Pediatr Radiol (2000) 30: 685–688

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MRI in the management of scaphoid fractures in skeletally immature patients

Received: 1 October 1999
Accepted: 1 June 2000

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Abstract *Background.* The scaphoid is the commonest fractured carpal bone, but excluding a scaphoid fracture with plain radiographs is difficult. Other imaging modalities are being increasingly evaluated in the management of scaphoid injuries. MRI has been shown to be of considerable value in the adult population but there have been limited studies of its use in children.
Purpose. To evaluate the role of MRI in the acute management of suspected scaphoid injuries in children.
Methods and materials. Fifty-six children (57 injuries) who had a suspected scaphoid injury underwent MRI within 10 days of their initial trauma. The results of MRI were used to dictate management of the injury.
Results. In 33 (58%) of the 57 injuries, MRI was normal and the patient was discharged from care. In 16 cases (28%), a fractured scaphoid was diagnosed and appropriate treatment started early. Additionally, other fractures around the wrist joint and ganglion cysts were demonstrated on MRI.
Conclusions. MRI of acute scaphoid injuries in children significantly alters management. Those children with normal scans are discharged earlier. Scaphoid fractures are confirmed earlier and other pathological conditions are also detected.

Introduction

The scaphoid is the most commonly fractured carpal bone in children [1, 2]. As in the adult population, excluding a fracture with conventional radiographs can be difficult [3, 4]. The detection of scaphoid fractures can be improved by multiple views, including projections with ulnar deviation and with tube angulation. Traditionally, regardless of the radiographic findings, all patients who have a clinically suspected scaphoid fracture are immobilised for at least 2 weeks and then followed up with a series of clinical and radiological examinations. This continues until a fracture has been excluded or adequately treated. This conservative approach to scaphoid injuries is to avoid the complications of an undiagnosed and untreated fracture, namely non-union, avascular necrosis and development of osteoarthritis [5, 6].

Because of this uncertainty in the diagnosis of scaphoid fractures, many patients are treated as for a fracture despite the fact that they have no significant bony injury. A large proportion of children presenting with a history of trauma and tenderness in the anatomical snuffbox are unnecessarily immobilised for 2–6 weeks. In children, this has a considerable impact on family and school life, as well as the resource implications for the hospital with unnecessary radiographs and clinic appointments.

Other imaging modalities have been used to improve the detection of scaphoid fractures; in particular, there has been considerable experience of bone scintigraphy and MRI, both of which have been shown to be superior to plain radiographs [7–9]. Bone scintigraphy entails radiation dose to the patient and is less sensitive than MRI [10]. The majority of MRI studies have concentrat-

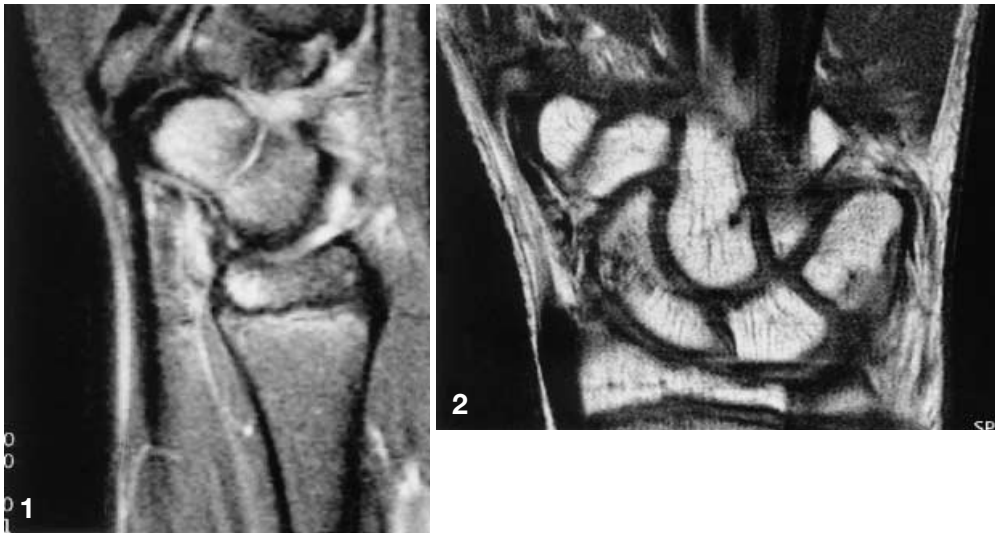

Fig. 1 Sagittal STIR MRI shows a cortical break and bone-marrow oedema in the scaphoid. There is some oedema in the distal radius

Fig. 2 Coronal T1-W MRI shows cortical disruption and bone marrow oedema in the scaphoid

ed on an adult population rather than children, though work has shown that MRI is as sensitive in children as in adults [11]. This is the first study to evaluate MRI in the management of suspected scaphoid fractures in children.

Materials and methods

Fifty-seven MRI examinations were performed on 56 patients (one boy had repeat MRI of the same wrist 6 months following a normal examination after sustaining a similar type of injury). Children were aged between 6 years 6 months and 15 years 10 months (mean 12 years 5 months, median 11 years 7 months). There were 32 boys and 24 girls. These children had presented to a major open-access paediatric emergency unit. Initially all patients had a 'routine scaphoid series' of plain radiographs. This series consists of four views: lateral, dorsipalmar (DP) with ulnar deviation, DP oblique and DP oblique with 35º angulation towards the elbow. Patients in whom a clinical diagnosis of scaphoid fracture was suspected were treated by wrist immobilisation, even if the radiographic findings were normal. They were reviewed clinically by senior Accident and Emergency staff at 48–72 h. If they still had clinical signs and symptoms, a traditional scaphoid plaster was applied and the patient was then referred for MRI.

All MRI examinations were performed at 1.5 T (Siemens Symphony, Siemens, Erlangen, Germany) within 10 days following the initial injury (mean 7 days, no sedation). The patient was imaged in the prone position with the arm extended ('superman' position) and the wrist was immobilised in a 'comfort bag'. T1-weighted (T1-W) coronal (TR/TE 500/20, 3-mm-thick slices, matrix 192 × 256, field of view [FOV] 100 × 100 mm, acquisition time 3 min 15 s), T2-weighted (T2-W) fast spin-echo fat-saturated coronal (TR/TE 3,500/72, flip angle 180°, 3-mm thick slices, matrix 256 × 256, FOV 100 × 100 mm, acquisition time 4 min 17 s) and sagittal short tau inversion recovery (STIR) (TR/TE 5,100/30, flip angle 180°, 3-mm-thick slices, matrix 189 × 256, FOV 100 × 100 mm, acquisition time 4 min 40 s) images were obtained.

In all the MRI examinations the integrity of the scaphoid and the other carpal bones along with any associated ligamentous or soft tissue injuries was reported. A fracture was diagnosed if there was a cortical fracture line, cortical disruption and oedema, bone marrow abnormality over a diffuse area of a single carpus (Figs. 1, 2) or a combination of these signs [11–13]. All plain radiographs and MRI images were reported by consultant paediatric radiologists (K. J. J., S. F. H.).

If the MRI was abnormal, the patients were reviewed clinically within 2 weeks and were managed appropriately. If the MR was normal, the patients were reviewed clinically at the earliest opportunity and discharged from care. There was no further imaging following a normal MRI examination. Follow-up of children with a normal examination was from 5 months to 10 months.

The MRI examinations were generally well tolerated by the children and there were no failed examinations. There were some sequences that were sub-optimal due to movement artefact, but overall it was possible to obtain a definitive examination in all cases.

Results

The initial plain radiographs performed when the child presented to the Emergency Department demonstrated 3 definite fractures, 10 possible fractures (i. e. the reports were equivocal) and 44 negative examinations.

MRI demonstrated 16 scaphoid fractures (28 %), 3 capitate fractures, 2 radial fractures (1 occurred concurrently with a scaphoid fracture), 1 ulnar fracture, which also occurred with a scaphoid fracture, and a bruised pisiform. There were two ganglion cysts, but it was not possible to determine if these cysts were incidental findings or post-traumatic in nature. Of the scaphoid fractures, six were distal pole, four were through the waist, three were lower pole and three were transverse through the length of the scaphoid. Thirty-three MRI examinations were classified as normal and these patients were mobilised as soon as possible after the MRI examination. The results of the MRI studies and plain

Table 1 A comparison of the plain radiographic and MRI findings

X-ray findings		MRI findings	
No fracture	44	Normal	27
		Scaphoid fracture	9
		Scaphoid fracture & other injury	2
		Carpal Injury	6
Equivocal	10	Normal	6
		Scaphoid fracture	2
		Carpal/Radial injury	2
Scaphoid fracture seen	3	Scaphoid Fracture	3

film findings are summarised in Table 1. Patient management was directed by the result of the MRI examination, with it being regarded as the definitive examination. The time from MRI to follow-up clinical consultation varied from the same day to 7 days.

Of the ten plain radiographs that had an equivocal report, MRI was positive in four cases and negative in six. The positive examinations included one of the capitate fractures and a distal radial fracture that were both discernible on the initial plain radiographs but had been missed at the time of reporting.

Those children who were discharged with a normal MRI have been followed up for 5–10 months. None have represented with symptoms of a carpal injury; all have resumed normal daily activities.

Discussion

MRI can now be regarded as the gold standard for the imaging of scaphoid fractures [10]. The use of MRI allows a definitive diagnosis to be made at a much earlier stage compared to the plain radiographs, and there are no ionising radiation implications as with bone scintigraphy and CT [12]. MRI is able to demonstrate marrow changes and cortical disruption and can clearly delineate fracture lines, particularly as the imaging is performed in more than one plane. A proportion of our positive scans demonstrated that the fracture extended in an oblique/spiral plane through the scaphoid bone, confirming the difficulty in recognising the fracture on plain radiographs (Fig. 3). MRI also makes it possible to detect undisplaced compression fractures [13]. Previous reports have shown that MRI has a 100 % negative predictive value for scaphoid fractures, so that patients with a normal scan can be confidently treated as having no bony injury [10, 12].

MRI has the advantage that it can detect associated soft-tissue changes around the wrist joint and carpal joint effusions between the carpal bones. In our series, we detected other carpal injuries that would account for some of the children's symptoms and may affect management.

Fig. 3 Sagittal STIR MRI shows a fracture of the scaphoid with bone-marrow oedema. The fracture line passes obliquely through the scaphoid

The MRI sequences chosen in our study have been used in other studies [11–13]. They allow the scaphoid to be imaged in two orthogonal planes and allow anatomical evaluation of all the carpal bones. They are a sensitive indicator of marrow oedema. Only three sequences were used routinely, as this reduces scan time enables the younger children to tolerate the examination better. Shorter scan times also allow the whole examination to be completed within 20 min and be easily accommodated within a busy MRI list. Movement artefact was minimised by the fact that the children were all in immobilisation casts, and a comfort evacuated beanbag was used to further immobilise the wrist. All the examinations were of satisfactory quality, and none was regarded as uninterpretable. A few problems were encountered with movement artefact in younger children, but with reassurance all examinations were completed. No child needed sedation.

In those children who had a normal MRI, clinical review was organised as soon as possible so that the results could be discussed with the patient and parent and discharge arranged. Repeat radiographs were not required in any patient with a negative MRI. Overall, 33 of the 57 examinations were negative on MRI. Thus 58 % of the study population avoided having repeat films and unnecessary immobilisation. Of those patients discharged, none has represented after 5–10 months' follow-up.

Reviewing the plain radiographs of the 33 patients with negative MRI showed that 6 (18 %) had an equivocal X-ray report in which a scaphoid fracture could not be excluded. Conversely, in those patients with positive MRI, 75 % of the original X-ray reports indicated that a fracture was not seen. Our study confirms that plain radiographs are a poor discriminator of scaphoid injuries. In 24 cases (42 %), an abnormal finding was demonstrated on MRI, and the patient then had the appropriate management instigated.

In our study, three patients who had a scaphoid fracture diagnosed on the initial plain radiographs had this confirmed on MRI. The features on MRI did not alter patient management, and our current policy is that if a fracture is radiologically certain, there is no need to perform MRI.

We recommend that the diagnostic work-up of scaphoid injuries becomes a simple two-stage procedure. When the history and examination suggest a scaphoid injury, the patient should have plain radiographs with four views of the scaphoid (in ulnar deviation). If no fracture is observed and the clinical suspicion of a fracture persists, the patient should be referred for MRI at the earliest available opportunity. If MRI is not readily available, clinical review at 2 weeks and possible repeat radiographs are performed as is currently widely practised. If these repeat radiographs are still normal and clinical suspicion persists, then MRI is advocated.

The use of bone scintigraphy or CT scanning could possibly replace MRI as the next investigation. In some institutions these modalities are more readily available. They both involve ionising radiation in the growing child, which is considerable with bone scintigraphy. Additionally, CT can show fractures [14], but it has not been evaluated in the acute situation and its negative predictive value is not known [7]. We would therefore recommend that MR imaging become the definitive investigation in the acute situation. At clinical follow-up, the diagnosis of a scaphoid injury will have been confirmed or refuted by MRI. Appropriate therapy can thus be initiated with confidence. In particular, those patients with negative MRI can be confidently mobilised early. We believe that, if available, this technique will significantly alter patient management in over 50 % of cases. The use of MRI will reduce the number of unnecessary radiographs taken and avoid the patient being unnecessarily immobilised by a cast. Early immobilisation in children allows resumption of normal activities such as playing, schoolwork and sports. There is also less demand on the time and help of the parents and carers. MRI is more costly than plain radiographs and slightly more time consuming, but if the examination is performed promptly, then the number of patients that need to be reviewed and followed up in busy orthopaedic clinics and radiology departments will be significantly reduced. Overall patient care will be improved.

References

1. Greene MH, Hadied AM, LaMont RL (1984) Scaphoid fractures in children. J Hand Surg Am 9: 536–541
2. Vahvanen V, Westerlund M (1980) Fracture of the carpal scaphoid in children. A clinical and roentgenological study of 108 cases. Acta Orthop Scand 51: 909–913
3. Curtis DJ, Downey EF Jr, Brower AC, et al (1984) Importance of soft-tissue evaluation in hand and wrist trauma: statistical evaluation. AJR 142: 781–788
4. Staniforth P (1991) Scaphoid fractures and wrist pain – time for new thinking. Injury 22: 435–436
5. Leslie IJ, Dickson RA (1981) The fractured carpal scaphoid: natural history and factors influencing outcome. J Bone Joint Surg Br 63: 225–230
6. Southcott R, Rosman MA (1977) Non-union of carpal scaphoid fractures in children. J Bone Joint Surg Br 59: 20–23
7. Breitenseher MJ, Metz VM, Gilula LA, et al (1997) Radiographically occult scaphoid fractures: value of MR imaging in detection. Radiology 203: 245–250
8. Munk PL, Lee MJ, Logan PM, et al (1997) Scaphoid bone waist fractures, acute and chronic: imaging with different techniques. AJR 168: 779–786
9. Hunter JC, Escobedo EM, Wilson AJ, et al (1997) MR imaging of clinically suspected scaphoid fractures. AJR 168: 1287–1293
10. Fowler C, Sullivan B, Williams LA, et al (1998) A comparison of bone scintigraphy and MRI in the early diagnosis of the occult scaphoid waist fracture. Skeletal Radiol 27: 683–687
11. Cook PA, Yu JS, Wiand W, et al (1997) Suspected scaphoid fractures in skeletally immature patients: application of MRI. J Comput Assist Tomogr 21: 511–515
12. Tiel-van Buul MM, van Beek EJ (1998) Value of MR imaging in the detection of occult scaphoid fractures. Radiology 206: 291–292
13. Van Gelderen W, Gale RS, Steward AH (1998) Short Tau inversion recovery magnetic imaging in occult scaphoid injuries: effect on management. Australas Radiol 42: 20–24
14. Hindman BW, Kulik WJ, Lee G, et al (1989) Occult fractures of the carpals and metacarpals: demonstration by CT. AJR 153: 529–532