Percutaneous fixation of selected scaphoid fractures by dorsal approach

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Abstract The aim of our study was to evaluate clinical, radiological and functional outcomes of selected cases of percutaneous fixation of scaphoid fractures via a dorsal approach. Percutaneous fixation by dorsal approach was done in 32 patients (mean age 32.2 years) involving both fresh and late scaphoid fracture presentations (mean 17 days). Fourteen cases of B1 type, ten cases of B2 and eight cases of C type (Herbert's classification) were treated. The patients were prospectively followed up clinically and radiologically for a minimum follow-up of 14 months (mean 16 months), and functional outcome and complications were assessed. All fractures united over an average of nine weeks. There was no avascular necrosis or screw cutout with preservation of wrist

movement and grip strength. There were no injuries to any at risk anatomical structures. Percutaneous fixation of scaphoid fractures through dorsal approach gives good clinical and functional outcome in acute and chronic scaphoid fractures of B1, B2 and C types (Herbert's classification).

Introduction

Scaphoid fractures commonly occur in a young, working population with an average age of 25 years with an incidence of 23–43 per 100,000 persons per year [1, 2]. Scaphoid fractures can go on to nonunion which can cause significant morbidity in terms of time off work and activities if not treated adequately [3, 4]. Non-displaced (<1 mm displacement), stable fractures of the distal and middle third of the scaphoid can be treated conservatively. However, recently prospective randomised studies comparing acute fixation to closed (cast) treatment of stable fracture have shown that patients with surgically fixed fractures have a faster rate of healing and earlier return to work. Hence there has been a trend towards surgical fixation of these fractures.

Open repair of scaphoid fractures is associated with stiffness and painful hypertrophic scars [5, 6]. Therefore, many authors have tried to find out whether percutaneous fixation of these fractures is effective. Percutaneous fixation of scaphoid fractures with headed cannulated screws was first performed in Germany by Streli [7], beginning in 1962, as modification of the technique of open reduction with solid bone screws of McLaughlin [8].

Both palmar and dorsal approaches can be used for fixation of scaphoid fractures. However, there has been

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controversy regarding the best approach for these fractures and many studies have been carried out to find out which one is the best [9–11]. We felt that the dorsal approach is very useful in fixation of body and waist fractures of the scaphoid as securing a purchase with the screw in the distal third of the scaphoid in more distal fractures is difficult with this approach. We therefore postulated that dorsal approach percutaneous fixation of body and waist fractures of the scaphoid (B1, B2 and C types of Herbert's classification) [12] could give a good clinical outcome.

The aim of our study was to evaluate prospectively radiological and functional outcome of percutaneous fixation of scaphoid fractures in selected cases (B1, B2 and C types of Herbert's classification) by dorsal the approach.

Materials and methods

Between February 2004 and August 2007, thirty two cases involving both acute ($n=26$) and delayed ($n=6$) presentation (mean 17 days, max 21 days, min 4 days) were treated by percutaneous fixation (via a dorsal approach) with Herbert–Whipple screws and were followed up prospectively for a minimum of 14 months.

The fractures were diagnosed and classified with the help of standard anteroposterior, lateral and semipronated radiographs. Computed tomography (CT) scan was done if fracture assessment was not adequate on radiographs. The fractures were graded according to Herbert's classification [12]. Fourteen cases were B1 type, ten cases were of B2 and eight cases were C type. All patients were managed with percutaneous screw fixation via dorsal approach by hand surgeons.

The study group included 26 male and six female patients with an average age of 32.2 years (range, 20–42 years). Twenty eight right hands (26 dominant) were involved. Fifteen patients were students at the time of surgery. The remaining 17 patients included five manual

workers, eight office workers, and four sportsmen. Almost all patients had sustained their fractures during forced dorsiflexion of the wrist caused by falls.

Surgical technique

Patients were placed in a supine position after either brachial block or general anesthesia. First the dorsal scapholunate joint was marked with the help of gentian violet under fluoroscope (Philips BV 25 Gold). The direction of the screw was marked starting from the scapholunate joint (Fig. 1). Then the wrist was pronated and flexed so that the scaphoid was seen as a circle on fluoroscope (Fig. 1). The centre of the circle was chosen as the landmark for the insertion of the guide wire into the proximal pole of the scaphoid. A small stab incision (3 mm) over the centre of the circle (usually over the scapholunate joint) was made. With a small haemostat the stab was carefully developed until a bony landmark was felt. This is a very useful measure to avoid injury to the extensor tendons and superficial branch of the radial nerve which is one of the major concerns while using this approach. Then the guide wire was driven dorsal to palmar to exit at the radial base of the thumb. The reduction and placement of the guide wire was confirmed under an image intensifier (Fig. 2). A hole was drilled over the guide K-wire. After tapping, a Herbert–Whipple screw was inserted under image intensifier control over the guidewire (Fig. 3). After fixation, the position of the screw was verified using an image intensifier (Fig. 4).

Postoperative management

The wrist was supported in a below elbow plaster of Paris slab for two weeks. Active assisted finger exercises were encouraged immediately after surgery. The slab was removed and wrist exercises were initiated two weeks after the operation. Resisted or weight-bearing exercise was

Fig. 1 **a** Preoperative positioning under image intensifier with scaphoid as a circle. **b** Determination of guide wire direction under fluoroscopy. **c** Marking the direction of wire

Fig. 2 a Opening of capsule. b Drilling of guide wire. c Cannulated drilling over wire

allowed after fracture union was established. Clinical and radiographic assessments were performed at four, eight, and 12 weeks and at the end of follow-up (14 months).

Evaluation

Clinical evaluations were done with regard to the pain scale, range of motion, and grip strength. Functional outcome assessment based on the Mayo wrist scoring system [13] was performed. Plain radiographs of posteroanterior and lateral views were obtained for each case. The axes and angles were measured manually. The long axis of the scaphoid in the posteroanterior was defined as a line between the centre of the distal tuberosity and the most convex point of the proximal pole of the scaphoid, and the long axis of the scaphoid was determined as the palmar outline in the lateral view [11]. The radiological assessment involved finding the relationship between the long axis of the Herbert screw with respect to the long axis of the scaphoid and the fracture line with respect to the long axis of the Herbert–Whipple screw on the posteroanterior (Fig. 5) and lateral (Fig. 6) radiographs. This measurement was done by one author who was not involved in the treatment. Bony healing was assessed radiologically and union was defined as cross-trabeculation on all radiographic

views. Radiographic signs of arthrosis were checked. Range of motion was assessed by goniometer whereas grip strength was assessed by comparing to the normal side.

Results

The mean operating time was 28 minutes (range 12–42) and there were no intraoperative complications. All patients were discharged within 42 hours of admission.

Most subjective pain was reduced by internal fixation of the scaphoid three or four days postoperatively. The outcome measurements of pain, tenderness, range of motion, grip strength, and Mayo wrist score were measured at minimum follow-up of 14 months. Overall, the final range of motion of the wrist averaged 64° (range, 58–74°) of flexion, 60° (range, 52–64°) of extension (Fig. 5), 24° (range, 22–32°) of radial deviation, and 34° (range, 30–38°) of ulnar deviation. According to the Mayo wrist score system [13] the functional results were excellent for 27 patients, good for four patients, and fair for one patient. Fracture union was achieved in all by the time of the visit at 12 weeks. There were no cases of wound infection, reflex sympathetic dystrophy, scar pain or hypertrophy. None of the patients had pain at rest at the time of the first review

Fig. 3 a Confirmation of direction of drill. b Passing screw over guide wire. c Tightening of screw to achieve compression

Fig. 4 **a** Checking the position of screw. **b** Small incision prevents devascularisation of scaphoid

and all were satisfied at three months. Return to work ranged from seven to 36 days depending on the patients' occupation and return to active sports from 46 to 68 days. Most of the delay was due to the wait for radiological evidence of fracture union. Mean power grip was 91% of the contralateral hand at eight weeks, and 100% at twelve weeks. Pinch grip rapidly returned to normal and the mean value was equal to the contralateral side at fourteen months.

Radiographic outcome

Radiographs were taken postoperatively for axis measurements. The mean inclination angle was 84° . Radiographs at the time of the most recent follow-up revealed that all fractures had healed.

The angle between the screw and the scaphoid long axis in two different views was measured. The position of the screw was almost parallel to the long axis of the scaphoid. The average angle between the screw and the scaphoid was 9° in the posteroanterior view and 7° in the lateral view.

Fig. 5 The angle between the long axis of the scaphoid (black solid line) and the Herbert-Whipple screw (red semisolid line) and the angle between the fracture line (blue dotted line) and the Herbert-Whipple screw (red semisolid line) are measured using the standard postoperative posteroanterior radiograph. Note that the screw placement is almost parallel to the axis of the scaphoid and almost perpendicular to the fracture line

The angle between the screw and fracture line in two different views were measured. The screws were positioned almost perpendicular to the fracture lines of the scaphoid. The average angle between the two axes was 82° in the posteroanterior view and 84° in the lateral view.

In all cases the fracture was bridged by the screw, and no migration or loosening was observed. Fracture union was seen at a mean of 64 days (range, 36–78) (Fig. 7). There has been no evidence of avascular necrosis at the latest follow-up, and none of the screws have been removed.

Discussion

In 1970, Streli [7] first advocated use of percutaneous fixation of scaphoid fractures, but it required both improved fluoroscopic imaging for better screw placement and the

Fig. 6 The angle between the long axis of the scaphoid (black solid line [line A parallel to line B]) and the Herbert-Whipple screw (red semisolid line) and the angle between the fracture line (blue dotted line) and the Herbert-Whipple screw (red semisolid line) are measured using the standard postoperative lateral radiograph. Note that the screw placement is almost parallel to the axis of the scaphoid and almost perpendicular to the fracture line

Fig. 7 Preoperative (a) and postoperative (b) radiographs of fracture scaphoid treated by percutaneous dorsal approach with Herbert–Whipple screw

development of a more easily placed screw. Development of the headless compression screw developed by Herbert [14], and later its modification into a headless cannulated screw by Whipple [15] and others [16, 17], made this possible. With the use of a headless compression screw, Whipple [15] added the use of arthroscopy to assist in reduction and developed a cannulated headless screw to allow for percutaneous insertion. During this time the majority of series used the palmar distal approach with successful outcome. Later, Slade et al. [17] expanded on Whipple's concept of arthroscopic assistance with a dorsal, arthroscopy-assisted, percutaneous approach, using the ring sign of the flexed scaphoid to aid in guidewire placement within the centre of the scaphoid, and popularised the dorsal approach.

The palmar approach has achieved much popularity since its evolution because of the excellent clinical outcome documented by various authors [18, 19]. However, recent work by some authors [10, 17] has shown that the dorsal approach provides better targeting and more precise placement of the screw. Therefore, we felt the need to assess the efficacy of this approach for percutaneous fixation of scaphoid fractures. This study is one of the largest series analysing the outcome of percutaneous scaphoid fixation by the dorsal approach.

Herbert and Fisher [14] reported a much higher rate of union for acutely stabilised scaphoid fractures. O'Brien and Herbert [20] reported 97% success in a series of acute scaphoid fractures treated by primary internal fixation. The average period to return to work was 3.7 weeks. Inoue and Shionoya [16] have shown a shorter time to union and an earlier return to manual labour when acute fixation is compared with conservative treatment. Early intervention is also supported by Filan and Herbert's operative findings [21]; in 82 acute fractures they noted that they were often in a worse position than suggested by radiographs and that there was soft-tissue interposition in 28 cases. Our results confirm previous findings that acute fixation of the

scaphoid allows rapid return to full function and activity, including contact sports.

The overall results of recent studies of percutaneous fixation of scaphoid fractures have shown a 100% union rate for surgically fixed fractures from both the palmar and dorsal approach [16, 17, 22]. In our study we also had a 100% union rate. McQueen et al. [23] have recommended that all active patients with scaphoid waist fractures should be offered percutaneous stabilisation. Drac et al. [24] have found that in indicated fracture types, the percutaneous osteosynthesis of a fractured scaphoid provides better functional outcome than conservative treatment.

The importance of screw position in the scaphoid has been emphasised by various authors [10, 11]. The central placement of the screw in the proximal fragment of the scaphoid is associated with excellent clinical outcome. Clinical outcome in terms of range of motion is also associated with the degree of scaphoid alignment achieved by good screw positioning. The near perfect screw positioning in our cases that resulted in excellent functional and radiological outcome emphasises the importance of screw positioning. Chan and McAdams [10] demonstrated that the proximal/dorsal approach to percutaneous screw fixation of scaphoid waist fractures allowed for a more central placement in the distal pole. We also attribute this near accurate screw placement in the scaphoid to the dorsal approach. This is because, in the palmar approach, the guide wire tends to lead the screw to palmar placement in the distal pole.

Complications were also reported related to both methods of fixation [11]. Injury to the superficial branch of the radial artery, delayed union, complex regional pain syndrome, and infection using the palmar approach have been reported in literature [11, 25]. However, there has been controversy about the complication rate in the dorsal approach, with some authors [26] reporting it to be higher than others [27]. In our study we had no complications, thus indicating that the dorsal approach is a safe approach

for percutaneous fixation of scaphoid fractures. The palmar approach may be advantageous in certain cases as it is easy to find the entry because the guide wire does not cross the radiocarpal joint, it is technically less demanding and it is easy to maintain fracture reduction with wrist extension. Further, there is no risk of injuring the extensor tendons. Though Bushnell et al. [26] have suggested that complications in dorsal percutaneous cannulated screw fixation of scaphoid fractures may be more common than previously reported, recently it has been demonstrated by experimental studies that the dorsal approach is more appropriate in terms of screw placement and is associated with no complications [11]. In our study there were no complications, hence it contradicts Bushnell's study.

The anatomy at risk using a percutaneous palmar approach to the scaphoid has been well described [28], but there are very few studies that have mentioned the anatomy at risk with the percutaneous dorsal placement of a scaphoid screw [9]. The structures at risk with the dorsal approach include the extensor pollicis longus tendon, the extensor indicis proprius tendon, the extensor digitorum communis to the index, and the posterior interosseous nerve [9]. Many authors [29] have described placement of the guide wire for the scaphoid screw in a true percutaneous (no incision) manner using fluoroscopy, while others [30] have advocated making a 3-mm incision around the guide wire to accommodate the placement of the screw. In our study, we encountered no damage to these structures. We recommend placement of the guidewire on the bony landmark after making a small stab (3 mm) and avoiding the vital structures with the help of a haemostat.

There were a few limitations to this study. A control group was not included and the results could not be compared with those treated by palmar approach or conservative management. The radiographs did not included a 45 degree pronated view for better assessment of the screw position as recommended recently by Jeon et al. [11]. This study was carried out in a selected type of scaphoid fracture. So this approach may not be suitable for other types of scaphoid fractures.

We suggest that percutaneous fixation of scaphoid fractures by the dorsal approach gives good results in acute and delayed scaphoid fractures of B1, B2 and C types (Herbert's classification).

References

- Hove LM (1999) Epidemiology of scaphoid fractures in Bergen, Norway. *Scand J Plast Reconstr Surg Hand Surg* 33(4):423–426
- Larsen CF, Brondum V, Skov O (1992) Epidemiology of scaphoid fractures in Odense, Denmark. *Acta Orthop Scand* 63(2):216–218
- Huang YC, Liu Y, Chen TH (2008) Long-term results of scaphoid nonunion treated by intercalated bone grafting and Herbert's screw fixation—a study of 49 patients for at least five years. *Int Orthop*. doi:10.1007/s00264-008-0663-3
- Ribak S, Medina CE, Mattar R Jr et al (2009) Treatment of scaphoid nonunion with vascularised and nonvascularised dorsal bone grafting from the distal radius. *Int Orthop*. doi:10.1007/s00264-009-0862-6
- Barton NJ (1996) The Herbert screw for fractures of the scaphoid. *J Bone Joint Surg Br* 78(4):517–518
- Garcia-Elias M, Vall A, Salo JM et al (1988) Carpal alignment after different surgical approaches to the scaphoid: a comparative study. *J Hand Surg [Am]* 13(4):604–612
- Strelis R (1970) Percutaneous screwing of the navicular bone of the hand with a compression drill screw (a new method). *Zentralbl Chir* 95(36):1060–1078
- McLaughlin HL (1954) Fracture of the carpal navicular (scaphoid) bone; some observations based on treatment by open reduction and internal fixation. *J Bone Joint Surg Am* 36-A(4):765–774
- Adamany DC, Mikola EA, Fraser BJ (2008) Percutaneous fixation of the scaphoid through a dorsal approach: an anatomic study. *J Hand Surg [Am]* 33(3):327–331
- Chan KW, McAdams TR (2004) Central screw placement in percutaneous screw scaphoid fixation: a cadaveric comparison of proximal and distal techniques. *J Hand Surg [Am]* 29(1):74–79
- Jeon IH, Micic ID, Oh CW et al (2009) Percutaneous screw fixation for scaphoid fracture: a comparison between the dorsal and the volar approaches. *J Hand Surg Am* 34(2):228–236
- Herbert TJ (1990) *The fractured scaphoid*. Quality Medical Publishing, St. Louis, Missouri
- Amadio PC, Berquist TH, Smith DK et al (1989) Scaphoid malunion. *J Hand Surg Am* 14(4):679–687
- Herbert TJ, Fisher WE (1984) Management of the fractured scaphoid using a new bone screw. *J Bone Joint Surg Br* 66(1):114–123
- Whipple TL (1995) Stabilization of the fractured scaphoid under arthroscopic control. *Orthop Clin North Am* 26(4):749–754
- Inoue G, Shionoya K (1997) Herbert screw fixation by limited access for acute fractures of the scaphoid. *J Bone Joint Surg Br* 79(3):418–421
- Slade JF III, Grauer JN, Mahoney JD (2001) Arthroscopic reduction and percutaneous fixation of scaphoid fractures with a novel dorsal technique. *Orthop Clin North Am* 32(2):247–261
- Ledoux P, Chahidi N, Moermans JP et al (1995) Percutaneous Herbert screw osteosynthesis of the scaphoid bone. *Acta Orthop Belg* 61(1):43–47
- Wozasek GE, Moser KD (1991) Percutaneous screw fixation for fractures of the scaphoid. *J Bone Joint Surg Br* 73(1):138–142
- O'Brien L, Herbert T (1985) Internal fixation of acute scaphoid fractures: a new approach to treatment. *Aust N Z J Surg* 55(4):387–389
- Filan SL, Herbert TJ (1996) Herbert screw fixation of scaphoid fractures. *J Bone Joint Surg Br* 78(4):519–529
- Haddad FS, Goddard NJ (1998) Acute percutaneous scaphoid fixation. A pilot study. *J Bone Joint Surg Br* 80(1):95–99
- McQueen MM, Gelbke MK, Wakefield A et al (2008) Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomised study. *J Bone Joint Surg Br* 90(1):66–71
- Drac P, Manak P, Labonek I et al (2004) Percutaneous osteosynthesis of scaphoid fractures: preliminary results. *Acta Chir Orthop Traumatol Cech* 71(3):165–170
- Bond CD, Shin AY, McBride MT et al (2001) Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. *J Bone Joint Surg Am* 83-A(4):483–488

26. Bushnell BD, McWilliams AD, Messer TM (2007) Complications in dorsal percutaneous cannulated screw fixation of nondisplaced scaphoid waist fractures. *J Hand Surg [Am]* 32:827–833
27. Bedi A, Jebson PJ, Hayden RJ et al (2007) Internal fixation of acute, nondisplaced scaphoid waist fractures via a limited dorsal approach: an assessment of radiographic and functional outcomes. *J Hand Surg Am* 32(3):326–333
28. Kamineni S, Lavy CB (1999) Percutaneous fixation of scaphoid fractures. An anatomical study. *J Hand Surg Br* 24(1):85–88
29. Slade JF III, Gutow AP, Geissler WB (2002) Percutaneous internal fixation of scaphoid fractures via an arthroscopically assisted dorsal approach. *J Bone Joint Surg* 84-A(Suppl 2):21–36
30. Bond CD, Shin CA (2000) Percutaneous cannulated screw fixation of acute scaphoid fractures. *Tech Hand Up Extrem Surg* 4(2):81–87