# Dorsolateral Biplane Closing Radial Osteotomy and Lunate Fixation for Stage IIIC Kienböck Disease: A New Surgical Approach

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**Abstract:** The treatment of advanced-stage Kienböck disease (KD) remains highly controversial. Particularly important is stage IIIC KD, which includes patients with a lunate coronal fracture. The purpose of this paper was to describe a new approach to KD in patients with Lichtman stage IIIC KD, and our results using it. The procedure combines a dorsolateral biplane closing radial osteotomy and lunate fixation. A total of 11 patients from January 2002 through December 2016 with documented KD who underwent this technique were included. The patients were assessed before surgery, then postoperatively at 1 and 10 days, 3 and 6 weeks, 3 and 6 months, and annually. Wrist range of motion, grip and pinch strength, the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score, a Modified Mayo Wrist Score (MMWS), 10-point visual analog scale, radiologic measurements, and data related to consolidation were collected. All statistical analyses were performed using the statistical software package SPSS. Some degree of pain relief, improvements in the QuickDASH score, MMWS score, grip strength, and the degrees of flexion and extension were observed, the results being statistically significant ($P<0.05$). After surgery, the values for radial and sagittal tilt were statistically different than those measured before surgery. Carpal collapse was not evident either before or after surgery. In conclusion, combining a dorsolateral radial osteotomy and a lunate compression screw may expand the options for patients with Lichtman stage IIIC KD. Our experience indicates that it is a viable option in challenging clinical scenarios.

**Key Words:** Kienböck disease, treatment, dorsolateral osteotomy, IIIC

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Kienböck disease (KD), or lunatomalacia, was described in 1910 by Dr Robert Kienböck. This disease is usually seen in young adults aged between 20 and 40 years and is more common in male individuals.[1] Its etiology is unknown, but it has been associated with several factors, which include mechanical/traumatic and anatomical factors, and various systemic diseases. The most important anatomical factors described in the literature are negative ulnar variance, as speculated by Hulten in 1928, and variability in lunate blood supply and intraosseous pressures.[2] The treatment of advanced-stage KD remains highly controversial. The goals of treatment are to alleviate pain, improve function, and avoid the progression of disease. Many different interventions have been proposed for the various stages of KD defined using the Lichtman classification system; however, none has been shown to be superior to others.[3] Surgical treatment is the first choice, because progressive collapse and continued pain have been the result of casting in most series.[2] However, surgical treatment options can be classified into 5 groups: (1) lunate unloading procedures (including temporal unloading with external fixators or midcarpal pinning, radial shortening, ulnar lengthening, and capitate shortening); (2) lunate revascularization procedures (including vascularized transfer of the pisiform bone, distal radius vascularized pedicled transfers, the direct implantation of metacarpal arteries, and free vascularized grafts); (3) salvage procedures like proximal row carpectomy (PRC); (4) fusion procedures (scapho-capitate fusion, scapho-trapezio-trapeziod fusion, radio-scapho-lunate arthrodesis, and total wrist fusion); and (5) replacement procedures, which include lunate excision with silicon/pyrocarbon prosthetic lunate replacement or tendon/muscle ball arthroplasty, PRC with or without interpositional arthroplasty of the dorsal wrist capsule, and total wrist arthroplasty.[2] These different techniques are usually combined, but results have remained equivocal.

Since KD was described, several treatment options with specific sets of advantages and disadvantages have been described to treat advanced stages, but the treatment of KD remains a challenge among hand surgeons, because carpal alignment is disrupted and the revascularization capacity of the collapsed lunate is limited.[4] Particularly important is stage IIIC KD, most recently described by Lichtman in 2010,[5] which includes patients with a lunate coronal fracture. This is a nongeneralized concept and generally treated with conventional procedures.

The purpose of this paper was to describe a new approach to KD in patients with Lichtman stage IIIC KD, and our results using it. The procedure combines a dorsolateral biplane closing radial osteotomy and lunate fixation through a posterior-anterior headless compression screw. The primary objective of this treatment is to promote lunate revascularization and consolidation with radial decompression osteotomy, drilling, and lunate fracture compression with a compression screw.

## MATERIALS AND METHODS

### Patients

The study was approved by the Institutional Research Ethics Committee, and informed consent was obtained from all patients. From January 2002 through December 2016, 11 patients with documented KD and lunate coronal fracture, who underwent a dorsolateral radial subtraction osteotomy and lunate fixation, were examined clinically and radiologically and selected for retrospective study. Patients were operated upon by a single hand surgeon (X.M.-B.) at 2 regional hand surgery institutions in Barcelona, Spain: Hospital Quirón-Dexeus and Hospital Vall d'Hebron). Patients with KD and lunar coronal fracture diagnosed

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FIGURE 1. Patient with IIIC Kienböck disease. Lunate coronal fracture is observed in sagittal (A) and coronal (B) computed tomographic scan planes, and in sagittal T2 (C) and coronal T1 magnetic resonance imaging sequences (D).

with preoperative computed tomographic (CT) scan were included (Fig. 1). We defined KD as fractures of >3 months duration without clinical (pain reduction) or radiologic (sclerosis, cyst formation, or bone resorption) evidence of healing. Patients with incomplete medical records or radiographs, or with follow-up <2 years were excluded from the study.


FIGURE 2. Preoperative anteroposterior (A) and lateral x-ray (B) view of a patient with IIIC Kienböck disease. Intraoperative fluoroscan with the dorsolateral biplanar osteototomy performed and fixed with a 2.4 mm T locking plate (C, D).

## Operative Technique

With locoregional anesthesia and using an arm tourniquet at 250 mm Hg, a 7 cm longitudinal zig-zag incision according to the Langer lines is made on the dorsal aspect of the wrist, to get a wide view of the dorsal aspect of the wrist and to prevent soft tissue retraction. The incision is made from the carpometacarpal joint, reaching to a point 3 cm proximal to the radiocarpal joint, following the Lister tubercle and third metacarpal axis. Sensitive branches of the radial nerve and dorsal veins are identified and preserved. The dorsal extensor retinaculum is opened through the third compartment, approaching between the extensor digitorum communis and extensor radialis brevis. We elevate the retinacular floor under the periosteum to expose completely the dorsal face of the radius. This allows us to perform the osteotomy of the radius easily and preserve the periosteum of the radius to ensure the consolidation of the radius osteotomy. After dissecting the dorsal distal radial metaphysis, a dorsolateral wedge osteotomy is designed and performed. This osteotomy has a dorsolateral base with both a lateral (radial) and dorsal component. The osteotomy is performed by sectioning the cortex of the radius proximal to the Lister tubercle without involving the medial cortex, making one cut parallel to the articular surface and another cut perpendicular to the shaft of the radius with a motorized saw. Afterwards, the wedge is extracted and the osteotomy reduced in both the frontal plane and lateral plane, then fixated with a 2.4 mm T locking plate under intraoperative radiologic guidance (Fig. 2). The osteotomy was individualized in each case to get a radial tilt <15 degrees and a sagittal tilt <5 degrees. This technique allows us to reduce the radial tilt or the radial inclination angle and palmar tilt.

Thereafter, under fluoroscopy, the dorsal pole of the lunate is sought, and, without opening the radiocarpal dorsal capsule, a K-wire is placed in the sagittal axis perpendicular to the lunate fracture pattern. Afterwards, through the K-wire, a 2 mm cannulated headless compression screw is placed under intraoperative radiologic guidance (Fig. 3). This allows us to achieve lunate compression in Lichtman stage IIIC KD with a

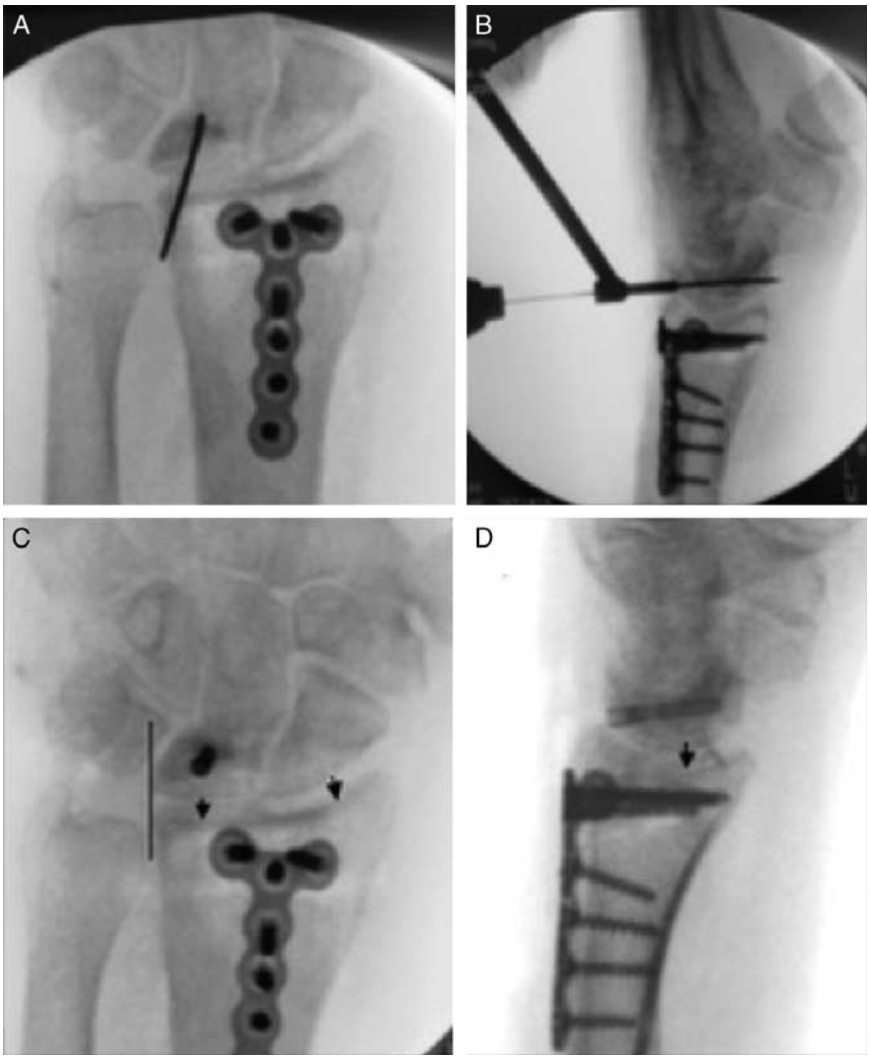


FIGURE 3. Lunate fixation. A K-wire is placed in the sagittal axis perpendicular to the lunate fracture pattern (A, B). Afterwards, through the K-wire, a 2 mm cannulated headless compression screw is placed (B). This technique allows us to reduce radial inclination angle and sagittal tilt, increasing lunate coverage, decreasing the pressure on the lunate and increasing the pressure on the scaphoid (black arrow) and achieving compression in coronal fracture (C, D).

coronal fracture line. Finally, the capsule is closed with good coverage of the implant, which protects extensor movements and reconstructs the dorsal extensor retinaculum.

After surgery, patients are told to wear a cast for 3 weeks, after which physical therapy is initiated, with limited range of movement (flexion-extension from −45 to +45 degrees) for the first 6 months.[4,6–8]

## Assessment

The patients were assessed before surgery, then postoperatively at 1 and 10 days, 3 and 6 weeks, 3 and 6 months, and annually thereafter, combined with radiologic reviews. At follow-up, an independent examiner evaluated all patients clinically. The objective outcome measures of interest included wrist range of motion and grip strength. Each patient's wrist range of motion was recorded in degrees to the nearest 5 degrees using a goniometer from a wrist-neutral position, assessing extension, flexion, and ulnar and radial deviation. Grip and pinch strength were recorded in kilograms using standard dynamometers (Jamar Dynamometer, Jackson, MO). A subjective assessment was performed using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score (0, no disability; 100, complete disability) and a Modified Mayo Wrist Score (MMWS) (0, complete disability; 100, no disability). A 10-point visual analog scale (VAS) was used to record pain (0, no pain; 10, severe pain). All patients had preoperative and postoperative radiographs of the wrist available at each follow-up examination. Coronal and sagittal tilt, semilunar coverage, and ulnar variance were measured. The radiographic angles were measured using software on our radiology imaging system (Centricity PACS; GE Systems, Bucks, UK). To assess the extent of carpal collapse, the carpal height ratio, described by Youm et al,[9] was used. All patients underwent additional CT using a standard reformatting protocol to document union (union was considered complete if bridging was documented in >50% of the lunate) and assess the degree of correction obtained. Lunate morphology was classified according to Viegas into 2 types: type I, in which the lunate has a single distal facet for the capitate, but does not articulate with the hamate and type II, with 2 distal facets in the lunate (a radial facet for the capitate and ulnar facet for the hamate).[10] The KD cases were classified according to Lichtman, into 6 types[5]: I (normal morphology on x-ray and CT scan, and edema pattern in bone marrow with magnetic resonance imaging); II (sclerosis in bone marrow on x-ray and CT); IIIA (collapse of the lunate bone and a radioscaphoid angle <60 degrees); IIIB (collapse and a radioscaphoid angle >60 degrees); IIIC (collapse of the lunate bone and a chronic coronal lunate fracture); and IV (radiocarpal or midcarpal degenerative arthritis). The degenerative joint disease was categorized according to the Trumble and Vo[11] classification scheme. Two independent radiologists specializing in musculoskeletal imaging interpreted the images. Intraoperative and postoperative complications (infection, hardware failure, lunate nonunion, lunate collapse, scaphoid bone rotation, and degenerative changes around the lunate) and the need for further operations were also recorded.

## Statistical Analysis

For all continuous variables, we calculated a mean ± SD; this included the patients' mean age at presentation and the mean time interval between the onset of symptoms and surgery. Outcomes of interest, measured both preoperatively and postoperatively to allow for comparisons against baseline were as follows: wrist range of motion (measured in degrees); grip and pinch strength (measured as percentages relative to the normal, contralateral wrist); self-rated level of pain (on a 10-point VAS), both at rest and with exercise; 2 measures of hand function (QuickDASH, MMWS score); and the degrees of radial and sagittal tilt on imaging. The Wilcoxon signed-rank test was used for categorical comparisons of these data, with $P > 0.05$ set as the criterion for a statistically significant intergroup difference. Data related to consolidation were also collected. All statistical analyses were performed using the statistical software package SPSS.

# RESULTS

Baseline patient characteristics are summarized in Table 1. A total of 11 patients with KD and lunate coronal fracture were included. After 2010, using the Lichtman classification scheme,[12] all these patients were classified retrospectively as type IIIC KD. Eight of these patients were women, while 3 were men. The patients' mean age at the time of operation was 32.8 years (SD ±10.23 y; range, 19 to 53 y).

The median period of follow-up was 39 months (SD ±2.8 mo; range, 33 to 54 mo). The right hand was involved in 9 patients and the left hand in 2 (the dominant hand in all 11). The average time from the onset of symptoms to surgery was 9.8 months (SD ±6.1 mo; range, 2 to 24 mo). According to the Trumble and Vo[11] classification, no patient had any preoperative signs of arthrosis.

In terms of lunate consolidation, we documented nonunion in 3 of the 11 patients. Despite the lunate nonunion, we achieved some degree of pain relief, and improvements in the DASH score, MMWS score, grip strength, and the degrees of flexion and extension in all 3 of these patients.

**TABLE 1.** Baseline Patients' Characteristics

| | Sex | Age (y) | Side | Profession | Diagnosis Time (mo) | Lunate Type | Cubital Variance | Litchman's Classification |
|---|---|---|---|---|---|---|---|---|
| Case 1 | Female | 25 | Dominant | Sedentary | 5 | II | Neutral | IIIC |
| Case 2 | Female | 30 | Dominant | Sedentary | 6 | II | Neutral | IIIC |
| Case 3 | Female | 29 | Dominant | Active | 11 | II | Neutral | IIIC |
| Case 4 | Male | 27 | Dominant | Active | 13 | I | Neutral | IIIC |
| Case 5 | Female | 24 | Dominant | Active | 3 | II | Neutral | IIIC |
| Case 6 | Male | 19 | Dominant | Active | 2 | II | Negative | IIIC |
| Case 7 | Female | 42 | Dominant | Active | 12 | II | Neutral | IIIC |
| Case 8 | Female | 53 | Dominant | Sedentary | 8 | II | Negative | IIIC |
| Case 9 | Female | 40 | Dominant | Active | 24 | I | Negative | IIIC |
| Case 10 | Female | 43 | Dominant | Active | 12 | II | Neutral | IIIC |
| Case 11 | Male | 29 | Dominant | Active | 12 | II | Negative | IIIC |

**TABLE 2.** Range of Motion, Grip Strength, and Radiologic Measurements

| | Before Surgery | | | | | After Surgery | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grip Strength (kg) | ROM Extension (deg.) | ROM Flexion (deg.) | Radial Tilt (deg.) | Sagittal Tilt (deg.) | Grip Strength (kg) | ROM Extension (deg.) | ROM Flexion (deg.) | Radial Tilt (deg.) | Sagittal Tilt (deg.) |
| 1 | 15.5 | 25 | 30 | 31 | 12 | 18.5 | 55 | 40 | 15 | 5 |
| 2 | 14.1 | 30 | 35 | 29 | 14 | 19.3 | 52 | 45 | 17 | 2 |
| 3 | 11.2 | 20 | 25 | 25 | 11 | 19.2 | 30 | 40 | 14 | 0 |
| 4 | 27.8 | 30 | 35 | 27 | 11 | 26.8 | 10 | 25 | 12 | 4 |
| 5 | 16.7 | 15 | 20 | 24 | 13 | 20.7 | 40 | 45 | 18 | 3 |
| 6 | 12.4 | 25 | 20 | 28 | 12 | 16.2 | 35 | 30 | 15 | 2 |
| 7 | 18.2 | 20 | 25 | 30 | 13 | 20.2 | 35 | 35 | 13 | 2 |
| 8 | 24.3 | 30 | 35 | 26 | 11 | 26.4 | 40 | 40 | 17 | 5 |
| 9 | 13.2 | 20 | 30 | 29 | 13 | 15.2 | 25 | 40 | 18 | 3 |
| 10 | 16.5 | 25 | 25 | 27 | 14 | 18.4 | 35 | 35 | 12 | 4 |
| 11 | 20.4 | 15 | 20 | 30 | 11 | 19.5 | 15 | 25 | 14 | 4 |

ROM indicates range of motion.

## Range of Motion and Grip Strength

Preoperative and postoperative values for range of motion and grip strength are shown in Table 2. Motion for each individual set of measurements improved significantly after surgery ($P<0.05$). Degrees of flexion and extension after surgery averaged 36.4 and 33.8 degrees, respectively, reflecting gains of 9.1 and 10.6 degrees versus the preoperative baseline. Mean grip strength after surgery was 20 kg, compared with 17.3 kg before surgery. These improvements were statistically significant ($P<0.05$).

There, ultimately, were no statistically significant differences between the surgically treated and untreated hands, in terms of range of motion and grip strength, across the 11 patients.

Significant improvements in the VAS, QuickDASH, and MMWS scores are noted ($P<0.05$). VAS score improved in every patient with preoperative and postoperative averages of 6.45/10 and 1.1/10, with no pain (0 point in VAS score) in 7 of the 11 patients. The MMWS and DASH scores also improved in every patient, with postoperative means of 73.2 and 6.8, reflecting preoperative to postoperative score differences of 30 and 25.4, respectively, with the follow-up QuickDASH averaging $6.6\pm3.2$ (range, 0 to 10) and the MMWS $96.2\pm3.7$ (range, 90 to 100). These differences were statistically significant also ($P<0.05$). Pain at rest and during exercise subsided significantly after surgery too ($P<0.05$).

## Radiologic Measurements

Preoperative and postoperative measurements of coronal and sagittal tilt are summarized in Table 2. After surgery, the values for radial and sagittal tilt were statistically different than those measured before surgery ($P<0.05$). The preoperative mean radial tilt of 27 degrees reduced to 15 degrees postoperatively. Corresponding means for sagittal tilt were 12 and 3 degrees.

Carpal collapse was not evident either before or after surgery on comparing with contralateral carpal height (distance between the base of the third metacarpal and the distal radial articular surface). Postoperative radiographs and CT imaging revealed no hardware migration or deterioration of lunate and scaphoid alignment at final follow-up. We also noted no identifiable arthrosis at the radiocarpal or midcarpal joints. The average time to radiologically documented lunate union was 12.6 weeks ($\pm$2.3 wk; range, 10 to 18 wk) (Figs. 4, 5).

Summary mean differences between preoperative and postoperative results are described in Table 3.


**FIGURE 4.** One-month follow-up (A) anteroposterior and (B) lateral x-ray.


FIGURE 5. Postoperative (A) axial, (B) coronal, and (C) sagittal computed tomographic scan planes at 3 months' follow-up with lunate coronal fracture and osteotomy consolidation.

## DISCUSSION

The treatment algorithm for KD is largely based on the radiographic stage of disease. The first classification system for this condition was described by Stahl[13] in 1947, differentiating KD into 5 stages according to the degree of radiolucency, sclerosis, fragmentation, and osteoarthritis of the lunate bone. This classification was later modified by Lichtman et al[14] in 1977, who differentiated the disease into stage I, stage II, stage III (divided into IIIA and IIIB), and stage IV. Finally, in 2010, Lichtman et al[15] added stage IIIC, which corresponds to those patients with a chronic coronal lunate fracture.

TABLE 3. "P"-Value Summary Results

| | Before Surgery Mean | After Surgery Mean | Difference | "P" |
|---|---|---|---|---|
| Radial tilt (deg.) | 27.8 | 15 | 12.81 | < 0.05 |
| Sagittal tilt (deg.) | 12.3 | 3.1 | 9.2 | < 0.05 |
| QuickDASH | 32.1 | 6.7 | 25.4 | < 0.05 |
| VAS | 6.5 | 1.1 | 5.4 | < 0.05 |
| MMWS score | 43.2 | 73.2 | 30 | < 0.05 |
| Grip strength (kg) | 17.3 | 20 | 2.7 | < 0.05 |
| ROM extension (deg.) | 23.2 | 33.8 | 10.6 | < 0.05 |
| ROM flexion (deg.) | 27.2 | 36.4 | 9.1 | < 0.05 |

DASH indicates disabilities of arm shoulder and hand score; MMWS, modified Mayo wrist score; ROM, range of motion; VAS, visual analog scale.

In patients with advanced KD, in whom there is lost carpal height because of collapse and necrosis of the lunate (Lichtman stages IIIB, IIIC, and IV), salvage procedures are usually adopted. For stage IIIC, lunate excision and arthrodesis or PRC[3,5] are the treatments of choice. Even after lunate collapse, there is a large body of published patient outcome literature and biomechanical data that support surgical procedures designed to unload the lunate, with or without revascularization and bone grafting.[8,13–19] Some surgeons have reported satisfactory clinical results lasting 10 or more years in patients who underwent radial shortening for advanced stages of KD (IIIB and IV).[18]

With respect to mechanical factors, the radial inclination angle has been shown to be an anatomic factor that influences the appearance of disease,[17,20] and dorsolateral radial osteotomies were described by Lamas et al[6] in 2000. Their technique was a modification of techniques previously proposed by Nakamura et al[19] and Miura et al.[4,21] In accordance with the concept proposed by Lamas and colleagues, we propose a less invasive approach to managing stage IIIC KD through a combined technique of a dorsolateral biplane closing radial osteotomy to unload the lunate, and lunate fixation and compression to improve mechanical factors of the bone.

Viable first-line options consist of revascularization and/or lunate unloading. Although initially we discarded revascularization of the lunate for stage IIIC KD, consolidating all our patients shows us that this could be a misconception. In our opinion, the success of this technique is partially due to the mechanical decompression generated by the osteotomy, due to the effect of interfragmentary compression, without altering vascularity, produced by the compression screw and partially due to the growth factors' release secondary to radial osteotomy. It is proved that any bone trauma generates a local and regional healing response with many proteins' liberation, including VEGF and several growth factors. We think that might be important for revascularization stimulus of the lunate.[12]

In summary, we believe that combining a dorsolateral radial osteotomy and a lunate compression screw may expand the options for those patients with Lichtman stage IIIC KD. Our experience indicates that it is a viable option in challenging clinical scenarios, such as the one described in this report.

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