

Promising Outcomes Following Pyrocarbon Lunate Replacement For Kienböck Disease

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Abstract

Kienböck Disease is progressive osteonecrosis of the lunate bone, without a clearly defined aetiology. Disease progression may lead to pain and loss of function in an otherwise young and healthy patient. Surgical interventions traditionally used may appear unattractive to young patients. Lunate arthroplasty with a PyroCarbon implant is a relatively new procedure, and favourable results are being demonstrated in small studies with limited follow up.

This report describes three cases of patients with Kienböck disease who underwent PyroCarbon lunate replacement. These patients were routinely assessed at follow up with flexion/extension and grip strength assessment, quick Disabilities of the Arm, Shoulder and Hand (qDASH) scores, patient satisfaction surveys and plain radiographs.

Existing literature on PyroCarbon lunate replacement is restricted by small study sizes and limited follow up. Considering this, results comparable to accepted conventional surgical interventions have been demonstrated, including proximal row carpectomy (PRC), total wrist fusion (TWF), scaphocapitate fusion (SC fusion) and scaphotrapeziotrapezoid fusion (STT fusion).

Patients afflicted with Kienböck disease are seeking surgical interventions that are likely to alleviate pain whilst maintaining function. PyroCarbon lunate replacement could provide one such option, but further evidence is required to support this procedure as a reliable surgical intervention.

INTRODUCTION

Kienböck Disease was first described in 1910 by Robert Kienböck in patients presenting with dorsal wrist pain and reduced range of motion, with isolated changes to the lunate on radiograph¹. The disease, characterised by avascular necrosis of the lunate, most frequently affects the dominant hand of men aged 20-40, with prior trauma and manual labour as additional risk factors¹. There is no general consensus on the ideal treatment of symptomatic late stage (Lichtman IIIb or IV) Kienböck disease, at which point the lunate is considered to be unsalvageable due to collapse with hyaline cartilage delamination and fragmentation^{2,3}.

Fusion of the scaphocapitate (SC) and scaphotrapezialtrapezoid (STT) joints redistribute forces away from the radiolunate joint towards the radioscapoid joint aiming to alleviate pain, though this leads to a significant loss of wrist movement⁴. Proximal row carpectomy (PRC) has been shown to improve pain whilst

maintaining reasonable range of movement, grip strength and function⁵. There is, however, a risk with this procedure, of the development of secondary arthritis of the capitate⁵. Total wrist fusion (TWF) reliably relieves pain but at the expense of all wrist movement².

Pyrocarbon is a biocompatible synthetic material⁶, first used to create a lunate implant by Ascension OrthopaedicsTM (Texas, USA) in the late 2000s. Pyrocarbon has proven its reliability as an implant material elsewhere in the wrist⁶ to treat arthritis such as the carpometacarpal joint, however further studies are required to validate its use in replacing necrosed lunate. It has been proposed that this novel procedure be considered to treat Kienböck Disease where the lunate is compromised or unsalvageable, but the remaining carpal bones are intact¹.

The purpose of this case series is to document the outcomes of this newer implant.

SURGICAL TECHNIQUE

All surgeries were performed by two surgeons (MLS PJ). Surgery was performed under General Anaesthesia, with one dose of intravenous cephazolin given beforehand. A tourniquet was inflated prior to surgery and surgical loupes worn. A dorsal approach was performed between the third and fourth compartments. Neurectomy of the posterior interosseous nerve was performed at the time of surgery. In one case (Case 1) the wrist was arthroscopically inspected to confirm the disease and that the lunate bone could not be internally fixed. The joint capsule was opened and the lunate fragments excised. These were used to size the lunate replacement implant. Bony tunnels were drilled with a 2.7 mm cannulated drill through the scaphoid and triquetrum bones under fluoroscopy control. A palmaris graft was harvested and passed through these tunnels to prevent implant escape. The graft was then tied over the lunate replacement with the knot reinforced with 0 ethibond. The capsule and extensor retinaculum were closed with 1 vicryl. The skin was closed with 3-0 monocryl. The patients were placed in a plaster of paris. This was changed to a splint within a week of surgery. Once the wounds had healed gentle range of motion was started with the hand therapist. The splint was worn for 6 weeks after surgery.

CASE 1

A 39-year-old woman presented with a 3-month history of pain and swelling in her left wrist without any history of trauma. She is right-handed, and was working as a sales assistant at the time. Her wrist was obviously swollen and focally tender over the radiocarpal and mid carpal joint. She demonstrated a global reduction in range of movement. An MRI demonstrated a comminuted, minimally displaced fracture through the mid-pole of the lunate. CT corroborated the finding of a lunate fracture, also displaying moderate collapse. Surgical options were discussed with the patient, who elected to undergo lunate replacement surgery. At 8 months post-operatively, she was pain free with improved range of movement. She was unable to perform push-ups, but was otherwise operating at full function and planned to return to netball the following season. She demonstrated an average grip strength of 30.6kg/F on the left (operated side) compared with 39.6kg/F on the right. On her left she demonstrated flexion of 38 degrees and extension of 55 degrees. Plain radiographs demonstrated volar tilt of the prosthesis (capitolunate angle 63 degrees). Her qDASH score was 31.8%, and on satisfaction survey she indicated that she strongly agreed she would be likely to recommend a

lunate replacement as a management option to others in her situation.

CASE 2

An 18-year-old right hand dominant man presented after developing pain in the right wrist over an eight-month period. He worked as a manager in a fast food establishment, and was not playing any sport. A CT demonstrated mild collapse of the lunate with maintained alignment, and Lichtman IIIB Kienbock disease. Surgical options discussed included partial wrist fusion (SC or STT), lunate replacement, TWF and PRC. He elected to proceed with a Pyrocarbon lunate replacement procedure. At 6-weeks post operatively, his plain radiographs revealed a prosthesis with an increased dorsal tilt compared to intraoperative imaging. Tendon graft revision surgery was discussed with the patient, who elected to persist with his rehabilitation. At 2 years 3 months follow up, he reported an aching pain following functional use which settled with rest, and severe pain on accidental knocking. He was continuing to work in his role as manager. His grip strength on the right was 45.5kg/F compared to 58.7kg/F on the left. Range of movement testing revealed flexion of 45 degrees and extension of 50 degrees. Plain radiographs repeated at this review were unchanged from his 6-week images. This patient's qDASH score was 15.9% at 2 years 3 months follow up. On satisfaction survey, he agreed he would recommend lunate replacement as a management option to others patients.

CASE 3

A 40-year-old right hand dominant manual labourer reported a five-year history of atraumatic right wrist pain. His pain was felt dorsally, and not relieved by splinting. On examination, he was focally tender over the lunate with a modest range of movement causing discomfort. Plain radiographs and CT showed sclerosis of the lunate without significant collapse. An MRI displayed avascular necrosis of the lunate with sclerosis and multicystic degenerative changes, along with severe chondral thinning with full thickness loss at the ulnar aspect of the lunate. Surgical options were discussed and he consented to undergo lunate replacement surgery. He was advised to consider a less manual vocation. At nine-months post operatively, he reported excellent pain relief and had commenced career retraining in a non-manual role. His active range of movement was 47 degrees extension and 30 degrees flexion, with a grip strength of 22.13kg/F on the right compared with 38.03kg/F on the left, and his prosthesis was well aligned on

plain radiographs. He returned a qDASH score of 29.5% and strongly agreed that he would recommend the surgery to others in his position.

DISCUSSION

Traditional options for advanced Kienböck disease, such as limited fusion, are unattractive to high demand patients due to the loss of movement, and risk of leading to secondary arthritis elsewhere in the wrist⁵. Lunate replacement aims to maintain the normal architecture of the wrist, and preserve range of movement.

All patients in this case series reported they would recommend the procedure to others in their position; two patients reported that they strongly agreed to this likelihood, and one patient agreed. In two out of the three patients there was asymptomatic prostheses tilting despite a tendon graft being used to stabilise the implant. Of note, given the longevity of the lunate replacement is unknown, PRC and TWF can be utilised as salvage procedures should the pyrocarbon lunate replacement fail. To the authors' knowledge, there is no published literature comparing outcomes of PRC or TWF performed as a primary procedure versus following failed lunate replacement. Conversely, pyrocarbon lunate replacement cannot be used as a salvage procedure in the event that other surgical options fail.

In a study of 13 pyrocarbon lunate replacement recipients, Henry et al found favourable objective outcomes for patients who underwent the procedure to treat Kienböck disease³. The mean follow-up time for Henry et al's study was 30.3 months, compared with only 14.8 months in this case series. These 13 patients were shown to have a mean flexion/extension arc of 96.7 degrees, 85.2% of their contralateral grip strength, and a mean DASH score of 7.7%. Of note, qDASH and DASH scores can not be directly compared, as the qDASH questionnaire is known to yield higher scores than DASH⁷. Range of motion after lunate replacement is better than partial wrist fusion, which ranged from 77 degrees in STT fusion to 91 degrees in SC fusion^{4,8,9} which makes lunate replacement an attractive option to patients. Pyrocarbon lunate replacement appears to perform similarly to PRC in the short term, with a mean flexion/extension arc of 105 degrees in 15 patients, 87% of contralateral grip strength and mean qDASH score of 12%⁵. Follow up in the study by Croog et al is limited to 10 years, which would fail to capture the increased risk of progression of capitate arthritis as this is predicted to occur 10-20 years

post operatively⁵. Inconsistency of recorded outcome measures and variability of results for each intervention creates a challenge for objective analysis between interventions.

The surgical technique for this case series varied from that reported in Henry et al, in that a palmaris longus tendon graft was utilised in place of a flexor carpi radialis tendon graft. The stabilisation technique of utilising the coronal plane openings of the implant through which to weave the tendon graft remained consistent. Henry et al suggested that this technique was insufficient to maintain dynamic carpal stability, leading their surgeons to focus on stabilising the scaphoid and triquetrum with tendon graft to obtain indirect control of the lunate position in subsequent procedures³.

Lunate replacement with PyroCarbon prosthesis presents another surgical option to treat advanced Kienböck disease with an unsalvageable lunate. Lunate replacement carries the additional benefit, compared to fusion surgery, of preserving other surgical options as salvage procedures should the primary procedure prove unsuccessful. Consistent with previous studies, patient satisfaction following the procedure was high in this case series, despite less than optimal objective outcomes and radiographic abnormalities.

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