard PA, oblique, and lateral views of the right wrist, revealed distal radial physeal widening, sclerosis, and subchondral cysts which raised suspicion for physeal injury (Figs. 1 and 2). Additionally, there was mild ulnar angulation but no significant volar angulation. Mild ulnar negative variance was present, though this is considered a normal finding in skeletally immature patients. No displaced fracture or periosteal reaction was identified, and there was no abnormal hypertrophy of the scaphoid rim or lunate to suggest dorsal impaction syndrome. Bone age as determined by the standard reference Greulich and Pyle was considered normal. As there was additional concern for possible occult stress fracture, the patient was instructed to refrain from activity and an MRI of the wrist was ordered.

MR imaging of the right wrist revealed asymmetric marrow edema predominantly affecting the metaphyseal side of the physis with evidence of cartilage ingrowth into the radial metaphysis (Figs. 3 and 4). Edema was also present within the trapezoid. The scaphoid was intact. There was no evidence of avascular necrosis or ligamentous injury. The overlying soft tissues appeared normal. No evidence of tenosynovitis was demonstrated. Given the patient's presenting symptoms and MR findings, infection was considered unlikely. The patient was diagnosed with chronic physeal stress injury. Because of the advanced findings of cartilage ingrowth, a sign of more advanced disease, the patient was placed in a brace and restricted from activity for 3 weeks and instructed to not bear weight on her upper extremities during that time. Given the complications associated with premature physeal growth arrest (tearing of the triangular fibrocartilage, ulnar abutment syndrome, and lunotriquetrial ligament tearing) [1] and the fact that she had presented with advanced findings of physeal injury, surveillance radiographs were recommended to ensure that complications did not arise. Because growth arrest may

Fig. 2 – Lateral radiograph demonstrating widening of the physis. No abnormal volar angulation.

not be detected for several months to be detected, serial radiographs (every 6-12 months) were recommended [2].

On follow-up, the patient reported mild improvement in symptoms. Given the MR findings and the patient's improved symptoms with rest, the decision was made to delay her return to sport further, with a gradual return emphasizing avoidance of wrist intensive maneuvers. Due to her positive response to conservative measures, no follow-up imaging was ordered.

Discussion

In recent decades, competitive gymnastics has become increasingly popular with over 4.6 million participants in the United States alone. A majority of these individuals are between the ages of 6 and 14 [2]. Due to its competitive nature and increasing popularity, participants have begun training longer and harder and at earlier ages than ever before [3–5].
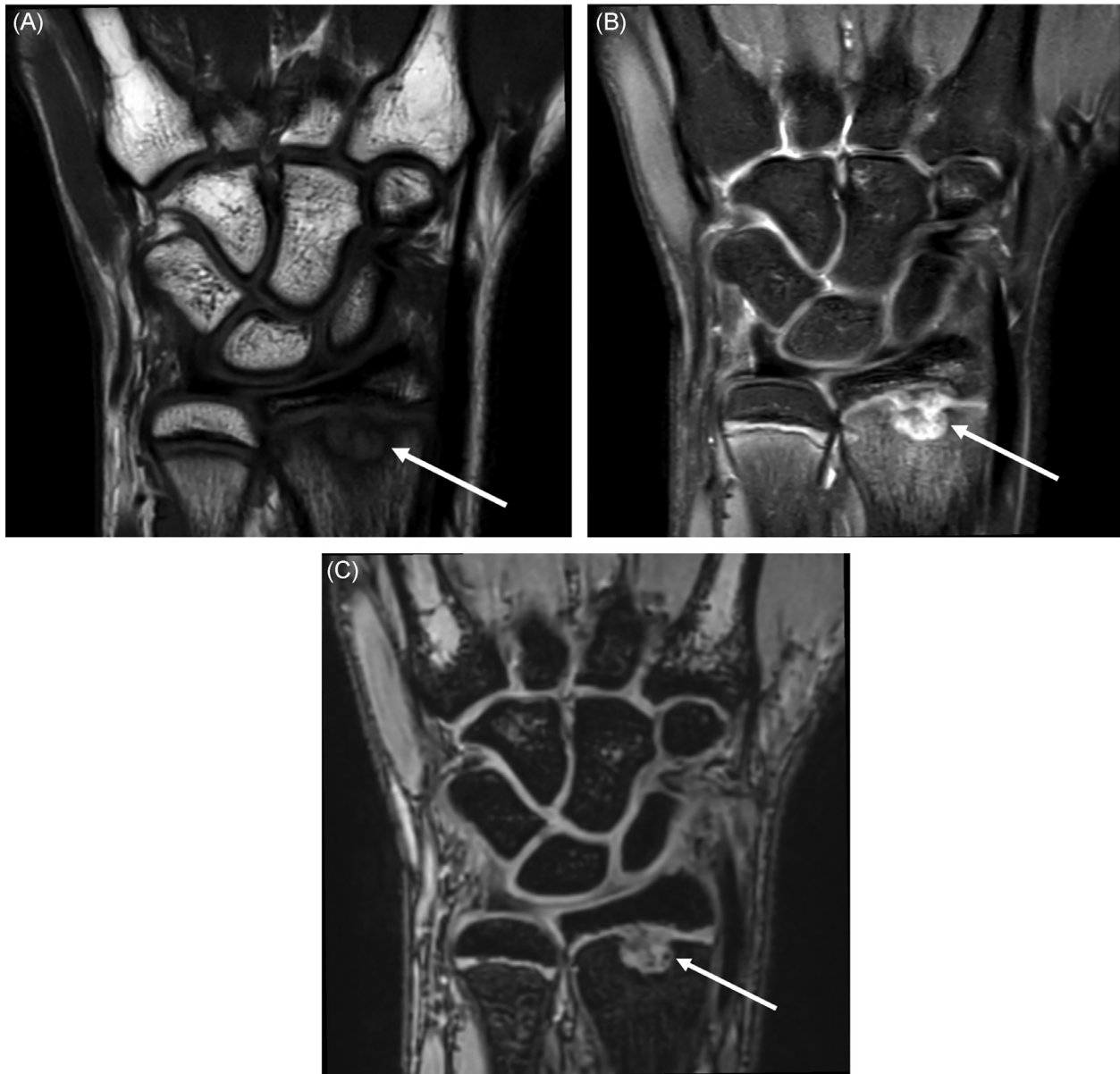
Fig. 3 – (a) Coronal T1-weighted MRI showing cartilage ingrowth (arrow) into the metaphysis and mild assymetric edema of the metaphysis. (b) Coronal T2-weighted MRI showing cartilage ingrowth (arrow) into the metaphysis and mild assymetric edema of the metaphysis. (c) Coronal GRE MRI showing cartilage ingrowth (arrow) into the metaphysis and mild asymmetric edema of the metaphysis.

Some studies indicate that elite level gymnasts may train for up to 45 hours a week for extended durations [3,6]. Unlike other similarly competitive sports, gymnasts rely heavily on their upper extremities when performing maneuvers. Studies indicate that compressive forces at the wrist may exceed 300% of an athlete's weight during specific tasks [7]. When one adds the torsional effects of activities such as horse and parallel bars, it is not surprising that over 80% of participants may develop wrist pain. In 47% of individuals, this pain limits their performance during training [5]. Epidemiologic studies estimate that the prevalence of injury in gymnasts is 8.78 per 1000 in men and 9.37 per 1000 in women, with the substantial majority of injuries affecting the upper extremity [8].

The steady trend toward intense training beginning at earlier ages has led to a substantial increase in pediatric sports related injuries [9,10]. While there is some overlap in injury patterns seen in the pediatric and adult populations, a number of unique entities exist. These injuries predominantly occur around the developing physis. In the developing skeleton, adjacent ligaments are 2-5 times stronger than open physes [11,12]. This imbalance leaves the physes prone to both acute trauma and also chronic injury due to repetitive microtrauma. This scenario is further amplified during rapid growth spurts and near the time of physeal closure [13].

The normal physis consists of 4 distinct layers. From the epiphysis to the metaphyis these include the reserve zone, the
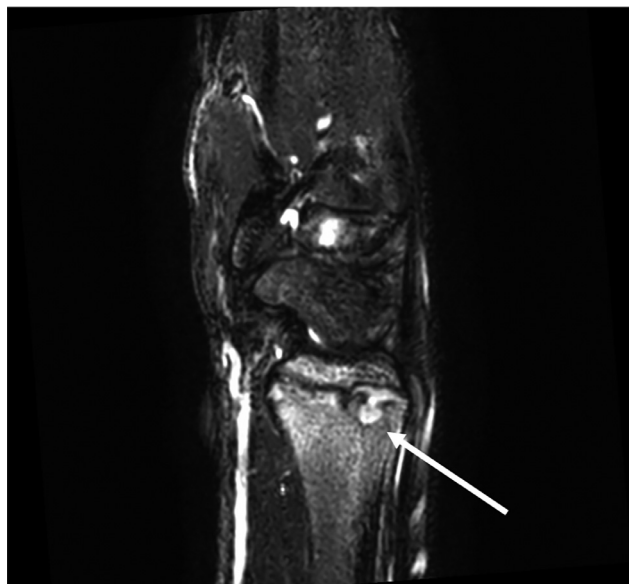
Fig. 4 – Sagittal T2-weighted MRI showing cartilage ingrowth (arrow) into the metaphysis and mild asymmetric edema of the metaphysis.

proliferative zone, the zone of maturation and hypertrophy, and finally the zone of provisional calcification [14,15]. During normal development a physis averages 2-4 mm in thickness with undulating borders. The growth plate is normally uneven, with small convolutions that act to decrease stress within the developing cartilage [16]. The hypertrophic zone is considered the weakest layer due to its lack of a collagen matrix and its absence of mineralization, increasing its susceptibility to injury [17].

Chronic compressive and shearing forces applied to the physis can result in temporary ischemia which can inhibits ossification of the zone of provisional calcification with the potential for developing subsequent microfractures [17,18]. Fortunately, injury here is typically not permanent as the cells of the reserve zone are not involved [19]. Unfortunately, if not identified and treated, there is risk of progression. In the more severe setting, trauma can result in communication between epiphyseal and metaphyseal vessels, with resultant development of a bony bridge across the physis leading to asymmetric growth of the physis or even premature growth arrest [20]. As such, it is essential for the radiologist to be aware of such entities so that the provider may take action before injuries become irreversible.

Injuries involving the physis were first classified by Salter and Harris in 1963 [21]. In the pediatric population Salter Harris type I and II constitute the majority of injuries. Since the 1980s radiographic abnormalities of the physis have been identified in pediatric gymnasts with painful wrists including widening of the physis with irregular margins and metaphyseal cyst formation [22]. Since that time the entity known as gymnast's wrist has gained further attention in the literature. Presently there are 3 distinct stages: stage 1, where there are clinical symptoms without radiographic correlates; stage 2, where physeal irregularities are present; and stage 3, where there is positive ulnar variance in addition to the

physeal findings [23]. Additional radiographic findings of stress injury include the development of cysts, sclerosis, and striations [24–26]. Long-term sequelae which can be seen radiographically include the development of positive ulnar variance and bone bar formation [27] as well as increased ulnar and volar inclination of the distal radius [5].

MRI has contributed substantially to improving the sensitivity of detecting physeal injury and has since become the imaging modality of choice in evaluating stress injury to the physis [28]. The normal MR appearance of the physis is trilaminar with a hyperintense cartilaginous layer, a hypointense zone of provisional calcification, and a hyperintense area of metaphyseal vascularization [29,30]. The normal physis appears undulating but is typically of uniform thickness with mildly increased T2 signal along both the epiphyseal and metaphyseal borders [31]. When stress injury occurs, marrow edema becomes more apparent [32]. Caution must be applied when interpreting this finding, as there is substantial overlap between the pattern seen in both symptomatic and asymptomatic children [33,34]. In fact, marrow edema about the physes has been demonstrated in up to 49% of asymptomatic children, particularly during periods of rapid growth [33,34]. In stress injury, close inspection typically reveals an asymmetric pattern of edema which favors the metaphyseal margin. Additionally, a thin, irregular band of increased T2 signal extending into the metaphysis may be seen, possibly due to persistent unmineralized chondrocytes [35]. More specific findings of physeal injury include thickening of the hyperintense cartilaginous layer due to abnormal mineralization resulting in the appearance of physeal widening with asymmetric irregular margins. This metaphyseal widening can be focal, leading to asymmetric widening or diffuse. When focal, discrete foci of increased T2 signal may be seen, representing ingrowth of cartilage into the metaphysis due to failed ossification of physeal cartilage [26,36]. A reliable internal control for assessing for the presence of physeal widening includes comparison to the cartilage at the first metacarpophalangeal joint, which typically incurs less compressive loading in adolescents [37].

Treatment of physeal injury is staged and based upon severity of symptoms. Initially, patients are instructed to rest, typically for 3-6 months and are frequently immobilized for up to 6 weeks, after which a physical therapy regimen in introduced to regain strength and mobility [38]. Typically, there is close follow-up to ensure appropriate progression toward healing, as indicated by resolution of clinical symptoms and corresponding decreased marrow edema on MRI. Radiographic evidence of healing lags behind clinical resolution but demonstrates gradual return to normal physeal width and alignment, assuming no physeal bar has formed [2].

Our case report highlights the important features of an injury mechanism which has steadily become more common in recent decades. It aims to familiarize practicing radiologists with the important imaging characteristics of gymnast's wrist. Fortunately, most cases of chronic overuse injury affecting the physis have been shown to resolve with rest and early intervention [3]. It is our hope that with additional knowledge on this entity, radiologists will be better able to diagnose physeal injuries in the setting of chronic overuse, with the goal of preventing the known long-term sequelae.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.radcr.2018.09.010.

REFERENCES

[1] Davis KW, Gill KG. Upper extremity injuries in young athletes. Semin Musculoskelet Radiol 2012;16(4):269–79.

[2] Benjamin H, Engel S, Chudzik D. Wrist pain in gymnasts: a review of common overuse wrist pathology in the gymnastics athlete. Curr Sport Med Rep 2017;16(5):322–9.

[3] Caine D, Howe W, Ross W, Bergman G. Does repetitive physical loading inhibit radial growth in female gymnasts? Clin J Sport Med: Off J Can Acad Sport Med 1997;7(4):302–8.

[4] McAuley E, Hudash G, Shields K, et al. Injuries in women's gymnastis: the state of the art. Am J Sport Med 1987;15:558–65.

[5] Guerra M, Estelles J, Abdouni Y, Falcochio D, Rosa J, Catani L. Frequency of wrist growth plate injury in young gymnasts at a training center. Acta Ortopedica Brasileira 2016;24(4):204–7.

[6] Sands WA, Henschun KP, Shultz BB. National women's tracking program. Technique 1989;9:14–20.

[7] Takai Y. A Comparison of techniques used in performing the men's compulsory gymnastic vault at 1988 olympics. Int J Sport Biomech 1991;7(1):54–75.

[8] Westermann R, Giblin M, Vaske A, Grosso K, Wolf B. Evaluation of men's and women's gymnastics injuries: a 10-year observational study. Sport Health: Multidiscip Approach 2015;7(2):161–5.

[9] Taylor DC, Krasinski KL. Adolescent shoulder injuries: consensus and controversies. J Bone Jt Surg Am 2009;91(2):462–73.

[10] Mariscalo MW, Saluan P. Upper extremity injuries in the adolescent athlete. Sport Med Arthrosc Rev 2011;19(1):17–26.

[11] Paz DA, Chang GH, Yetto JM Jr, Dwek JR, Chung CB. Up- per extremity overuse injuries in pediatric athletes: clinical presentation, imaging findings, and treatment. Clin Imaging 2015;39(6):954–64.

[12] Raissaki M, Apostolaki E, Karantanas AH. Imaging of sports injuries in children and adolescents. Eur J Radiol 2007;62(1):86–96.

[13] Mann DC, Rajmaira S. Distribution of physeal and nonphyseal fractures in 2,650 long-bone fractures in children aged 0–16 years. J Pediatr Orthop 1990;10(6):713–16.

[14] Rogers LF, Jones S, Davis AR, Dietz G. "Clipping injury" fracture of the epiphysis in the adolescent football player: an occult lesion of the knee. AJR Am J Roentgenol 1974;121:69–78.

[15] Oh WH, Craig C, Banks HH. Epiphyseal injuries. Pediatr Clin N Am 1974;21:407–22.

[16] Lipp EJ. Athletic physeal injury in children and adolescents. Orthop Nurs 1998;17:17–22.

[17] Carter SR, Aldridge MJ, Fitzgerald R, Davies AM. Stress changes of the wrist in adolescent gymnasts. Br J Radiol 1988;61:109–12.

[18] Salter RB, Harris WR. Injuries involving the epiphyseal plate. J Bone Jt Surg Am 1963;45-A:587–622.

[19] Larson RL. Epiphyseal injuries in the adolescent athlete. Orthop Clin N Am 1973;4:839–51.

[20] Ecklund K, Jaramillo D. Imaging of growth disturbance in children. Radiol Clin N Am 2001;39(4):823–41.

[21] Salter RB, Harris WR. Injuries involving the epiphyseal plate. J Bone Jt Surg Am 1963;45-A:587–622.

[22] Roy S, Caine D, Singer KM. Stress changes of the distal radial epiphysis in young gymnasts. A report of twenty-one cases and a review of the literature. Am J Sports Med. 1985;13(5):301–8.

[23] Hoang QB, Mortazavi M. Pediatric overuse injuries in sports. Adv Pediatr 2012;59(1):359–83.

[24] DiFiori JP, Puffer JC, Aish B, et al. Wrist pain, distal radial physeal injury, and ulnar variance in young gymnasts: does a relationship exist. Am J Sports Med 2002;30:879–85.

[25] Jawetz ST, Shah PH, Potter HG. Imaging of physeal injury: overuse. Sport Health 2015;7:142–53.

[26] Jaramillo D, Laor T, Zaleske DJ. Indirect trauma to the growth plate: results of MR imaging after epiphyseal and metaphyseal injury in rabbits. Radiology 1993;187:171–8.

[27] DiFiori JP, Caine DJ, Malina RM. Wrist pain, distal radial physeal injury, and ulnar variance in the young gymnast. Am J Sports Med 2006;34(5):840–9.

[28] Shamliyan TA, Kane RL, Ansari MT, et al. Development quality criteria to evaluate nontherapeutic studies of incidence, prevalence, or risk factors of chronic diseases: pilot study of new checklists. J Clin Epidemiol 2011;64:637–57.

[29] Lomasney LM, Lim-Dunham JE, Cappello T, et al. Imaging of the pediatric athlete: use and overuse. Radiol Clin N Am 2013;51:215–26.

[30] Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009;339:b2700.

[31] Poletto ED, Pollock AN. Radial epiphysitis (aka gymnast wrist). Pediatr Emerg Care 2012;28:484–5.

[32] Delgado J, Jaramillo D, Chauvin N. Imaging the injured pediatric athlete: upper extremity. Radiographics 2016;36(6):1672–87.

[33] Chang CY, Shih C, Penn IW, et al. Wrist injuries in adolescent gymnasts of a 24 Chinese opera school: radiographic survey. Radiology 1995;195:861–4.

[34] Kirby RL, Simms FC, Symington VJ, et al. Flexibility and musculoskeletal 25 symptomatology in female gymnasts and age-matched controls. Am J Sports Med 1981;9:160–4.

[35] Lieblinig MS, Berdon WE, Ruzal-Shapiro C, Levin TL, Roye D Jr, Wilkinson R. Gymnast's wrist (pseudorickets growth plate abnormality) in adolescent athletes: findings on plain films and MR imaging. AJR 1995;164:157–9.

[36] Ecklund K, Jaramillo D. Patterns of premature physeal arrest: MR imaging of 111 children. AJR 2002;178:967–72.

[37] Kox L, Kuijer P, Kerkhoffs G, Maas M, Frings-Dresen M. Prevalence, incidence and risk factors for overuse injuries of the wrist in young athletes: a systematic review. Br J Sport Med 2015;49(18):1189.

[38] Wolf MR, Avery D, Wolf JM. Upper extremity injuries in gymnasts. Hand Clin 2017;33:187–97.