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Results of scaphocapitate arthrodesis with lunate excision in advanced Kienböck disease at 10.7-year mean follow-up

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Abstract

Scaphocapitate arthrodesis with lunate excision was performed for treatment of advanced Kienböck disease in 17 patients (18 wrists). Ten were women and seven men. Five were Lichtmann Stage IIIA, 12 Stage IIIB, and one Stage IV. Minimum follow-up period was 24 months; mean follow-up was 10.7 years (range 2.3 to 22 years, SD 7.1). At the latest follow-up, six patients were very satisfied, nine were satisfied and two were disappointed. Pain was significantly decreased in all cases. Wrist mobility was unchanged. Grip strength was significantly increased. Consolidation of the arthrodesis was confirmed in 17 wrists. We encountered a scaphocapitate nonunion at 12 years follow-up and two cases of styloscapoid arthritis at 17 and 22 years. Scaphocapitate arthrodesis with lunate excision performed in an advanced stage of Kienböck disease significantly alleviates pain, while preserving functional mobility and satisfactory grip strength in the long term.

Level of evidence: IV

Keywords

Kienböck disease, wrist pain, partial wrist arthrodesis, lunate excision

Introduction

Kienböck disease is a rare condition, defined as idiopathic avascular necrosis of the lunate. It affects mainly young subjects, and understanding of the pathophysiology is currently incomplete. Full development of the condition results in collapse and disorganization of the carpus, followed by osteoarthritic wrist degeneration. Treatment is difficult, and consensus is lacking. While conservative treatments are indicated in early stages, palliative surgical techniques may be more appropriate at later stages. In the case of lunate collapse or fragmentation, the techniques that have been advocated include wrist denervation, intercarpal arthrodesis, resection of the proximal carpal row or pancarpal arthrodesis (Lichtman and Degnan, 1993). Intercarpal partial arthrodesis is indicated in the context of advanced osteoarthritis in patients wishing to maintain gripping force and functional mobility of the wrist.

Scaphocapitate arthrodesis was proposed by Pisano et al. (1991) for the treatment of Kienböck disease, and the procedure was evaluated biomechanically by Garcia-Elias et al. (1989). His findings indicated a risk of degenerative change in the radio-scaphoid and midcarpal joints, with potential for deterioration in the results over time. However, more recent clinical studies have reported encouraging results (Iorio et al., 2015; Rhee et al., 2015). The hypothesis of this study was that scaphocapitate arthrodesis with lunate excision in advanced-stage Kienböck disease with lunate collapse gives satisfactory and stable results over time. The results

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of a series of patients treated with scaphocapitate arthrodesis for this condition were reviewed, with clinical and radiographic evaluation at a mean follow-up of 10.7 years.

Method

Patients

This was a retrospective study of procedures performed in a university hospital. Patients were informed of the use of their clinical and radiographic data for this study. The inclusion criteria were patients with Kienböck's disease with lunate bone collapse, treated between 1994 and 2007 with lunate excision and scaphocapitate arthrodesis, and reviewed clinically and radiographically at a follow-up of more than 2 years. Exclusion criteria were patients with Kienböck disease without lunate collapse. Patients who could not be reviewed both clinically and radiographically were also excluded.

Preoperative clinical data

Before surgery, all patients were examined and the level of pain was recorded, using a visual analogue scale (VAS) from 0 (no pain) to 10 (extremely severe pain). The duration of symptoms was also recorded, along with the range of wrist motion (flexion, extension, ulnar and radial deviation, pronation and supination) and the grip strength using a JAMAR[®] dynamometer. Grip strength was also measured in the healthy wrist for comparison.

Preoperative radiological data

Preoperative posteroanterior and lateral wrist radiographs were performed in all patients. The stage of development of Kienböck disease according to the Lichtman classification was assessed, and was confirmed by an independent radiologist.

In order to assess the development of scaphoid flexion at follow-up, the radio-scaphoid and scaphocapitate angles were measured on a preoperative lateral radiograph. On a posteroanterior X-ray, the preoperative degree of ulnar variance was assessed using the distal radio-ulnar index (the distance between the adjacent radial and ulnar joint surfaces measured on the perpendicular passing through the distal radio-ulnar joint to the cubital line). The mean carpal height ratio described by Youm et al. (1978) was measured. This is the distance between the distal end of the radius and the base of the third metacarpal, measured on a vertical line passing through the long axis of the latter, divided by the length of the third metacarpal.

Surgical technique

The operation was carried out by open dorsal approach for all patients. A radial and ulnar subcutaneous undermining was performed with section of the superficial articular nerve branches coming from the sensory branches of the radial and the ulnar nerve, thus achieving a partial wrist denervation. The extensor retinaculum was incised between the 3rd and 4th extensor compartment. The denervation was completed by a resection of the terminal branch of the posterior interosseous nerve. After retracting the extensor tendons, an arthrotomy was performed by a T-shape opening of the articular capsule. The articular surfaces of the scaphoid and the radius were inspected in order to check the absence of degenerative change. A lunate excision was then performed, followed by preparation of the articular surfaces between the scaphoid and the capitate using a bone drill.

Correction of scaphoid flexion was performed using a Kirschner (K-)wire inserted into the bone and allowing a 'joystick' effect. The scaphoid was fixed when the radio-scaphoid angle was less than 60°. Then the arthrodesis between scaphoid and capitate was fixed using two K-wires in 11 cases (Figure 1), staples in six cases and two screws in one case (Figure 2). Cancellous bone autograft was added in 11 cases, using as donor site the iliac crest in five cases, distal radius in five cases and resected ulnar head in one case, respectively. In seven cases, no bone graft was used; simple resection of articular cartilage was performed and the bones stabilized in compression, obliterating the intervening gap. In all cases the triquetrum was left in place to avoid ulnar translation of the carpus.

Post-operative care

A hand forearm cast was held in place for a mean of 2.7 months (range 2 to 3 months). Consolidation of the arthrodesis was monitored by posteroanterior and lateral wrist radiographs. Rehabilitation started after cast removal. Kirschner wires were removed 3 to 4 months postoperatively. Staples and screws were not removed.

Postoperative assessment method

All the patients were examined at follow-up by a clinician independent from the case surgeon. Clinical evaluation analysed pain level on a VAS, and joint mobility measured by a goniometer. Grip force was measured by the JAMAR dynamometer. The quick-DASH and PRWE scores were also performed,



Figure 1. Anteroposterior radiographs with arthrodesis fixed by K-wires.



Figure 2. Anteroposterior radiographs with arthrodesis fixed by screws available.

although no scores were available preoperatively. Patient satisfaction was evaluated. Patients were considered to be 'very satisfied' when they resumed all previous activities at the same level without symptoms. They were considered 'satisfied' when functional return to activity was complete but with mild symptoms, 'moderately satisfied' if activity modification was necessary and 'unsatisfied' if full return to activity was not possible due to residual symptoms.

Posteroanterior and lateral wrist radiographs were performed to confirm joint fusion, to measure the radio-scaphoid angle and the scaphocapitate angle, the carpal height ratio, the distal radioulnar index and the occurrence of osteoarthritis.

Statistical analysis

The chi-square test was used for the qualitative variables and the student *t*-test for mean and standard deviation. Differences was considered significant when the *P* value was <0.05.

Results

From 1994 to 2007, 18 wrists were treated with scaphocapitate arthrodesis in 17 patients. There were 10 women and seven men. Mean age at the time of the

intervention was 36 years (range 19 to 56). There were 12 right and six left wrists, with dominant wrist involvement in 11 cases. One patient had a prior history of radial shortening osteotomy. The patients were employed in heavy manual work (carpenter, mason) in seven cases, moderate manual work in three cases and non-manual in six cases. One patient was unemployed. Patients were reviewed postoperatively at a mean follow-up period of 10.7 years, with a minimum of 24 months (range 2.3 to 22 years; SD 7.1).

Overall results

Patients were very satisfied in seven cases, satisfied in nine cases and unsatisfied in two cases. Nine patients complained of stiffness in their wrist, five patients had persistent pain, four patients had significant loss of strength, one patient had no complaints. The mean QuickDASH score was 38.3 (SD 13). The mean PRWE score was 36 (SD 22.4). The mean Mayo score was 72/100 (SD 12.3). Eleven patients were able to resume their employment prior to surgery, four were reclassified and two were retired. The mean duration off-work was 7.7 months (SD 7 months). A complex regional pain syndrome was

observed in two patients, with favourable resolution after 1 year of individualized management.

Preoperative clinical data

Before surgery, all patients reported pain and in seven cases a limitation of joint motion (Table 1). The mean preoperative pain VAS was 4.2 out of 10 (range 3 to 8). The mean duration of symptoms was 30 months (range 4 to 280 months). The mean mobility of the affected wrist measured by the goniometer was 35° in flexion (range 5° to 60°), 40° in extension (range 40° to 60°), 86° in pronation (range 50° to 90°), 86° in supination (range 51° to 90°), 25° in ulnar deviation (range 10° to 40°) and 13° in radial deviation (range 3° to 30°). The mean grip strength of the affected hand measured using a JAMAR® dynamometer was 16.2 kg (SD 8.4 kg), compared with 36.4 kg (SD 15.6 kg) for the healthy wrist. This corresponded to 45% (SD 32.3%) of the grip strength in the healthy wrist (Table 1).

Post-operative clinical outcomes

The mean VAS score for pain decreased from 4.2 (SD 1.35) to 2.4 (SD 2) and this was statistically significant

($p=0.01$) (Table 1). Four patients were completely pain free. Flexion and extension both improved by 5° compared with the preoperative values, without statistical significance ($p>0.05$). There were minor losses in both pronation and supination, without statistical significance. Ulnar deviation was improved by 5° and radial deviation was decreased by 1° compared with the preoperative values, again without significance. Grip strength was significantly improved. The mean was 25.8 kgf (SD 8.4 kgf) at latest follow-up, thus an increase of 9.6 kgf compared with the preoperative strength ($p<0.02$). This represents 74% of healthy wrist strength (25.8 kgf versus 34.6 kgf).

There were two cases of superficial infection requiring K-wire removal at 5 and 6 weeks post operatively.

Radiological findings

According to the Lichtman classification, changes indicating Stage IIIA were present before surgery in five cases, Stage IIIB in 12 cases and Stage IV in one case (Table 2).

Radiographic outcomes are summarized in Table 2. When compared with the preoperative

Table 1. Preoperative and postoperative clinical results.

	Preoperative	Postoperative	<i>p</i> value
Flexion (°)	35 (SD 14; 5°–60°)	40 (SD 14; 20°–70°)	$p>0.05$
Extension (°)	40 (SD 11; 40°–60°)	45 (SD 15; 25°–70°)	$p>0.05$
Pronation (°)	86 (SD 10; 50°–90°)	83 (SD 9; 55°–90°)	$p>0.05$
Supination (°)	86 (SD 10; 51°–90°)	85 (SD 7; 70°–90°)	$p>0.05$
Ulnar tilt (°) 11/18	25 (SD 10; 10°–40°)	30° (SD 6; 20°–40°)	$p>0.05$
Radial tilt (°) 11/18	13 (SD 11; 3°–30°)	12° (SD 3; 6°–20°)	$p>0.05$
Grip strength (kg)	16.2 (SD 8.4; 3–30)	25.8 (SD 8.4; 10–40)	$p<0.02$
Pain (visual analogue scale)	4.2 (SD 1.4; 3–8)	2.4 (SD 2; 0–6)	$p=0.01$
PRWE	—	36 (SD 22; 9–87)	—
Quick DASH	—	38 (SD 13; 18–63)	—
Mayo score	—	72 (SD 12; 55–95)	—

PRWE: patient related wrist evaluation; DASH: disabilities of arm, shoulder and hand.

Table 2. Preoperative and postoperative radiological results.

	Preoperative	Postoperative	<i>p</i> value
Radio-scaphoid angle (°)	61 (SD 15; 20°–80°)	58 (SD 11; 25°–73°)	$p>0.05$
Scapho-capitate angle (°)	75 (SD 13; 37°–90°)	72 (SD 16; 32°–95°)	$p>0.05$
Carpal height ratio	0.48 (SD 0.05; 0.38–0.57)	0.45 (SD 0.04; 0.4–0.54)	$p=0.05$
Distal radio-ulnar index (mm)	–1.8 mm (SD 2.56; 5/+5)	–1.8 mm (SD 1.39; 4/0)	$p>0.05$

lateral radiograph, some correction of scaphoid flexion was observed, with a mean decrease in radioscapoid angle of 3° compared with the preoperative values. The scaphocapitate angle was also reduced by 3° . Neither change was statistically significant (Table 2).

Comparing the distal radio-ulnar index on pre- and postoperative films, the degree of ulnar variance was unchanged; the mean preoperative measurement was -1.8mm (SD 2.6), compared with -1.8mm (SD 1.4) postoperatively. The mean carpal height ratio was slightly reduced; the ratio before surgery was measured at 0.48 (SD 0.05) compared with 0.45 (SD 0.04) at follow-up. This change was statistically significant ($p=0.05$).

Consolidation was achieved in 17 out of 18 cases. One patient presented with a painful and disabling pseudarthrosis at 12 years follow-up, but declined a new intervention (Figure 3). Two patients had stylo-scaphoid arthrosis at 17 years and 22 years of follow-up, respectively (Figure 4). They showed no painful symptomatology, and mobility was preserved, with 80° and 70° mobility in flexion and extension of the wrist.

Discussion

Partial intercarpal arthrodesis is a technique often used in advanced-stage pathologies of the carpus, generally with the aim of maintaining grip force and a certain degree of wrist mobility. In the case of lunate bone collapse, simple excision of the lunate allows a local debridement and synovectomy whose effectiveness is noticeable in the medium term (Allan et al., 2001; Menth-Chiari et al., 1999). However, excision alone promotes further proximal migration of the capitate and thus carpal disorganization. The filling of vacant space by interposition of tendon, silicone or pyrocarbon offered variable results (Allan et al., 2001; Bellemère et al., 2012; Lichtman et al., 1993). Partial wrist fusions prevent this complication and provide functional improvement (Allan et al., 2001). Scaphocapitate arthrodesis appears to arrest the progression of osteoarthritic change; only two of our patients with the longest follow-up presented with asymptomatic, radiographic narrowing between the radial styloid and the scaphoid.

The most frequently used intercarpal arthrodesis in the context of Kienböck disease is the scapho-trapezio-trapezoid arthrodesis, and good results have been described, although consolidation is sometimes difficult to obtain (Voche et al., 1992; Watson et al., 1996). Pisano et al. (1991) used scaphocapitate arthrodesis for the treatment of advanced-stage Kienböck disease for the first time.



Figure 3. Scaphocapitate pseudarthrosis at 12 years follow-up.



Figure 4. Stylo-scaphoid osteoarthritis at 22 years follow-up.

Table 3. Influence of flexion scaphoid correction on clinical and functional outcomes.

	Correction (n = 9)	Without correction (n = 9)	p value
Flexion (°)	46 (SD 15)	35 (SD 13)	p > 0.05
Extension (°)	48 (SD 17)	43 (SD 14)	p > 0.05
QuickDASH	35 (SD 12)	42 (SD 13)	p > 0.05
PWRE	33 (SD 16)	39 (SD 28)	p > 0.05
Mayo score	72.2 (SD 12.2)	71.7 (SD 12.9)	p > 0.05
Grip strength (kg)	26.2 (SD 8.2)	25.3 (SD 11)	p > 0.05
Pain (VAS)	2.2 (SD 1.8)	2.6 (SD 2.2)	p > 0.05
Off-work duration (month)	9.6 (SD 8.5)	5.6 (SD 4.7)	p > 0.5
Preoperative radioscapoid angle (°)	72 (SD 6)	52 (SD 15)	p = 0.01
Post-operative radioscapoid angle (°)	59 (SD 9)	58 (SD 13)	p > 0.05

'Correction' indicates that the radioscapoid angle was reduced by greater than 10° when postoperative and preoperative films were compared. 'No correction' indicates that correction was less than 10°. Measurements are given as mean (standard deviation).

DASH: disabilities of arm, shoulder and hand; PRWE: patient related wrist evaluation; VAS: visual analogic scale.

Douglas et al. observed no difference in mobility between scapho-trapezio-trapezoid, scapholunate and scaphocapitate fusions (Douglas et al., 1987). Sennwald proved its efficacy on 11 patients with Kienböck disease (10 Stage III and one Stage II): at a mean follow-up of 36 months the wrist became totally painless for 10 patients (Sennwald and Ufenast., 1995). Resection of the first row of carpal bones (proximal row carpectomy) is an alternative. The meta-analysis of Chim (Chim and Moran, 2012) found good results in terms of mobility, with 96° flexion/extension (Croog and Stern., 2008; Lumsden et al., 2008) and retained strength at 90% of the power of the healthy side. However, it reported a failure rate of 15%, requiring reintervention by total wrist fusion. The results were better in terms of pain reduction, mobility and strength recovery in partial arthrodesis (Nakamura et al., 1998).

Most authors report the use of a cancellous bone autograft in the operative technique (Iwasaki et al., 1998; Leblebicioğlu et al., 2003; Sennwald and Ufenast., 1995). Non-unions have been observed in each series, but the causation varied. Chantelot et al. (2005) encountered a high incidence of nonunion in scaphocapitate arthrodesis for scapholunate dissociation with advanced collapse (SLAC) wrist despite the routine use of bone graft. They recommended a stable osteosynthesis with compression. In our series, autograft was used in 10 of 18 wrists. All fusions apart from one appeared to consolidate. In this case, iliac bone graft was used and osteosynthesis was performed by one staple. This partial consolidation may relate to the type of osteosynthesis employed.

Secondary scaphoid rotational subluxation is difficult to correct (Ambrose et al., 1992). In this study, the mean correction was 2.7°, with great variability (from

0° to 26°), confirming this impression. However, the degree of correction of scaphoid flexion does not seem to affect clinical outcome greatly. We compared cases in which correction of more than 10° was achieved, with those in which correction was less successful. There was no significant difference in any of the clinical parameters examined (Table 3). Loss of grip strength is frequently reported following an intercarpal fusion. Yet, although decreased during the first postoperative year, we noticed a gradual increase of the grip strength with the passage of time. Twelve out of 18 patients returned to their original employment after surgery. Return to work was possible at an average of 7.7 months (range 0 to 30). Pisano reported that 94% of his patients returned to work, with only one reclassified patient. For Sennwald, 69% of patients returned to work, including two reclassifications (Sennwald and Ufenast., 1995).

In conclusion, this study confirmed our hypothesis concerning the long-term results of scaphocapitate arthrodesis with lunate excision for the treatment of advanced Kienböck's disease. This series has a mean follow-up of 10.7 years, with a maximum follow-up of more than 22 years, superior or comparable with the recent series of Luegmair and Saffar (2014) and Rhee et al. (2015). With 90% satisfied patients, absent or minimal pain, a functional arc of mobility and preserved grip strength, we have found this procedure is a reliable and durable solution in this condition.

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