Clinical and radiological results following radial osteotomy in patients with Kienböck’s disease

FOUR- TO 18-YEAR FOLLOW-UP

Radial osteotomy is currently advocated for patients with Lichtman’s stages II and IIIA of Kienböck’s disease; its place in the treatment of patients with stage IIIB disease remains controversial. The purpose of this study was to evaluate the medium-term results of this procedure and to compare the outcome in patients with stage IIIB disease and those with earlier stages (II and IIIA). A total of 18 patients (18 osteotomies) were evaluated both clinically and radiologically at a mean follow-up of 10.3 years (4 to 18). Range of movement, grip strength and pain improved significantly in all patients; the functional score (Nakamura Scoring System (NSSK)) was high and self-reported disability (Disabilities of Arm, Shoulder and Hand questionnaire) was low at the final follow-up in all patients evaluated. Patients with stage IIIB disease, however, had a significantly lower grip strength, lower NSSK scores and higher disability than those in less advanced stages. Radiological progression of the disease was not noted in either group, despite the stage. Radial osteotomy seems effective in halting the progression of disease and improving symptoms in stages II, IIIA and IIIB.

Patients with less advanced disease should be expected to have better clinical results.

Over 100 years after its first description, Kienböck’s disease, or avascular necrosis of the lunate, is still a clinical challenge. Its aetiology remains uncertain, with treatment ranging from conservative measures, usually immobilisation during the acute phase, to surgical procedures such as resection arthroplasty, joint levelling procedures (radial shortening, ulnar lengthening or radial wedge osteotomy), intra-carpal arthrodesis or a vascularised graft procedure. Several experimental biomechanical studies have confirmed that these techniques significantly reduce both the load across the lunate and the maximum pressure in the radiolunate joint.

Decompression of the lunate seems to be achieved by redistributing the load to adjacent normal structures, such as the column formed by the triangular fibrocartilage and the triquetrum. Metaphyseal osteotomy is said to be associated with fewer complications than diaphyseal osteotomy. Clinically, both radial shortening and ulnar lengthening are equally effective in reducing pain and increasing range of movement (ROM) and grip strength, allowing revascularisation of the lunate in Lichtman’s stages II and IIIA, but controversy exists regarding their use in stage IIIB. The only documented difference between radial shortening and ulnar lengthening is that the latter is associated with higher rates of nonunion.

Iwasaki et al proposed a laterally based wedge osteotomy of the radius to treat patients with ulnar neutral and positive variance. Later studies demonstrated a reduction in the compressive forces across the lunate, and its results were satisfactory.

Joint levelling procedures, being extra-articular, prevent post-operative loss of wrist function. They are relatively simple techniques with few associated complications. There are only a few published reports of long-term follow-up after this procedure and all but one refer to the Asian population.

There is no clear agreement as to whether radial osteotomy is a valid treatment for advanced Kienböck’s disease (Stage IIIB). Some studies still argue that the appropriate surgical treatment should be a carpal procedure, such as inter-carpal arthrodesis or proximal row carpectomy. However, others have
reported favourable results after radial osteotomy for stage IIIB disease, but have not compared them with those of less advanced stages.

The purpose of this study was to evaluate the long-term results of this procedure and to compare its efficacy in advanced stages (stage IIIB) with that in less advanced stages (II and IIIA). Our hypothesis was that the outcome would be similar in the two groups.

**Patients and Methods**

Between January 1993 and January 2007, 18 consecutive patients underwent 18 radial osteotomies for the treatment of Kienböck’s disease. Indications for surgery were wrist pain and stage II, IIIA and IIIB disease. There were 13 men and five women, and the dominant side was involved in 13 patients. The mean age of the patients at the time of surgery was 31.6 years (16 to 52) and the mean follow-up was 10.3 years (4 to 18). Fifteen patients had ulnar negative variance and three had ulnar neutral variance. Before surgery, patients reported pain for a mean of 18 months (6 to 40); pre-operative pain was graded by the attending surgeon (either MT, RL or CS) as severe in 12 cases and moderate in six.

Independent staging was performed by one of the authors (RRP) according to Lichtman’s classification and using CT or MRI images, the latter in cases where grading of the disease was unclear from CT scans or where a strong suspicion of this disease existed in the absence of a CT scan. One patient had stage II, 11 had stage IIIA and six had stage IIIB disease. Patients were placed under either general or regional anaesthesia in the supine position and a tourniquet was used. A volar Henry approach to the radius was used, with careful protection of the radial artery and median nerve, and the pronator quadratus was identified and elevated with an L-shaped incision, so that the distal diaphysis and the metaphyseal–diaphyseal junction of the radius could be identified. The amount of shortening was determined pre-operatively based on the radiological measurements. Two parallel cuts were made with an oscillating saw at the metaphyseal–diaphyseal junction and the bone block was removed. A compression plate was used for fixation in all cases. After fixation, the pronator quadratus was reattached to its fascia and wound closed. A drain was left in for 24 hours and a splint was used for the first 48 hours, after which gradual active mobilisation exercises were encouraged. Physiotherapy was started after the third post-operative week. The data were collected by an independent observer (RRP).

Two patients with stage IIIA disease were not available for recent clinical evaluation. Both of these had a telephone interview in which their pain score and work disability were assessed; their last available radiographs were used for comparison. The ROM and grip strength were not evaluated in these patients and follow-up time was defined by the last radiograph available. Informed consent was given by all patients in the study.

Patients were clinically evaluated for pain, ROM and grip strength. A visual analogue scale (VAS) was used to quantify pain, ranging from 0 to 10 points, with 0 corresponding to no pain, between 1 and 4 corresponding to increasing degrees of mild pain, 5 and 6 corresponding to increasing degrees of moderate pain and between 7 and 10 to increasing degrees of severe pain.

A goniometer to measure ROM and a dynamometer (Jamar Hydraulic Hand Dynamometer; Lafayette Instruments, Lafayette, Indiana) to evaluate grip strength. Data were compared with available pre-operative data, when available, and with the contralateral side; in the latter case data are referred to as ‘relative to’.

Both pre-operative and follow-up radiographs of the wrist were obtained for all patients; radiographs were taken in neutral rotation of the forearm and with the wrist in neutral. Radiological parameters, including carpal height ratio and Stahl’s index, were measured. The carpal height ratio was defined on the anteroposterior (AP) radiograph as the carpal height divided by the length of the third metacarpal. Stahl’s index uses lateral radiographs to quantify collapse of the lunate: the height of the lunate (proximal–distal dimension) is divided by its diameter (AP dimension). All radiographs were also analysed by one of the authors (RRP) for progressive sclerotic, cystic and degenerative changes.

The overall results were evaluated using the Nakamura Scoring System for Kienböck (NSSK). The Portuguese version of the Disabilities of the Arm Shoulder and Hand (DASH) questionnaire was distributed at last follow-up to all patients and was analysed as a measure of self-reported pain and disability.

**Statistical analysis.** Statistical analysis was performed using Student’s t-test whenever distribution was normal; non-parametric tests were applied to the remaining cases. Results comparing stages II and IIIA with stage IIIB were further corrected using the Bonferroni test and p-values < 0.05 were considered to be significant.

**Results**

**Clinical evaluation.** At the last follow-up 12 patients were asymptomatic (VAS grade 0) and six reported mild pain (one patient VAS grade 1 and five VAS grade 2). The mean NSSK was 24.4 points (20 to 29). The mean DASH score was 14.94 points (0 to 35).

The mean ROM improved from 76.8° (30° to 107°) pre-operatively to 100.5° (65° to 140°), at the latest follow-up; this represents a significant mean increase of 23.7° (p < 0.001). Compared with the unaffected side, mean extension was 71.4% (21% to 100%) and flexion was 79.4% (40% to 117%).

No grip strength measures were available pre-operatively, so follow-up data were compared with the unaffected side, being a mean of 73.2% (59% to 95%) of the contralateral strength. This was corrected for bias arising from hand dominance.
Table I. Overall clinical results

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pre-operative</th>
<th>Last follow-up</th>
<th>Mean variation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual analogue pain scale (at last follow-up) (n)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0 points</td>
<td>12</td>
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<tr>
<td>1 point</td>
<td>1</td>
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<td>2 points</td>
<td>5</td>
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<tr>
<td>Mean (sd) range of movement (ROM)</td>
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<tr>
<td>Pre-operative ROM (°)</td>
<td>77 (20)</td>
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<tr>
<td>ROM at last follow-up (°)</td>
<td>101 (19)</td>
<td></td>
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<tr>
<td>Increase in ROM (°)</td>
<td>24 (10)*</td>
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<td></td>
<td></td>
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<tr>
<td>Operated wrist extension (°)</td>
<td>45 (12)</td>
<td></td>
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<tr>
<td>Contralateral wrist extension (°)</td>
<td>63 (8)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Relative extension (operated/contralateral) (%)</td>
<td>71 (20)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Operated wrist flexion (°)</td>
<td>56 (12)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Contralateral wrist flexion (°)</td>
<td>71 (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative flexion (operated/contralateral) (%)</td>
<td>79 (20)</td>
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<tr>
<td>Mean (sd) grip strength</td>
<td></td>
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<tr>
<td>Operated wrist grip strength (kg)</td>
<td>27 (9)</td>
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<tr>
<td>Contralateral wrist grip strength (kg)</td>
<td>36 (10)</td>
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<tr>
<td>Relative grip (operated/contralateral) (%)</td>
<td>73 (12)</td>
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<tr>
<td>Mean (sd) Nakamura Scoring System for Kienböck (at last follow-up) (points)</td>
<td>24 (2)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean (sd) DASH questionnaire score (points)</td>
<td>15 (12)</td>
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</table>

* significant increase compared with pre-operative value (p < 0.001)

Table II. Overall radiological results

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative</th>
<th>Last follow-up</th>
<th>Mean variation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (sd) Stahl’s index</td>
<td>0.32 (0.08)</td>
<td>0.31 (0.07)</td>
<td>-0.01 (0.03)</td>
<td>0.42</td>
</tr>
<tr>
<td>Mean (sd) carpal height ratio</td>
<td>0.52 (0.02)</td>
<td>0.52 (0.02)</td>
<td>-0.01 (0.01)</td>
<td>0.53</td>
</tr>
</tbody>
</table>

In all, 15 patients returned to their original work or sport; two changed their job and one stopped sport for reasons other than their wrist symptoms. Clinical results are summarised in Table I.

Radiological evaluation. The objective of levelling the distal radioulnar joint (DRUJ) was achieved. The ulnar variance increased from a mean negative value of 0.63 mm (-1.23 to 0.00) pre-operatively to a mean positive value of 1.11 mm (0.53 to 1.62).

At the three-month follow-up evaluation all osteotomies showed radiological signs of union. There was no significant difference between the Stahl’s index and carpal height ratio both pre-operatively and at last follow-up (Table II). No wrist had radiological evidence of carpal degeneration at the final examination.

Stages II and IIIA versus stage IIIB. Patients in stages II and IIIA were compared with patients in stage IIIB.

Clinically, patients in both groups had an increase in ROM, relative extension, relative flexion and relative grip strength. However, the mean relative grip strength was significantly higher in patients in stages II and IIIA than in those in stage IIIB (79% (68% to 91%) versus 63% (43% to 75%), p = 0.01); no significant differences were found between groups in the other parameters. The mean NSKK at last follow-up was significantly higher in patients in stages II and IIIA than in those in stage IIIB (25.5 (23 to 29) versus 22.5 (20 to 24), p = 0.01). The mean DASH score was significantly lower, indicating less disability in patients in stage II and IIIA (8.67 points (sd 8) in stages II and IIIA versus 23.33 points (sd 7) in stage IIIB; p < 0.001).

Radiologically there was no difference between the two groups. Both Stahl's index and carpal height ratio did not improve significantly after surgery in either group (Table III).

Complications. No major complications were reported at the last follow-up. There were no nonunions and no infections. No patient reported ulnar-sided wrist pain. Three plates were removed at a mean of three years (at 22, 37 and 49 months) after surgery for pain in relation to the plate.

Discussion

There was no significant progressive lunate collapse in our patients. However, neither carpal height ratio nor Stahl's index improved significantly. This radiological 'stagnation' is nevertheless in contrast with the clinical improvement reported by all patients even after long follow-up. Almqquist and Burns reported no correlation between post-operative clinical and radiological improvement at between 5 and 10 years after radial shortening. Koh et al. studied this clinical improvement without apparent radiological correlation and proposed a grading system in which, besides evaluating conventional radiological parameters (carpal height ratio, Stahl's index and Lichtman classification), improvements in sclerosis, cystic change and fragmentation of the lunate were considered as indicators of revascularisation. With this new grading system, more than half of the patients previously considered to have had no radiological improvement proved to have radiologically excellent or good results, suggesting improvements in the inner structure of the lunate resulting from radial osteotomy.

Most patients were referred to our hospital from local primary care units, and although Lichtman’s stage II would be a primary indication for radial shortening in most patients, the disease had already progressed to later stages at the time of referral.

One question frequently raised is whether the amount of radial shortening should be equivalent to the amount of pre-operative negative ulnar variance. In our series, 15 patients had negative ulnar variance and three had...
neutral variance. In the former group we intended to level the DRUJ, being careful not to shorten the radius by > 2 mm or 3 mm; in the latter group an average of between 1 mm and 2 mm shortening was intended. In four cases, however, shortening was less than planned. Nevertheless, even in these cases the functional outcome was very good. These results show that pain relief may be related to the decompression effect (alteration of radial strength and stiffness and, therefore, reducing its load on the lunate), rather than to the amount of shortening. This hypothesis has been a matter of recent debate.\textsuperscript{35,36} Osteotomy of the radius is also believed to induce hyperaemia at the DRUJ, thereby accelerating revascularisation of the lunate.\textsuperscript{37,38}

Nakamura, Imaeda and Miura\textsuperscript{30} reported that radial shortening > 4 mm resulted in ulnar-sided wrist pain and an unsatisfactory outcome, suggesting that shortening should not exceed 2 mm or 3 mm. In our series no ulnar-sided wrist pain was reported.

Restoration of vascularity, morphology and the carpal relationships of the lunate should always be the main goals when treating patients with Kienböck’s disease. Following radial osteotomy we found substantial clinical improvement and cessation of or delay in further collapse of the lunate and arthritis of the wrist.

The association between negative ulnar variance and Kienböck’s disease in different regions of the world has been reported. Bonzar et al\textsuperscript{39} and Chen and Shih\textsuperscript{40} demonstrated a strong correlation between ulnar minus variance and Kienböck’s disease in both North American and Asian populations. D’Hoore et al\textsuperscript{41} suggest a negative association in the European population, contradicting the findings of Hultén.\textsuperscript{17,18} A total of 15 of our patients (83.3\%) had negative ulnar variance. Clinical and radiological results, however, were equivalent to published data from the above-mentioned North American and Asian populations. Therefore, despite the regional variation and pathogenesis of this disease, radial osteotomy appears to be equally effective.

One of the most important aspects of this study was to evaluate whether patients in later stages (IIIB) would have worse results than patients in less advanced stages (II and IIIA). We decided to analyse stage II and IIIA together, despite the fact that only one patient in this study had stage II disease, because stage II and IIIA disease are the ideal indications for this procedure; therefore, these should be compared together against stage IIIB. Despite several studies reporting favourable results with this procedure, its use in advanced stages remains controversial.\textsuperscript{19,25-28} Lichtman’s stage IIIB is defined as having gross collapse of the lunate with fixed rotation of the scaphoid. Biomechanical studies have demonstrated that realignment of the scaphoid is important in reducing the forces across the lunate.\textsuperscript{42,43} For this reason, some authors have stated that stage IIIB was a contraindication to radial osteotomy, as it would not correct the malrotation.\textsuperscript{31} Altay et al\textsuperscript{44} compared the effectiveness of the procedure in patients with stages IIIA and IIIB at a mean follow-up of 85 months and found no significant differences between the two groups. Iwasaki et al\textsuperscript{45} reported similar clinical outcomes in patients with stage IIIB and IV disease.

It must be emphasised that Lichtman’s classification for this disease has a non-negligible interobserver error.\textsuperscript{45} We must therefore assume that although the staging was done by an independent observer, some uncertainty may still exist in the classification of disease in our patients.

This is a long-term follow-up of 18 patients. Although important conclusions can be drawn from their clinical and radiological status after such period of time, it must be acknowledged that the power to interpret the results, especially when comparing patients in different stages of the disease, is low. Results addressing the same hypothesis in larger samples are needed to either confirm or deny these results. In this series, all patients, regardless of stage, reported improvements in pain, function and strength. There was improvement in all parameters evaluated. However, patients in stage IIIB had significant less relative grip strength and a lower mean NNSK score than those in less advanced stages and reported more disability, as measured by the DASH questionnaire. Nonetheless, improvement of their qualitative evaluation of pain and ROM over their previous status was seen in both groups.

Alternative treatments for these patients would be intra-carpal arthrodesis. Radial shortening osteotomy is technically simple and has a low incidence of nonunion and other complications. Also, as an extra-articular procedure it offers advantages over intra-carpal procedures, which potentially carry more post-operative pain and disability. Additionally, these are mainly young patients of working age, predominantly in hand-related jobs. The limitations of function after intra-carpal arthrodesis would probably prevent patients being able to continue working. Therefore, although results for stage IIIB were less good, especially with regard to strength, the final results did not greatly affect daily life and did not carry a drastic change.

For these reasons we believe that this procedure is a valid option in stage IIIB disease. However, the surgeon cannot ignore the fact that patients in later stages may have a worse clinical outcome, especially less grip strength, and more disability, and this should be explained when choosing this procedure for patients with advanced stages of the disease.

**Supplementary material**

Two tables detailing i) the breakdown of the post-operative results of the Nakamura Scoring System for Kienböck’s disease (NNSK) and ii) a comparison of the clinical results between the group with stage II and IIIA disease and the group with stage IIIB disease are available with the electronic version of this article on our website www.jbjs.org.uk

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.
References


