Comparison of headless screws used in the treatment of proximal nonunion of scaphoid bone

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Abstract Screws with different levels of compression force are available for scaphoid fixation and it is known that the Acutrak screw generates greater compression than the Herbert screw. We retrospectively compared two types of headless compression screw for their effectiveness in the repair of scaphoid nonunion. Twenty-nine cases of proximal scaphoid nonunion were surgically treated with non-vascularised bone graft: the Acutrak screw was used in 17 patients and the cannulated Herbert screw in 12 patients. Wrist range of motion, Mayo wrist score, grip strength and QuickDASH scores were indicators used for the functional evaluation. Radiographic findings were assessed for consolidation of nonunion and signs of arthrosis. The mean follow-up time was 49.2 months (range 12–96). Statistically, there was no significant difference between the Acutrak and Herbert screw types in terms of functional evaluation and time required for consolidation. Greater compression did not influence the functional outcome, consolidation rate or time to consolidation. The need for greater compression in the treatment of proximal scaphoid nonunions is thus questionable because it may increase the risk of proximal fragment comminution.

Introduction

Non-vascularised or vascularised bone grafting, with or without supplementary internal fixation is the current surgical treatment for cases of proximal scaphoid nonunion [21]. Numerous methods of bone grafting [6, 19, 20, 22, 24, 29, 30], healing response manipulation [5, 25] and fixation [2, 9, 14, 15] have been used in the treatment of proximal scaphoid nonunion. Screw fixation with grafting has better results (94% union) than K-wire fixation and grafting (77% union) [23]. Screws with a variety of compression forces are available for scaphoid fixation and each type of screw has specific biomechanical and structural properties. Acutrak or cannulated Herbert screws are commonly used and most biomechanical studies suggest that the Acutrak screw generates greater compression than the Herbert screw [4, 13, 18, 28]. Another biomechanical study states that the cannulated Herbert screw produces almost the same amount of compression as the Acutrak screw [1]. Although there are multiple studies offering a biomechanical comparison, there is a scarcity of clinical comparative studies. The purpose of this study was to compare screw types, namely, the Acutrak and Herbert screw, for functional outcome, consolidation rate and time to consolidation in the treatment of proximal scaphoid nonunion.

Patients and methods

Between 2001 and 2008 we operated on 43 patients in our hospital for proximal scaphoid nonunion. Cases that presented with avascular proximal pole requiring vascularised bone grafting [8, 30], or those that had already undergone surgery, or those with incomplete data or follow-up were excluded from the study. Cases with

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advanced collapse of scaphoid nonunion were also excluded [27] and the remaining 29 patients formed the study group. Patients were classified according to Mayo classification of scaphoid nonunions and all nonunions were type 5B (displaced proximal pole) [11]. Power analysis with an effect size of 3, α error probability of 0.05 and power 0.8 indicated a sample size of 12 in each group. Availability and costs were determining factors for the surgeon at the time of screw type selection. Seventeen patients were treated with the Acutrak screw (Acumed, Beaverton, US) (Fig. 1). There were 16 males and one female in the group with a mean age of 26.7 (range 17–38). The mean follow-up time for this group was 36 months (range 12–75 months). Twelve male patients were treated with the cannulated Herbert screw (Zimmer, Warsaw, US) with a mean age of 32 years (range 16–43). The mean follow-up time in this group was 70 months (range 12–96 months). The mean nonunion time was 17 months (range 6–96 months) in the Acutrak screw group and 15 months (range 6–60 months) in the Herbert screw group. Vascularity of the proximal pole was evaluated by a magnetic resonance (MRI) scan preoperatively and confirmed by intraoperative punctate bleeding observed in all patients [16, 21].

Surgical technique

All surgery was carried out through a dorsoradial longitudinal incision. The extensor pollicis longus tendon was moved aside and dorsal capsulotomy was performed. The nonunion site was prepared and fibrous tissue was removed. Fractured ends were neatened and an egg-shell

Fig. 1 Radiograph demonstrating a proximal nonunion of scaphoid bone treated with the Acutrak screw

cavity was produced with a curette. The cavity was filled and impacted with cancellous grafts. The iliac crest was used in 12 patients and the distal radius metaphysis was used in five patients as a graft source for the Acutrak screw group. The cancellous graft was harvested from the iliac crest in ten patients and the distal radial metaphysis in two patients for the Herbert screw group. There was no need to lengthen the scaphoid for humpback deformity. After the application of the graft, the fragment was reduced and stabilised with either a cannulated Herbert screw or a mini Acutrak screw. Stiloidectomy was also performed for one patient in both groups because of radioscapoid degeneration.

All wrists were immobilised in a scaphoid cast for four to six weeks postoperatively. Finger exercises were started the day after surgery. Rehabilitation was performed, after removal of the cast with protecting splint, for variable periods depending on the radiological appearance of the operation site.

The Mayo wrist score [10], wrist range of motion into extension, flexion, radial and ulnar deviation measured by goniometer, grip strength measured by dynamometer (Jamar, Preston, US) and QuickDASH scores were measures used for functional assessment. Posteroanterior, lateral and ulnar deviation X-rays were used to assess the consolidation. Consolidation was accepted when there was disappearance of the nonunion line, evidence of bone trabeculae crossing the nonunion line, absence of the gap at the fracture site, absence of the lucency around the implant and no signs of internal fixation failure [7, 12] (Fig. 2). Computed tomography was performed in doubtful cases.

Statistical analysis

Statistical analysis was carried out by a statistician. The material was processed and analysed using NCSS (Number Cruncher Statistical System) 2007 and PASS 2008 Statistical Software (NCSS, Kaysville, Utah, USA) packages. The chi-square test and Mann-Whitney U test were used to evaluate the significance of differences. A difference was considered to be statistically significant when $p < 0.05$.

Results

There was no statistically significant difference between the two groups with respect to ranges of flexion, extension, radial or ulnar deviation ($p > 0.05$). The mean values of wrist ranges of movement for both groups are shown in Table 1. The mean values for Mayo wrist score, end results point range and QuickDASH scores are shown in Table 2. The difference between both groups was not statistically

Fig. 2 The posteroanterior (PA) view showing a proximal nonunion of scaphoid bone treated with cannulated Herbert screw at 12 weeks. There is no gap at the fracture site, no lucency around the implant and no signs of internal fixation failure with the disappearance of the nonunion line and evidence of bone trabeculae crossing the nonunion line. These findings confirm the consolidation of nonunion

significant ($p > 0.05$). Consolidation was achieved in 15 of 17 wrists for the Acutrak screw group with the mean consolidation time being ten weeks (range 6–20 weeks). There were three grade I and two grade II degenerative changes observed in this group. Consolidation was achieved in 11 out of 12 wrists in the Herbert screw group. The mean consolidation time was 10.8 weeks (range 8–12 weeks). There were one grade I and three grade II degenerations in this group [27]. There was no statistical difference with respect to mean consolidation period between the two groups ($p = 0.256$). Average time lapse from injury to surgery was 17.5 months (range 6–96 months) in the Acutrak screw group and 15.5 months (range 6–60 months) in the Herbert screw group; therefore, there was no statistically significant difference ($p = 0.271$). Two cases in the Acutrak screw group showed persistence gap at the fracture site and one of them showed radio-

graphic signs of avascular necrosis three months after surgery. Four corner fusions were performed for the patient with avascular necrosis five months following the previous surgery. For the other patient with persistent gap, the vascular proximal pole was assessed with an MRI scan. The patient was treated with revision bone grafting (non-vascularised bone graft and Acutrak screw fixation) four months after the previous surgery and consolidation was finally achieved 20 weeks after that revision. One patient in the Herbert screw group had persistence gap at the fracture site three months after surgery. Revision bone grafting with Acutrak screw fixation was performed and consolidation was achieved ten weeks after the revision.

Discussion

Despite many reports in the literature, treatment of scaphoid nonunion has remained controversial. Screw fixation provides more successful union rates than K-wire fixation but which of the screw types provides better compression remains debatable [1, 4, 13, 18, 28]. Most previous studies suggest that the Acutrak screw generates greater compression; these studies have usually been performed on saw bone or cancellous bone simulations from foam or frozen human cadaveric bone models and their value for illuminating the problem of scaphoid proximal pole nonunion remains doubtful. Another area of debate is the optimal compression required to promote union [4, 17]. As a general rule, high compression load promotes fracture union and so compression is an important biomechanical factor in accelerated fracture healing [3, 26]. However, the distinction between treating scaphoid proximal pole nonunion and fresh fracture should be considered in relation to compressive screw insertion. In cases of vascularly compromised and longstanding nonunions, bone fragments may have become thin, weak and resorbed and therefore unable to resist compressive forces. Small proximal fragments may not possess adequate bone stock to carry a screw and compression may actually split the proximal fragment because of bone weakness (Fig. 3).

Our study shows that there is no significant difference between the Acutrak and cannulated Herbert screws with respect to functional outcome, consolidation rate and time

Table 1 The mean values of wrist ranges of movement for both groups measured by the Mann Whitney U test

Measurement	Acutrak group ($n = 17$)	Herbert group ($n = 12$)	p
Flexion	70.0 (9.3)	69.1 (9)	0.778
Extension	68.2 (10)	69.1 (9)	0.829
Ulnar deviation	33.5 (6)	34.1 (5)	0.845
Radial deviation	22.6 (5)	24.5 (5)	0.380

First values are degree, second values are standard deviation

Table 2 The mean values for Mayo wrist scores, end results point range and QuickDASH scores

Measurement	Acutrak group (<i>n</i> = 17) <i>n</i> (%)	Herbert Group (<i>n</i> = 12) <i>n</i> (%)	<i>p</i>
Mayo wrist scores			
Satisfactory	4 (23.5%)	4 (33.3%)	0.804
Good	4 (23.5%)	3 (25%)	
Excellent	9 (52.9%)	5 (41.7%)	
Mayo wrist score	86.4 (9)	86.67 (10)	0.964
QuickDASH score	3 (4)	2.65 (2.7)	0.925

Measured with the chi-square and Mann-Whitney-U tests

Values in the last two rows are *n* and (SD)

to consolidation in the treatment of proximal scaphoid nonunion. Complications were also similar. It seems that difference in compressive force between these screws does not influence the outcome. Apart from selection of the screw type, bone grafting and rigid fixation are required to achieve union. Rigid fixation is one of the primary goals in

the treatment of proximal scaphoid nonunion but the use of compression introduces the risk of fragmentation.

Despite multiple studies presenting a biomechanical comparison, there are few clinical comparative studies. We found one study in the English language literature that addressed the comparison of the two screws in the treatment of scaphoid nonunion [17]. Our results were similar; however, the superiority of our study is that it adopted a uniform procedure.

Our study was designed as a retrospective case analysis and it had certain limitations. For example, due to the fact that patient groups reflected developing treatment modalities in fixation technology, they were not equal with respect to follow-up period. Secondly, the study focuses on a specific type of injury and thus its small sample size does reduce the validity of statistical analysis. However, the inequality of mean follow-up time did not prevent us from making inferences for each group. All patients had proximal pole nonunion that was treated with dorsal capsulotomy, non-vascularised bone grafting and screw fixation. The patient rehabilitation procedure was also similar for both groups. The patient groups were well matched in terms of age, gender, time lapse from injury to surgery, complications and incidence of degenerative changes in the wrist joint.

Conclusion

We found no differences between patients treated with the Acutrak screw or the cannulated Herbert screw in terms of functional outcome, consolidation rate and time to consolidation, despite the difference in compression. In terms of the positive results of bone grafting, it seems that the use of greater compression is not an influencing factor in the achievement of proximal scaphoid union. The view that greater compression is desirable in the treatment of proximal scaphoid nonunion is questionable when we consider the added risk of proximal fragment comminution.

Disclosure All named authors hereby declare that they have no conflicts of interest to disclose.

Fig. 3 **a** The PA view showing a longstanding proximal scaphoid nonunion with small proximal fragment and low bone stock. **b** An arrow points towards the proximal fragment of the same patient. The bone is weak and resorbed. The surgeon should be aware of the risk of fragment comminution in relation to compressive screw insertion

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