North Clin Istanb 2021;8(5):507–512
doi: 10.14744/nci.2021.22844

Original Article ORTHOPEDICS & TRAUMATOLOGY

Is physical examination as effective as magnetic resonance imaging in the diagnosis of suspected pediatric scaphoid fractures?

Fevzi Saglam,[1] Ozgur Baysal[2]

[1]Department of Orthopedics and Traumatology, Sakarya University Faculty of Medicine, Sakarya, Turkey

[2]Department of Orthopedics and Traumatology, Marmara University Pendik Training and Research Hospital, Istanbul, Turkey

ABSTRACT

OBJECTIVE: The aim of this study was to evaluate whether careful physical examination is as effective in diagnosis as magnetic resonance imaging (MRI) in pediatric patients with suspected scaphoid fractures and whether radiography is sufficient in the follow-up of these patients.

METHODS: This prospective study included patients with tenderness of the anatomic snuffbox on physical examination and no fracture on radiography between 2015 and 2019, and the data were evaluated retrospectively. A short-arm thumb spica casting was applied for an initial diagnosis of suspected scaphoid fracture. MRI was performed within 1 week after initial trauma. Physical examination and X-rays at 2-week intervals were applied during the follow-up period. The functional outcomes were evaluated using the Modified Mayo Wrist score.

RESULTS: A total of 92 patients (28 girls and 64 boys; mean age: 12.32±2.22 years) were diagnosed with suspected scaphoid fracture on physical examination and MRI was performed. The MRI confirmed the suspected scaphoid fracture at the rate of 77.2% (n=71). The sensitivity obtained for the radiograph was 14.08%, specificity was 100%, positive predictive value was 100%, and negative predictive value was 25.61%. The mean Modified Mayo Wrist score was 92.43±2.64 (range, 85–98).

CONCLUSION: Detection of tenderness on the anatomic snuffbox without determination of fracture radiographically should be evaluated and treated in favor of a scaphoid fracture. These fractures are mostly treated successfully with conservative treatment.

Keywords: Pediatric scaphoid fracture; scaphoid magnetic resonance imaging; wrist examination.

Cite this article as: *Saglam F, Baysal O. Is physical examination as effective as magnetic resonance imaging in the diagnosis of suspected pediatric scaphoid fractures? North Clin Istanb 2021;8(5):507–512.*

Carpal bone fractures are rarely seen in children, but the most common of these are scaphoid fractures [1]. These fractures, which constitute 0.45% of all upper extremity fractures and 0.34% of all childhood fractures [2], are seen more in children over the age of 11 years and rarely in those aged <8 years [3–5]. As the majority of these fractures are incomplete, and not dislocated or accompanied by a bone fragment, they can be treated conservatively [4, 6–9]. Early diagnosis and correct treatment are extremely important for the prevention of complications.

As the primary mechanism of these fractures is a fall on the open hand in pronation, this increases the possibility of fractures seen in children involved in sporting activities [1]. Physical examination, X-rays, magnetic resonance imaging (MRI), computed tomography

Received: March 17, 2021 *Accepted:* June 07, 2021 *Online:* October 18, 2021

Correspondence: Fevzi SAGLAM, MD. Sakarya Universitesi Tip Fakultesi, Ortopedi ve Travmatoloji Anabilim Dali, Sakarya, Turkey.
Tel: +90 545 536 14 61 e-mail: drfevzisaglam@gmail.com

(CT), and scintigraphy can be used in the diagnosis of scaphoid fractures. The physical examination findings of most importance in suspected scaphoid fracture are sensitivity in the snuffbox, sensitivity over the scaphoid tubercle on the volar wrist, pain with radial deviation, and pain with active movement of the wrist [4, 8]. While adult scaphoid fractures occur more in the waist section, pediatric scaphoid fractures are seen more in the distal and waist sections [4, 10]. The first imaging method that should be requested in patients with suspected fracture is anteroposterior, ulnarly deviated oblique, lateral radiographs of the wrist [8, 11, 12].

Radiography is not sufficient in the imaging of non-ossified elements in immature bone [6]. There is even a high possibility of scaphoid fractures being missed on plain radiographs in adult patients. As the scaphoid secondary ossification nucleus starts to be seen at the age of 5 years and is completed from the distal pole of the scaphoid towards the proximal at 13–18 years old, fractures are often missed in pediatric patients only examined with X-rays. Therefore, most orthopedists apply a thumb spica cast to patients with clinically suspected scaphoid fracture but negative findings on radiography, and recommend follow-up with physical examination and X-rays at 2-week intervals [7, 13]. In children with suspected scaphoid fracture, MRI is the imaging method with the highest sensitivity and specificity [14–19].

The application of MRI does not expose the child to ionizing radiation, and sedation may not always be required. Although the assessment of MRI protocols was outside the scope of this review, one recommended protocol includes coronal T1 and STIR with diagnostic features being a high signal on STIR from bruising/bleeding and a low signal in the fracture line on T1 images [8].

The aim of this study was to evaluate whether careful physical examination is as effective in diagnosis as MRI in pediatric patients with suspected scaphoid fractures and whether radiography is sufficient in the follow-up of these patients.

MATERIALS AND METHODS

Approval for the study was granted by the Marmara University Faculty of Medicine Clinical Research Ethics Committee (protocol number: 09.2019.545, dated: 14.06.2019). All study procedures were applied in compliance with the principles of the Declaration of Helsinki. The study was planned prospectively and the data were collected retrospectively. The study was included pediatric patients (range; 6–16 years) who applied to the emergency department due to wrist trauma, had pain in the anatomic snuffbox, sensitivity over the scaphoid tubercle on the volar wrist, pain with radial deviation, and pain with active wrist movement. Patients who had older than 16 years old, had an open fracture, a displaced fracture on the radiograph, had any accompanying fracture, and did not follow the treatment recommendations were excluded from the study.

With the suspicion of scaphoid fracture, anteroposterior, ulnarly deviated oblique, and lateral radiographs of the wrist were taken. Patients who could not be determined with fracture on radiographs but had positive physical examination findings were applied with a thumb spica cast support for an initial diagnosis of scaphoid fracture. The number of patients with actual scaphoid fracture was determined from examination of wrist MRI taken within 1 week of the trauma (Fig. 1). All the wrist radiographs and MR images were evaluated by the same musculoskeletal radiologist.

Highlight key points

- Tenderness in snuffbox, tenderness over scaphoid pain with tubercle, radial deviation in the volar wrist, and pain with active movement of the wrist are the most important findings in scaphoid fractures.
- Careful physical examination was found to be as effective as MRI in the diagnosis of suspected pediatric scaphoid fractures.
- Suspected pediatric scaphoid fractures are much more common than expected (%77.2).

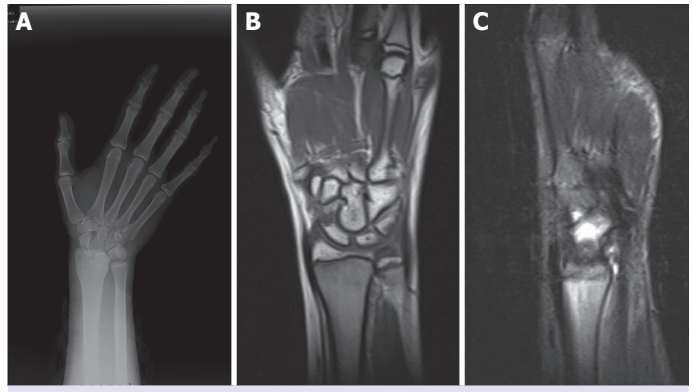

Figure 1. A 14-year-old male patient was admitted to the emergency department after falling on his right wrist. **(A)** AP X-ray in the ulnar deviation at the time of admission. **(B, C)** Wrist MRI taken on day 6, fracture line in the scaphoid distal in coronal and sagittal section.

After 2 weeks of splinting, the treatment was terminated for patients not determined with a fracture on MRI and no pain complaints. For patients with no fracture but with continuing pain, the splint was applied for a further week with the aim of rest. Patients determined with a fracture were called for follow-up examinations at 2-week intervals and the treatment was completed in 5–8 weeks. Fracture union was decided on the basis of no sensitivity on physical examination of the scaphoid, and thus, the treatment was completed. Approximately 4 weeks after the completion of the treatment, the wrist functions of the patients were evaluated using Mayo Modified Wrist scoring.

Statistical Methods

Data obtained in the study were analyzed statistically using NCSS 2007 software (Number Cruncher Statistical System, Kaysville, Utah, USA). Descriptive statistical methods were used in the evaluation of the data and results were stated as mean±standard deviation values, median, minimum, maximum, number, and percentage. Conformity of quantitative data to normal distribution was assessed with the Shapiro–Wilk test and graphic examinations. The Student's t-test was used to compare the Modified Mayo Wrist scores with normal distribution according to MR results. The McNemar test and diagnostic screening tests (specificity, sensitivity, etc.) were used to compare MR results and control radiography results. $P<0.05$ was accepted as statistically significant.

RESULTS

The study was conducted between November 01, 2015, and January 01, 2019, in the Orthopaedics and Traumatology Clinics of two Istanbul hospitals: Istanbul Sultanbeyli State Hospital and Marmara University Pendik Training and Research Hospital A total of 92 cases were included, comprising 30.4% (n=28) girls and 69.6% (n=64) boys, with a mean age of 12.32±2.22 years (range, 6–16 years) (Table 1). The mechanism of trauma was determined to be related to ball sports (football, basketball, and volleyball) in 52% (n=48), falling off a bicycle in 19% (n=17), falling while running in 10% (n=9), slipping and falling on ice in 8% (n=7), and other trauma in 11% (n=11). The mean Mayo Modified wrist score was 92.43±2.64 (range, 85–98). Scaphoid fracture was not observed on the first radiograph of any patient.

Table 1. Distribution of descriptive characteristics

Age (years)	
Median	13
Mean±SD	12.32±2.22
Gender (%)	
Female	30.4
Male	69.6
Fracture side (%)	
Right	47.8
Left	52.2
Mayo Modified Wrist score	
Median	92
Mean±SD	92.43±2.64
First X-ray result (%)	
Negative	100)
Magnetic resonance imaging result (%)	
Negative	22.8
Positive	77.2
Time to taking magnetic resonance imaging (days)	
Median	4
Mean±SD	4.14±1.31
Localization (n=71) (%)	
Distal	70.4
Shaft	29.6
Follow-up X-ray result (%)	
Negative	85.9
Positive	14.1
Time to taking follow-up X-ray (days)	
Median	15
Mean±SD	15.26±1.84
Treatment duration (days)	
Median	36
Mean±SD	32.49±10.10

SD: Standard deviation

Distal radius type 1 epiphysiolysis was determined concomitant to scaphoid fracture in 10 patients, and capitatum and hamatum fracture in one patient. In seven patients with positive findings on physical examination but no scaphoid fracture on MRI, isolated distal radius epiphysiolysis was determined in one patient, trapezium and trapezoideum fractures in one patient, isolated capitatum fracture in one patient, and ganglion cysts in three patients. Pediatric scaphoid fracture was determined on MRI in 71 (77.2%) cases and was not determined in 21 (22.8%) cases. The MRI results confirmed the suspected scaphoid frac-

Table 2. Compatibility between the magnetic resonance imaging results and the follow-up radiograph results

Follow-up radiograph result	Magnetic resonance imaging result			p
	Negative	Positive	Total	
Negative	22.8	66.3	82 (89.1)	**0.001***
Positive	0	10.9	10 (10.9)	
Total	22.8	77.2	92 (100)	

McNemar test; *: P<0.01

tures at the rate of 77.2%. The MRI was applied at mean 4.14±1.31 days (range, 1–7 days). When the fracture localization was examined in patients with fracture determined on MRI, distal localization was seen in 50 (70.4%) cases, the waist section in 21 (29.6%), and proximal pole fracture was not determined in any patient (Table 1).

The radiograph was applied in the 2nd week following the initial trauma, the scaphoid fracture was determined in 10 (14%) patients, and no fracture was determined in 61 (86%) patients. Radiography was not applied during the follow-up of patients with fractures not detected on MRI, and those patients were evaluated with physical examination only. The follow-up radiographs were taken at mean 15.26±1.84 days (range, 11–19 days). The duration of treatment of patients with scaphoid fracture determined on MRI was mean 37.46 days (range, 32–53 days) (Table 1).

Seventy-one patients were defined as positive on MRI, 61 were as negative on the follow-up radiographs, and 10 were positive findings. A statistically significant difference was determined between the MR results and the control radiograph results (p=0.001 and p<0.01). The MR results were taken as the gold standard, and the sensitivity obtained for the control radiograph was 14.08%, specificity was 100%, positive predictive value was 100%, and negative predictive value was 25.61% (Table 2).

The wrist functions of the patients were evaluated using the Modified Mayo Wrist score, which was determined as mean 92.43±2.64 (range, 85–98).

DISCUSSION

As pediatric scaphoid fractures contain more cartilage structures, they are rarely seen fractures [7, 20]. The majority of these fractures are non-displaced and incomplete, making them difficult to diagnose on plain radiography [7, 8]. In a study by Wilson et al. [12], the epidemiology of pediatric scaphoid fractures, the mechanism of injury, and optimal treatment were shown not to have been fully clarified. The mechanism of trauma in the majority of cases is a fall on the extended hand in hyperextension and pronation [8].

Several studies have reported that the suspicion of scaphoid fracture is strengthened by the presence of sensitivity in the snuffbox, sensitivity over the scaphoid in the volar, sensitivity with radial deviation, and pain with active wrist movement, in the physical examination following wrist trauma [21]. Studies recommend that in pediatric patients with clinically suspected scaphoid fracture, treatment with plaster casting should be applied for 2 weeks until stabilized and fracture is discounted or continued until treatment is completed [21]. In the current study, all the patients had sensitivity in the snuffbox, sensitivity over the scaphoid in the volar, sensitivity with radial deviation, and pain with active wrist movement and all of these patients were included for the radiological tests necessary for the initial diagnosis of scaphoid fracture.

As the majority of scaphoid fractures are non-displaced and seen in the distal third, they can be treated with immobilization and are fractures where non-union is rarely seen [1, 4, 5, 8, 10–12, 18, 22, 23]. The previous studies have reported that 59%–87% of the fractures are seen in the distal third and 12%–36% in the waist region [4, 7, 8, 24]. From a scan of the English literature, only six reports could be found of pediatric scaphoid proximal pole fracture, and in half of these, avascular necrosis was observed [7, 25, 26]. In the current study, the fractures were in the distal third in 50 (70.4%) cases, and in the waist region in 21 (29.6%), and no fracture in the proximal pole was determined in any patient.

It is widely accepted that "acute" scaphoid fractures in children show good prognosis after conservative treatment [7, 14, 22]. The duration of immobilization with plaster casting varies from 4 to 12 weeks, depending on the localization of the fracture [4, 7, 8, 22, 23]. D'Arienzo [7] reported good functional results in all of a series of 39 children treated conservatively for fracture healing. Huckstadt et al. [27] treated 17 children aged <18 years conservatively and reported full fracture healing with delayed union in only one patient. In the current study, all 71 patients diagnosed with scaphoid fracture were treated conservatively, and full

bone union was seen in all cases. Excellent results were obtained with a mean Modified Mayo Wrist score of 92.11±2.69. This was attributed to all the fractures being non-displaced and incomplete, in the waist section and distal pole, and that a correct diagnosis was made and appropriate treatment was applied.

As these fractures are not common, there is controversy about the optimal treatment. Some publications have recommended the surgery in fractures with >1 mm displacement and 10° angulation [28]. Gholson et al. [29] reported that chronic non-union could develop in a third of pediatric patients with displaced scaphoid fracture and recommended surgical reduction and internal fixation in the primary treatment. The most important point that the recommendation for surgery was based on was for children to have an earlier return to school and sporting activities. In the current study, as all the fractures were non-displaced and there was no angulation in the scaphoid, surgery was not planned for any patient. All the school-age children in the current study returned to school on the day after the treatment, so there was no academic loss.

Most authors recommend imaging methods such as MRI, CT, USG, and bone scintigraphy in addition to X-rays [11, 12, 22, 30]. MRI, which has been used recently for definitive diagnosis in patients with scaphoid fracture instead of plain radiographs, has been reported to have negative predictive value of 100% [27]. In the same study, Huckstadt et al. [27] applied a splint with thumb support to pediatric patients with suspected scaphoid fracture without applying MRI. With follow-up radiographs then taken at 2-week intervals, it was reported that fracture could be seen on plain radiographs taken at mean 5 weeks after the trauma.

While no scaphoid fracture was determined in 82 (89.1%) of the current study patients on the follow-up radiographs taken at mean 15.26±1.84 days, the fracture was determined in 10 (10.9%) cases. No statistically significant agreement was determined between the MRI and follow-up radiograph results and the difference was statistically significant ($p=0.001$ and $p<0.01$). According to these results, the sensitivity of the follow-up radiographs was determined as 14.08%, specificity as 100%, positive predictive value 100%, and negative predictive value 25.61%. It was concluded that taking follow-up radiographs in the 2nd week were not very reliable for the confirmation of diagnosis in patients with suspected fractures.

Although complications are rarely seen in pediatric scaphoid fractures, the most common complications are pseudarthrosis, non-union, and avascular necrosis. Non-union and avascular necrosis are occasionally seen in proximal pole fractures [1, 8]. The main reason that non-union is seen is delayed diagnosis or a missed fracture [27]. Therefore, in the determination of these fractures, the most important point is that physical examination and imaging must be applied carefully. In the current study, no complications were seen in any of the patients that were treated. The most important reason for this was considered to be that only non-displaced, incomplete fractures were included.

There were some limitations to this study, primarily the low number of patients. Moreover, although a 2-week follow-up radiograph was taken of patients diagnosed with fracture on MRI taken in the 1st week to check the evidence of the fracture line and whether or not displacement had developed, further radiographs were not taken until the treatment was completed. The splint was removed, as it was thought that the fracture would not have displaced after that time.

Conclusion

As scaphoid fractures can even be missed in adults, there is a more substantial possibility that they will be overlooked in children where the cartilage has not completely ossified. With a carefully applied physical examination of the wrist following a fall onto the hand in children, more scaphoid fractures than predicted will be determined in patients with suspected scaphoid fracture but for whom no pathology is seen on plain radiographs. In children suspected of having this type of wrist fracture, it must be kept in mind that there could be a scaphoid fracture, and the appropriate treatment should be applied. If all patients initially suspected of having a scaphoid fracture on their first physical examination underwent MRI, this would increase the cost of health care unnecessarily.

Ethics Committee Approval: The Marmara University Clinical Research Ethics Committee granted approval for this study (date: 14.06.2019, number: 09.2019.545).

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

Authorship Contributions: Concept – FS; Design – OB; Supervision – FS; Data collection and/or processing – FS; Analysis and/or interpretation – OB; Literature review – FS; Writing – FS, OB.

REFERENCES

1. Evenski AJ, Adamczyk MJ, Steiner RP, Morscher MA, Riley PM. Clinically suspected scaphoid fractures in children. J Pediatr Orthop 2009;29:352–5.
2. Pillai A, Jain M. Management of clinical fractures of the scaphoid: results of an audit and literature review. Eur J Emerg Med 2005;12:47–51.
3. Mussbichler H. Injuries of the carpal scaphoid in children. Acta radiol 1961;56:361–8.
4. Wulff RN, Schmidt TL. Carpal fractures in children. J Pediatr Orthop 1998;18:462–5.
5. Larson B, Light TR, Ogden JA. Fracture and ischemic necrosis of the immature scaphoid. J Hand Surg Am 1987;12:122–7.
6. Gajdobranski D, Zivanović D, Mikov A, Slavković A, Marić D, Marjanović Z, et al. Scaphoid fractures in children. Srp Arh Celok Lek 2014;142:444–9.
7. D'Arienzo M. Scaphoid fractures in children. J Hand Surg Br 2002;27:424–6.
8. Fabre O, De Boeck H, Haentjens P. Fractures and nonunions of the carpal scaphoid in children. Acta Orthop Belg 2001;67:121–5.
9. Bhatti AN, Griffin SJ, Wenham SJ. Deceptive appearance of a normal variant of scaphoid bone in a teenage patient: a diagnostic challenge. Orthop Rev (Pavia) 2012;4:e6.
10. Stuart HC, Pyle SI, Cornoni J, Reed RB. Onsets, completions and spans of ossification in the 29 bonegrowth centers of the hand and wrist. Pediatrics 1962;29:237–49.
11. Lögters TT, Linhart W, Schubert D, Windolf J, Schädel-Höpfner M. Diagnostic approach for suspected scaphoid fractures in children. Eur J Trauma Emerg Surg 2008;34:131.
12. Wilson EB, Beattie TF, Wilkinson AG. Epidemiological review and proposed management of 'scaphoid' injury in children. Eur J Emerg Med 2011;18:57–61.
13. Elhassan BT, Shin AY. Scaphoid fracture in children. Hand Clin 2006;22:31–41.
14. Patel NK, Davies N, Mirza Z, Watson M. Cost and clinical effectiveness of MRI in occult scaphoid fractures: a randomised controlled trial. Emerg Med J 2013;30:202–7.
15. Trigg M, Reeves PJ. The efficacy of plain films vs MRI in the detection of scaphoid fractures. Radiography (Lond) 2007;13:56–64.
16. Khalid M, Jummani ZR, Kanagaraj K, Hussain A, Robinson D, Walker R. Role of MRI in the diagnosis of clinically suspected scaphoid fracture: analysis of 611 consecutive cases and literature review. Emerg Med J 2010;27:266–9.
17. Yin ZG, Zhang JB, Kan SL, Wang XG. Diagnosing suspected scaphoid fractures: a systematic review and meta-analysis. Clin Orthop Relat Res 2010;468:723–34.
18. Breitenseher MJ, Metz VM, Gilula LA, Gaebler C, Kukla C, Fleischmann D, et al. Radiographically occult scaphoid fractures: value of MR imaging in detection. Radiology 1997;203:245–50.
19. McCullough NP, Smith FW, Cooper JG. Early MRI in the management of the clinical scaphoid fracture. Eur J Emerg Med 2011;18:133–6.
20. García-Mata S. Carpal scaphoid fracture nonunion in children. J Pediatr Orthop 2002;22:448–51.
21. Johnson KJ, Haigh SF, Symonds KE. MRI in the management of scaphoid fractures in skeletally immature patients. Pediatr Radiol 2000;30:685–8.
22. Toh S, Miura H, Arai K, Yasumura M, Wada M, Tsubo K. Scaphoid fractures in children: problems and treatment. J Pediatr Orthop 2003;23:216–21.
23. Weber DM. Scaphoid fractures in childhood. [Article in German]. Unfallchirurg 2011;114:285–91.
24. Rhemrev SJ, Ootes D, Beeres FJ, Meylaerts SA, Schipper IB. Current methods of diagnosis and treatment of scaphoid fractures. Int J Emerg Med 2011;4:4.
25. Hamdi MF, Khelifi A. Operative management of nonunion scaphoid fracture in children: a case report and literature review. Musculoskelet Surg 2011;95:49–52.
26. Gunal I, Altay T. Avascular necrosis of the scaphoid in children treated by splint immobilisation: a report of two cases. J Bone Joint Surg Br 2011;93:847–8.
27. Huckstadt T, Klitscher D, Weltzien A, Müller LP, Rommens PM, Schier F. Pediatric fractures of the carpal scaphoid: a retrospective clinical and radiological study. J Pediatr Orthop 2007;27:447–50.
28. Rockwood CA, Wilkins KE. Fractures in children. Philadelphia, PA: Lippincott Williams & Wilkins; 2001.
29. Gholson JJ, Bae DS, Zurakowski D, Waters PM. Scaphoid fractures in children and adolescents: contemporary injury patterns and factors influencing time to union. J Bone Joint Surg Am 2011;93:1210–9.
30. Foley K, Patel S. Fractures of the scaphoid, capitate and triquetrum in a child: a case report. J Orthop Surg (Hong Kong) 2012;20:103–4.