

Arthroplasty for advanced Kienböck's disease using a radial bone flap with a vascularised wrapping of pronator quadratus

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We have performed a form of lunate replacement arthroplasty, which included excision of the lunate and insertion of a vascularised radial bone flap wrapped in pronator quadratus, for stage IIIB or stage IV Kienböck's disease, in 41 patients who have been followed up for more than three years.

All patients reported an improvement in their symptoms, and 20 of the 41 became free of pain after the operation. Extension and flexion of the wrist were increased by a mean of 9° and 6°, respectively ($p < 0.05$). The radioscapoid angle and the carpal height ratio were not significantly changed and only minimal deterioration was observed due to degenerative change. The size, density or location of the inserted bone did not change with time.

A vascularised radial bone flap wrapped in pronator quadratus can be a reliable treatment option for advanced Kienböck's disease, when the pedicled bone and muscle envelope acts as a stable spacer for the excised lunate.

The natural history of Kienböck's disease is unclear. Most investigations have suggested that avascular necrosis of the lunate leads to carpal collapse and osteoarthritis of the wrist.¹⁻³ Although many forms of treatment have been proposed for patients with symptomatic Kienböck's disease, no consensus has been reached. Surgical options have included unloading procedures, limited intercarpal fusions, revascularisation procedures with implantation of a vascular bundle or a vascularised bone graft and salvage procedures such as excision arthroplasty or proximal row carpectomy.⁴

Since 1982, we have carried out replacement of the lunate in patients with advanced Kienböck's disease, with excision of the lunate and insertion of a vascularised radial bone flap wrapped in pronator quadratus, followed by distraction using an external fixator of the joint.

We present the results of 41 patients who were followed up for more than three years.

Patients and Methods

Between 1982 and 2000, we carried out an arthroplasty using a radial bone flap wrapped in pronator quadratus in 48 hands of 48 patients with advanced Kienböck's disease. We have undertaken a retrospective study using the medical records, radiographs and the evaluation of the patients. Seven patients were lost to follow-up, leaving 41 available for review.

There were 17 men and 24 women, with a mean age at the time of operation of 39 years (19 to 58). There were 26 right and 15 left hands. Six patients described previous trauma. The occupations of the male patients varied from heavy manual labour to sedentary work, while most of the female patients were housewives. The most frequent symptoms were pain and limitation of movement of the wrist. The stage of the disease was determined by plain radiography in accordance with the classification system of Lichtman et al.⁵ There were 13 stage IIIB and 28 stage IV patients. Patients with no remaining radiocarpal joint space on plain radiography were excluded, as we considered them to need a more reliable salvage procedure such as arthrodesis. The mean duration of follow-up was 6.1 years (3 to 22).

Surgical procedure. A zigzag palmar incision was made from the proximal one-third of the palm to the forearm (Fig. 1a). The median nerve and flexor tendons were wrapped in a wet swab and retracted radially to expose the wrist joint. The joint capsule was divided longitudinally and elevated together with the volar carpal ligaments in one layer. The collapsed lunate was separated from the surrounding carpal bones and removed piecemeal, preserving the dorsal capsule and the dorsal intercarpal ligament (Fig. 1b). The nerve and tendons were then retracted towards the ulna to expose the pronator quadratus muscle.

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Fig. 1a



Fig. 1b



Fig. 1c

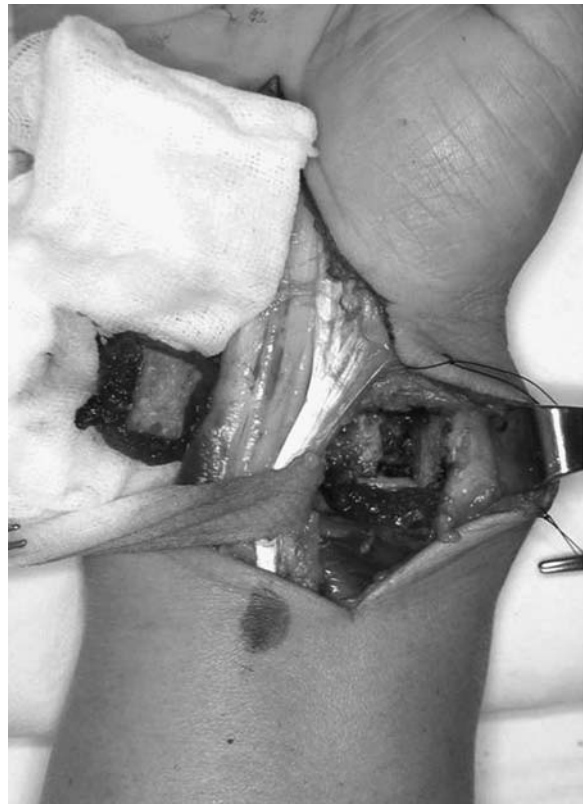


Fig. 1d



Fig. 1e

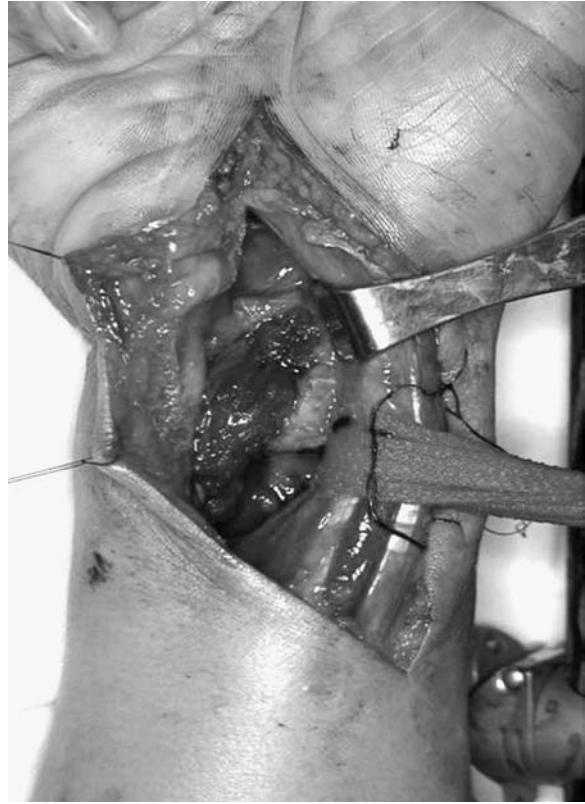


Fig. 1f

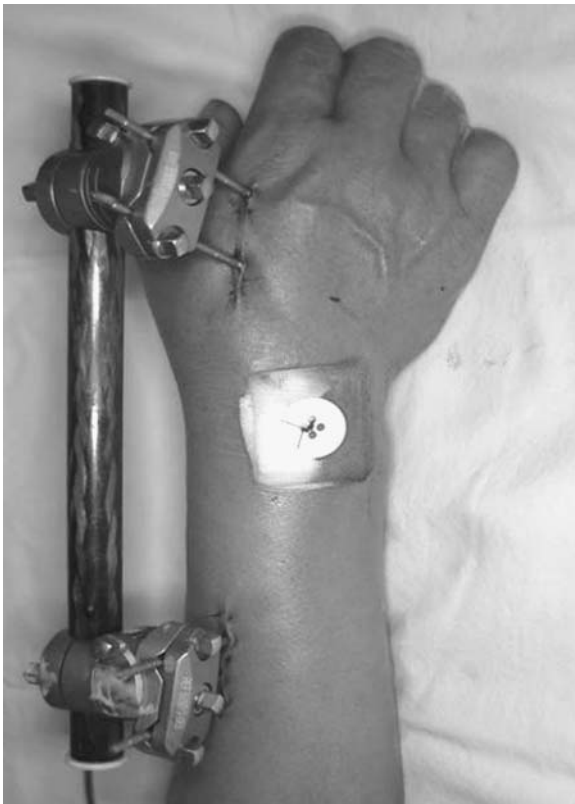


Fig. 1g

Arthroplasty for advanced Kienböck's disease using a radial bone flap wrapped in pronator quadratus. a) A zigzag palmar incision is made and b) the excised lunate fragments are shown on the gauze. c) About one-third of the width of the pronator quadratus muscle is marked and d) a 1 cm³-sized hexahedral bone flap attached to the muscle is lifted from the distal radius. e) The bone flap is then completely wrapped by the muscle. The joint is distracted using an external fixator and the bone flap is inserted into the space and fixed by pull-out sutures (f and g).

About one-third the width of the muscle was marked along its course (Fig. 1c). A bone flap with attached muscle was elevated using an osteotome as far laterally as possible and was passed to the ulnar side beneath the flexor tendons as far medially as possible, taking great care to preserve the anterior interosseous artery (Fig. 1d). The bone flap was a little smaller than the lunate in order to allow for the thickness of the wrapping muscle. The usual size was about 1 cm,³ composed of a square about 0.8 cm by 1.5 cm long. A separate release of the muscle from its proximal ulnar attachment was sometimes required to lengthen the pedicle. The tourniquet was released and bleeding from the bone flap confirmed. The flap was completely wrapped in muscle and sutured with absorbable materials (Fig. 1e). The wrist joint was then distracted using an external fixator. The muscle-wrapped bone flap was inserted into the empty space and fixed to the dorsal capsule using pull-out sutures (Figs 1f and 1g). The volar capsule and ligament were closed proximally and distally without compressing the pedicle. The distractor and sutures were removed four to six weeks post-operatively and both active and passive wrist exercises begun.

Outcome. We assessed pain, range of movement of the wrist, and radiographic findings. Measurements of grip and pinch strength were not included, because tools for these measurements were not available in the early cases. Pain was graded as none, mild (occasional pain), moderate (pain after strenuous activity, but tolerable) or severe (pain on daily activity, intolerable), similar to the modified Mayo wrist scoring system.⁶ We measured ulnar variance using the method of Palmer, Glisson and Werner,⁷ the radioscaphoid angle to assess palmar rotation of the scaphoid⁸ and calculated the carpal height ratio to identify carpal collapse.⁹ Special attention was paid to the progression of degenerative changes on plain radiographs. This was graded when present in either the radiocarpal or the intercarpal joints as mild, any degenerative change involving both the radiocarpal and the intercarpal joints was graded as moderate and advanced degenerative change or narrowing of both the radiocarpal and the intercarpal joints was graded as severe.

Statistical comparisons were analysed using the Student's *t*-test and the SPSS software package (SPSS Inc., Chicago, Illinois). The level of significance was accepted at $p < 0.05$.

Results

All patients reported an improvement in their symptoms after the operation and could return to their work and recreational activities. Before operation, 13 patients graded their pain as severe, 23 as moderate, and 5 mild. After operation, six described their pain as moderate, 15 as mild, and 20 had no pain. Before operation the mean active extension of the wrist was 46° (20° to 70°) and the mean active flexion was 39° (10° to 60°). These increased to 55° (30° to 80°) and 45° (20° to 80°), respectively ($p = 0.047$, 0.035). In the radiographic assessment, the mean pre-oper-

ative ulnar variance was 7 mm (-2.5 to 3.5), with 19 of the 41 patients having neutral, 13 positive and nine negative variance. Before operation, the mean radioscaphoid angle was 61° (45° to 85°) and the mean carpal height ratio was 0.52 (0.44 to 0.60). These values at follow-up were 66° (50° to 80°) and 0.48 (0.36 to 0.62), respectively. Although these figures showed a mild progression of carpal collapse, neither change was significant ($p = 0.074$ and 0.144 , respectively).

Only minimal progression of degenerative change was seen on plain radiographs. Before operation, of the 28 wrists with stage IV disease, 15 had degenerative arthritic changes graded as mild, ten were moderate and three severe. At the most recent examination, 13 wrists were graded as mild, 11 moderate, and four severe; thus, there was progression in only three wrists. Of the 13 patients with stage IIIB disease, two developed mild degenerative changes in the radiocarpal joint. In all cases, the size, density and location of the transferred bone flap did not change with time. There was no resorption or surrounding calcification (Fig. 2).

Minor complications occurred in two patients, related to pin-tract infection from the external fixator. No patient underwent further surgery to the wrist and none regretted having the operation.

Discussion

Advanced Kienböck's disease may include extensive collapse or fragmentation of the lunate, carpal instability and the development of arthritis. A salvage procedure is required rather than attempts at unloading or revascularisation. Replacement of the lunate or interposition arthroplasty with various materials has been described. A replacement arthroplasty is intended to function as an articulating spacer and to maintain mobility and stability of the wrist.^{5,10} However, foreign-body reactions and persistent carpal instability have led to disappointing results.¹¹ Satisfactory long-term results have been described following replacement arthroplasty using natural materials such as fascia and rolled-up tendon.^{12,13}

We considered that a bone with some form of articulating surface would be better as a stable load-bearing material to replace the lunate and that the size of the bone should be maintained without absorption, formation of new bone or union with other carpal bones. We used the radial bone flap as an insert and the pronator quadratus muscle as the articulating surface, with its pedicle vascularised in order to maintain the volume and shape of the bone. The anatomical basis and use of this graft has been described by many authors^{14,15} but its main clinical purpose has been for osteosynthesis of an ununited fracture of the scaphoid or revascularisation of avascular necrosis of the lunate.¹⁶⁻¹⁹

Further carpal collapse or instability was not observed in most of our patients. We speculate that the pedicle connecting the replaced bone and the ulnar origin of the muscle might act as a stabilising structure to prevent migration and



Fig. 2a



Fig. 2b



Fig. 2c

Anteroposterior and lateral radiographs of a 51-year-old woman with stage IV Kienböck's disease, a) pre-operatively with arthritic changes in the radioscaphoid joint; b) after arthroplasty using a radial bone flap wrapped in pronator quadratus; and c) eight years and six months after the operation, which shows minimal deterioration of arthritic changes and maintenance of the bone flap.

rotation of the bone flap. Another possible explanation is that we approach the lunate from the volar aspect and spare the dorsal capsule and the dorsal intercarpal ligament. The bone flap is tightly attached to the dorsal capsule by pull-out sutures and is secured both volarly by the pedicle and dorsally by the capsule and the ligament. The spared dorsal ligament may prevent flexion of the scaphoid in the absence of the scapholunate interosseous ligament. It is probable that the dorsal intercarpal ligament can function better by balancing flexion of the scaphoid and extension of the triquetrum when it is attached to a stable, centrally located bone.

Although MRI scans for evaluation of the vascularity of the bone flap were not undertaken, we believe that the vascularity was maintained, because the size and density of the bone flap did not change with the passage of time. Ueba et al¹³ noted that calcification occurred in half of their patients who underwent tendon-ball implantation and that the size, shape and density of the ossification were variable. This reflects the avascular nature of the tendon implants, similar

to the heterotopic ossification that occurs in hypovascular or degenerative tendons at other sites. Sakai et al²⁰ performed excision arthroplasty and inserted a palmaris longus tendon ball with a core of bone and reported that the grafted free core of bone resorbed in 20% of cases and was reduced to less than half its volume in 40%, indicating that an avascular core of bone cannot reliably maintain its contour.

There are some drawbacks to the current study. First, this retrospective view does not compare the results with those of other surgical procedures. The data collection and evidence for assessing the outcome are not as strong as would be produced by a randomised controlled study. Secondly, because of limited information about the natural history of Kienböck's disease, we could not prove any protective effect or improved outcome compared with conservative treatment, especially in patients with mild or no degenerative arthritis. However, the increased range of movement and relief of pain without serious radiographic deterioration justifies this technique. Thirdly, our radiographic grading of the arthritis cannot differentiate subtle degenerative

changes or assess the true severity of the disease, which would require a more generally accepted method for grading arthritis in advanced Kienböck's disease.

Arthroplasty using a vascularised radial bone flap wrapped in pronator quadratus can be used for the treatment of patients with advanced Kienböck's disease, with satisfactory results for at least three years.

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