Percutaneous Fixation And Bone Grafting Of Paediatrics Scaphoid Non-Unions

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Abstract

Objectives: Paediatric non-unions of scaphoid fractures are rare. We report a minimally invasive percutaneous technique with bone graft, which results in satisfactory union of the scaphoid fracture with minimal morbidity.

Material and methods: Four patients, all boys with a mean age of 14.6 years presented with symptomatic un-united B2 fractures through the waist of the scaphoid due to trauma. Preoperative radiographs confirmed the presence of scaphoid non-union and the pattern and extent of the non-unions were evaluated on CT scan. All fractures were fixed with a minimally invasive percutaneous technique involving supplementary use of autologous bone graft harvested from the ipsilateral iliac crest and Acutrak screws.

Results: The average operating time was 30 minutes. There were no intraoperative or postoperative complications. The wrist was immobilised in a splint after the operation for two weeks during which time gradual rehabilitation was started. All fractures healed clinically and radiologically at 10 weeks postoperatively. Range of movement, grip strength and functional scores were excellent at the 3 months review. There have been no cases of avascular necrosis or reoperation.

Conclusion: Percutaneous fixation and autogenous bone grafting of paediatric scaphoid non-unions is a novel technique with excellent results and minimal morbidity. We recommend this technique as an alternative to standard volar (Russe) bone graft in cases of scaphoid non-union in children.

INTRODUCTION

Scaphoid fractures constitute a rare entity in the paediatric population, accounting only for 0.4% of all paediatric fractures (1,2). The majority of those fractures involve the distal pole of the scaphoid which are treated conservatively by cast immobilization with excellent results (3). However, non-union of fractures of the scaphoid waist can occur with overall incidence of non-union being approximately 0.8% (4). Once non-union is established, many different treatment options have been advised: long-term cast immobilization, bone grafting without osteosynthesis, bone grafting with K-wire or Herbert screw fixation and percutaneous screw fixation without bone grafting (1,5-19).We report a novel, minimally invasive percutaneous technique using Acutrak screw with supplementary percutaneous autogenous bone grafting which results in satisfactory union of the fracture.

METHODS

Four children with a mean age of 14.6 years sustained injury to the wrist by a fall on the outstretched hand during sport activities. Radiographs showed evidence of fracture of the waist of the scaphoid with open growth plates. The fractures were initially managed conservatively with immobilisation in a scaphoid cast. All patients were followed up with regular appointments for clinical and radiological evaluation. Six to nine months after the initial injury, there was no evidence of union of the scaphoid fractures in all 4 cases. CT scan was performed in all patients confirming the presence of scaphoid non-union and the pattern and the extent of the injury (Fig. 1). The four fractures were classified as un-united B2 fractures through the waist of the scaphoid. The mean time from injury to surgery was 7.5 (range, 6.0-9.0) months.

Figure 1

Evidence of non-union 7 months after the initial injury – a) Plain A-P radiograph, b) CT image

Fig. 1a Fig. 1b

Operative technique

The fractures were fixed with a minimally invasive percutaneous technique with supplementary percutaneous autogenous bone grafting. The scaphoid is prepared to take the appropriate Acutrak screw in a standard way using either a dorsal or volar approach as described by Goddard et al (20). The fracture is reduced if necessary and the guide wire is passed across the scaphoid down its central axis. Proper position is checked on AP, lateral and oblique views. The scaphoid is then drilled to 2mm of its distal cortex. The appropriate length of the screw to be used is measured, ensuring that this is 2-4mm less than the prepared drill hole so as to make certain that the screw is buried in the bone. The drill is then removed and the guide wire is left in situ.

A small stab incision is then made over the ipsilateral iliac crest and cancellous bone is harvested using a proprietary bone marrow biopsy needle. Usually four or five passes of the bone marrow needle are sufficient to acquire sufficient bone graft.

We have been using an 8 gauge contoured Jamshidi bone marrow biopsy/aspiration needle (Allegiance healthcare) which will take 2.5mm diameter cores of cancellous bone (Fig. 2). This needle has the particular advantage that it has 3.4-4.2mm taper over the leading 15mm, which, purely by chance corresponds to the dimensions of the standard Acutrak screw. In addition, the opening of the needle is expanded into a 4mm, which facilitates insertion and impaction of the graft.

The bone marrow biopsy needle is used as a delivery conduit for the graft. The needle is passed over the guide wire down to the fracture site under image intensifier control. Once the position has been confirmed, the guide wire is withdrawn. We introduced the cancellous bone pellets down the bone marrow needle (Fig 3). The bone pellets are inserted into the open end of the bone marrow needle and are gently advanced across the fracture using the expelling probe. The extent and position of the graft are verified on the image intensifier. After inserting two such pellets the guide wire is replaced and the bone marrow needle is then slowly withdrawn. The drill is then used to compress the graft by employing a "reverse reaming" technique. If necessary one or two more pellets can be inserted but in practice we have found that in total two to three are usually sufficient.

Once adequate bone graft has been introduced it is essential to ensure that the prepared drill hole has been adequately reamed since insertion of the screw into an un-prepared graft risks separating the scaphoid or potentially exploding the outer cortex of the bone. The appropriate Acutrak screw is then inserted over the guide wire, so rigidly fixing the scaphoid.

Post-operatively a lightweight protective orthoplast splint is applied for 2 weeks during which time the patient can begin gentle supervised mobilisation and strengthening exercises.

Figure 2

a) The proprietary bone marrow biopsy needle used for harvesting of the graft, b) the bone marrow iliac crest graft.

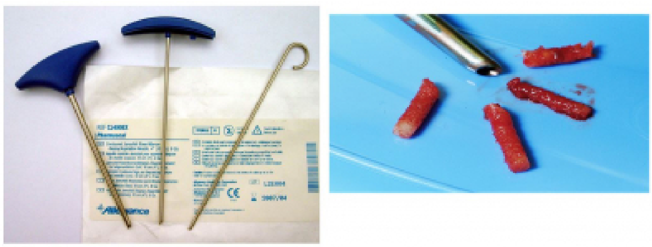

Fig. 2a Fig. 2b

Figure 3

a) Insertion of the bone biopsy marrow needle through the predrilled hole in the scaphoid, b) Using the biopsy needle as a delivery conduit for the passage of the graft.

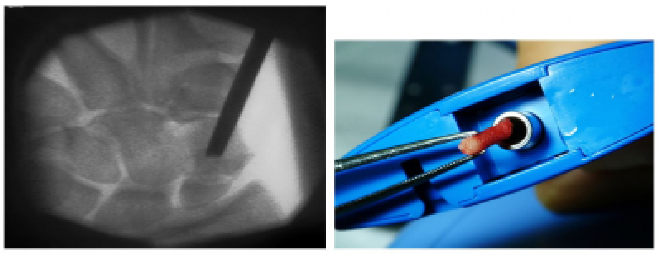

Fig. 3a Fig. 3b

RESULTS

The average operating time was 30 minutes. All four procedures were performed with the use of Tourniquet. No intraoperative complications were noted. All operations were performed as day cases. All four patients were re-examined at 2 weeks, 6 weeks and three months follow-up appointments.

We assessed the clinical outcome including pain at the anatomical snuffbox, at its proximal pole and over the scaphoid tubercle, subjective satisfaction, subjective function, return to sports, and range of movement, power grip and pinch grip (31). All achieved full flexion, extension and ulnar deviation in 3 months, and radial deviation was equal to the contralateral side after 3 months. All achieved mean power grip of 95% of the contralateral hand at 3 months and 100% at 6 months. Pinch grip rapidly returned to normal and the mean value was equal to the contralateral side at 6 months.

Radiological union was defined as cross trabeculation on all four standard views although the limitations of plain radiography in the assessment of scaphoid fractures are well recognised (20) (Fig 4). The screw was in a central position within the scaphoid as seen on follow-up radiographs. The fracture was bridged by the screw, and no migration or loosening was observed. Fracture union was seen at 10 weeks. There have been no cases of avascular necrosis or re-operation thus far, and the screw has not been removed.

Figure 4

Oblique radiograph of the wrist showing evidence of healing 3 months postoperatively.

DISCUSSION

Scaphoid fractures are uncommon in the paediatric population, constituting only 0.4% of all paediatric fractures (1,2). Maxted has attributed that to the fact that the paediatric scaphoid has a greater percentage of cartilage than the adult scaphoid which in relation to the cartilaginous architecture of the paediatric wrist offer superior resistance to the applied forces making them more resistant to injury and rendering the distal radius more vulnerable to fracture (13). Furthermore, the incidence of non-union is as low as 0.8%, merely due to delayed or failed diagnosis (4,7).

The company of bone grafting and internal fixation in unstable scaphoid non-union mingles the biologic properties of corticocancellous bone graft and the mechanical advantages of a compression screw (21). Iliac crest bone grafting facilitates bone healing and helps to correct bone loss or deformity, whereas compression screw fixation averts carpal collapse and provides adequate stability to allow early mobilization (14).

Despite the rarity of its prevalence, scaphoid fracture is the most common site of carpal fracture in children (22). Once the diagnosis of non-union is established and the extent as well as the pattern of the injury is clarified with the use of CT, surgical management is usually the preferred option (5). It was not until recently when Weber proposed conservative management of scaphoid non-unions in children based on their superior healing potential compared to adults, that conservative management has emerged as an alternative to surgical options. Prolonged immobilization in a cast can lead to eventual healing of the fracture as shown by the union achieved in 6 patients after a mean period of immobilization of 5.3 months (3-7). They all achieved excellent Modified wrist scores and managed to regain full range of motion since stiffness and osteoporosis are not an issue in the case of paediatric patients (23).

There have been reported several different methods of fixation in the literature. All of them have achieved successful results establishing operative management of these fractures as a recognized treatment modality. Autogenous bone grafting from the distal radius or the iliac crest, based on the technique described by Russe and Dooley, was used by Southcott in 1977 to treat a series of eight paediatric scaphoid non-unions through the anterior approach (24, 25, 17). Maxted has proposed the addition of Kirschner wires to augment the stability of the fixation until complete union is achieved and this technique was adopted in other series (13, 5, 11, 26). The use of a screw, AO initially and Herbert screw later on, with bone graft was another alternative that showed promising results in terms of healing and functional outcome (13, 11, 27). A dilemma emerged since the large size of the AO screw despite the advanced stability that it provided, could interfere with the normal growth of the scaphoid. Mintzer suggested that the smaller dimensions of the Herbert screw (14, 28, 29) are more suitable for the small paediatric scaphoid and can provide rigid internal fixation without the danger of growth disturbances. An alternative approach involved the use of a vascularized periosteal patch onlay graft for management of non-unions of the proximal pole of the scaphoid (30).

The peak incidence of scaphoid fracture in children is between the ages of 12 to 15 years of age which correlates well with the mean age of 14.6 years of our sample (31). The ossific centre usually appears by five to six years of age and full ossification is complete by the age of 13 to 15 (8).

The clinical and radiological union which was achieved at 3 months postoperatively in our study, is comparable to that reported by Chloros in his series of 12 paediatric scaphoid non-unions treated with open reduction and internal fixation using a Herbert screw (32). CT had a crucial role in establishing the diagnosis as well as defining the extent and the specific pattern of each fracture. The main advantage of our technique is the minimal invasive approach with reaming of the fracture over the guidewire without the need for open reduction, therefore avoiding to disturb the fracture environment. The patient is immobilised in a splint and active gentle physiotherapy can commence, avoiding the sequelae of long term immobilization including the need for physiotherapy to address the residual stiffness as well as the abstinence from sport activities.

The scaphoid percutenous fixation reduces the time to union. Jeon et al (33) described the average union time was shorter in percutaneous screw fixation group (nine weeks) than open procedure group (11.5 weeks).

CONCLUSION

Scaphoid non-union in children is a rare condition. Percutaneous fixation and autogenous bone grafting of paediatric scaphoid non-unions is a novel technique with excellent results and minimal morbidity. We recommend this technique as an alternative to standard volar (Russe) bone graft in cases of scaphoid non-union in children even in the presence a hump-back deformity.

References

1. Christodoulou AG, Colton CL. Scaphoid fractures in children. J Pediatr Orthop 1986;6:37-9.
2. Wulff RN, Schmidt TL. Carpal fractures in children. J Pediatr Orthop 1998;18:462-465.
3. Vahvanen V, Westerlund M. Fracture of the carpal scaphoid in children: aclinical and roentgenological study of 108 cases. Acta Orthop Scand 1980;51:909-913.
4. Fabre O, De Boeck H, Haentjens P. Fractures and nonunions of the carpal scaphoid in children. Acta Orthop Belg 2001;67:121-125.
5. Onuba O, Ireland J. Two cases of non-union of fractures of the scaphoid in children. Injury 1983;15:109-12.
6. Caputo AE, Watson HK, Nissen C. Scaphoid non-union in a child: a case report. J Hand Surg 1995;20A:243-245.
7. D'arienzo M. Scaphoid fractures in children. J Hand Surg 2002;27B:424-426.
8. Goddard N. Carpal fractures in children. Clinical Orthop Rel Res 2005;432:73-76.
9. Duteille F, Dautel G. Non-union fractures of the scaphoid and carpal bones in children: surgical treatment. J Pediatr Orthop B 2004;13:34-8.
10. Garcia-Mata S. Carpal scaphoid fracture non-union in children. J Pediatr Orthop 2002;22:448-51.
11. Henderson B, Letts M. Operative management of pediatric scaphoid fracture non-union. J Pediatr Orthop 2003;23:402-46.
12. Littlefield WG, Friedman RL, Urbaniak JR. Bilateral non-union of the carpal scaphoid in a child. A case report. J Bone Joint Surg 1995;77A:14-126.
13. Maxted MJ, Owen R. Two cases of non-union of carpal scaphoid fractures in children. Injury 1982;13:441-443.
14. Mintzer CM, Waters PM, Simmons BP. Nonunion of the scaphoid in children treated by Herbert screw fixation and bone grafting. A report of five cases. J Bone Joint Surg 1995;77(1):98-100.
15. Mintzer CM, Waters PM. Surgical treatment of pediatric scaphoid fracture nonunions. J Pediatr Orthop

1999;19:236-239.
16. Pick RY, Segal D. Carpal scaphoid fracture and non-union in an eight year old child. J Bone Joint Surg 1977;65A:1188-1189.
17. Southcott R, Rosman MA. Non-union of carpal scaphoid fractures in children. J Bone Joint Surg 1977;59B:20-23.
18. Greene MH, Hadied AM, LaMont RL. Scaphoid fractures in children. J Hand Surg 1984;9:536-41.
19. Larson B, Light TR, Ogden JA. Fracture and ischemic necrosis of the immature scaphoid. J Hand Surg [Am] 1987;12:122-7.
20. Haddad FS, Goddard NJ. Acute Percutaneous Scaphoid Fixation: A Pilot Study J Bone Joint Surg (Br), 1998: 80B: 95-9.
21. Masquijo JJ, Willis BR. Scaphoid Nonunions in Children and Adolescents. Surgical Treatment with Bone Grafting and Internal Fixation. J Pediatr Orthop 2010;30:119–124.
22. Waters PM. Operative carpal and hand injuries in children. J Bone Joint Surg [Am] 2007;89-A:2064-74.
23. Weber DM, Fricker R, Ramseier LE. Conservative treatment of scaphoid non-union in children and adolescents. J Bone Joint Surg Br. 2009;91:1213-1216.
24. Russe O. Fracture of the carpal navicular: diagnosis, non-operative treatment and operative treatment. J Bone Joint Surg [Am] 1960;42-A:759-68.
25. Dooley BJ. Inlay bone grafting for non-union of the scaphoid bone by the anterior approach. J Bone Joint Surg [Br] 1968;50-B:102-9.
26. Reigstad O, Thorkildsen R, Grimsgaard C, Reigstad A, Rokkum M. Excellent results after bone grafting and K-wire fixation for scaphoid non-union surgery in skeletally immature patients: a midterm follow-up study of 11 adolescents after 6.9 years. J Orthop Trauma 2013;27: 285-89.
27. McQueen MM, Gelbke MK, Wakefield A, Will EM, Gaebler C. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomised study. J Bone Joint Surg (Br) 2008;90-B:66-71.
28. Herbert TJ, Fisher WE. Management of the fractured scaphoid using a new bone screw. J Bone Joint Surg [Br] 1984;66-B:114-23.
29. Filan SL, Herbert TJ. Herbert screw fixation of scaphoid fractures. J Bone Joint Surg [Br] 1996;78-B:519-29.
30. Thompson NW, Kapoor A, Thomas J, Hayton MJ. The use of a vascularised periosteal patch onlay graft in the management of non-union of the proximal scaphoid. J Bone Joint Surg [Br] 2008;90-B: 1597-601.
31. Toh S, Miura H, Arai K, et al. Scaphoid fractures in children; problems and treatment. J Pediatr Orthop 2003;23:216-21.
32. Chloros GD, Themistocleous GS, Wiesler ER, et al. Pediatric scaphoid non-union. J Hand Surg [Am] 2007;32:172-76.
33. Jeon IH, Kochhar H, Micic ID, Oh SH, Kim SY, Kim PT. Clinical result of operative treatment for scaphoid non-union in the skeletally immature: percutaneous versus open procedure. Hand Surg. 2008;13(1):11-6.

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