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## Functional outcome following vascularised pedicle graft from 4, 5 extensor compartment artery in patients with Kienbock's disease

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### Abstract

**Objective:** Surgical management of Kienbock's disease is debatable and there is no clear evidence of any procedure more efficacious over the other. Our aim was to evaluate the functional and radiological outcome of patients with Stage 2 and 3 Kienbock's disease who underwent vascularised bone graft from 4, 5 extensor compartment artery to lunate. **Methods:** We retrospectively reviewed patients, who underwent vascularised bone grafts (VBG) using 4 and 5<sup>th</sup> extensor compartment artery for Kienbock's disease, between 2013 and 2019. We excluded those secondary to trauma, negative ulnar variances and advanced stage of disease. We used the Visual Analogue Score (VAS) for pain, qDASH for the functional outcome and radiological assessment at final follow up. **Results:** Ten patients underwent VBG for Kienbock's disease stage 2 and 3a. They were all operated by a single specialist hand surgeon, using the same surgical technique where a bone graft was harvested from the distal dorsal radius with vascular pedicle from the 4<sup>th</sup> and 5<sup>th</sup> extensor compartment artery. The average age at surgery was 40.6 years. There were 7 males and 3 females. The mean follow-up is 30 months. At the final follow up the mean VAS is 2.6 out of 10 against 9.5 pre-operatively and mean qDASH is 25.4/100 against 70.7/100 pre-operatively. Radiographs at the final follow up showed no progression of disease. All patients reported improvement in range of movement following surgery. **Conclusions:** Our study has demonstrated that vascularised bone graft is a viable treatment option for Kienbock's disease stage 2 and 3 on a carefully selected group of patients with improvement in pain and function.

**Keywords:** Kienbock's disease, Vascularised pedicle graft, Extensor compartment.

### INTRODUCTION

Kienbock's disease was initially identified and described by an Austrian radiologist in 1910 and was coined the term lunatomalacia in 1920 by Müller W<sup>[1]</sup>. With the aetiology being unknown, several causative factors such as trauma, anatomic and systemic conditions have been attributed to Kienbock's disease. Despite the lack of knowledge of the potential aetiology, a common theory associated with Kienbock's disease is, disruption of blood supply to the lunate bone. Management of Kienbock's disease has been done based on radiological staging by Lichtman *et al.* in 2010<sup>[2, 3]</sup>. Negative ulnar variance has been attributed to progression of the disease whereas neutral or positive ulnar variance has been reported as favourable to prevent further collapse of lunate on patients with Kienbock's disease<sup>[4]</sup>. One of the major challenges in management of Kienbock's disease is its late presentation. The radiological finding may not correlate with the symptoms of the patient and they may present with minimal symptoms even at Stage 3A or B<sup>[5]</sup>.

The surgical management of Kienbock's disease is debatable and these include lunate unloading procedures, revascularisation, salvage procedure and replacement arthroplasty<sup>[6]</sup>. Most studies recommend joint levelling procedures such as radial shortening for patients with or without vascularised bone graft for patients with negative ulnar variance in Stage 2 to 3a cases<sup>[2, 7]</sup>. Management in the form of vascularised pedicle graft to prevent further collapse of the lunate by re-establishing the intraosseous blood flow has been advocated as one of the most successful outcomes for patients with Kienbock's disease in the early stages without negative ulnar variance. Moran *et al.* suggested the advantages of using the 4<sup>th</sup> and 5<sup>th</sup> extensor compartment artery based bone graft for the treatment of lunate osteonecrosis when compared to exclusively 4<sup>th</sup> extensor compartment artery<sup>[8]</sup>. Though, both the procedures demonstrated similar

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benefits, uncertainty regarding the viability of pedicle was a concern as the donor site is more proximal in case of vascularised bone graft using the 4<sup>th</sup> extensor compartment artery. On the contrary, 4 and 5<sup>th</sup> extensor compartment artery required longer surgical time associated with the risk of graft failure as a result of kinking. The aim of our study is to determine the functional and radiological outcome of patients with Kienbock's disease from Stages 1 to 3a based on Lichtman's classification utilising the 4<sup>th</sup> and 5<sup>th</sup> extensor compartment artery vascularised bone graft.

**METHODS**

We retrospectively reviewed consecutive patients from 2013 to 2019 who underwent vascularised bone graft using 4 and 5<sup>th</sup> extensor compartment artery for Kienbock's disease. The target population was those who had idiopathic osteonecrosis of the lunate, neutral ulna variance and Lichtman's stage 3a or below. Patients with negative ulnar variances and late stages of Kienbock's disease, which involved complete collapse of the lunate and associated arthritis has been excluded from the study.

The list of patients who underwent vascularised pedicle graft for Kienbock's disease was collected from the electronic operating theatre record from 2013 to 2019. Their clinical details were collected from the electronic patient record and radiographs from the picture archiving and communication system (PACS).

All the cases were operated by the senior author who is specialised in hand and upper limb surgery using the same technique where the graft was harvested from the distal dorsal radius with vascular pedicle from 4<sup>th</sup> and 5<sup>th</sup> extensor compartment artery. The patients were followed up at 2 weeks, 6 weeks and 6 months and yearly thereafter. All the patients were immobilised in a cast for the first 6 weeks and then mobilisation was started under the supervision of specialist physiotherapists. Patients were not allowed loading activities for the first 6 weeks, which was gradually introduced afterwards.

Following the surgery, antero-posterior and lateral view X-rays were taken at 6 month and at yearly follow-up to evaluate for further collapse of the lunate or development of arthritis. The pain was evaluated using visual analog score (VAS) on a scale of 1 to 10. Functional assessment was determined by patient related outcome measure using Quick Disabilities of Shoulder Arm and Hand (qDASH).

**RESULTS**

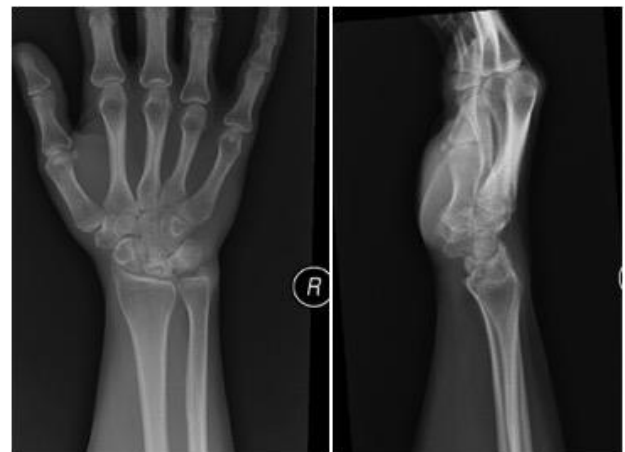
During the study period 10 patients underwent vascularised bone graft for Kienbock's disease. At the time of proposed plan for surgery 8 of the 10 patients were in Stage 3a and rest at Stage 2 of Kienbock's disease based on Lichtman's classification. There were 7 males and 3 females. The average age at the time of surgery was 40.6 years (range 34 - 68 years). The mean follow-up period was 30 months with a range of 12 months to 7 years.

At the latest review following the surgery and physiotherapy, patients showed satisfactory improvement in terms of function and pain. None of them had to amend their duties at work or activities of daily living. There was significant improvement in VAS score post-operatively at 2.6 out of 10 as against a score of 9.5 before the surgery. The mean qDASH score at final follow up was 25.4/100 (range 20.5 to 31.8) when compared to the pre-operative score of 70.7/100 (range 61.4 – 84.1). The patients also reported subjective improvement in range of movements to their wrists. Radiographs at final follow-up did not reveal any progression of the disease nor was there any decrease in carpal height or radio-scaphoid angle. Pre-operative and post-operative

radiographs of one of the patients are shown in Fig 1 and Fig 2. Pre-operative MRI scan of the same patient is shown in Fig 3. At the time of final follow-up, 9 of the 10 patients were still employed ranging from desk to heavy mechanical jobs and one patient had retired. Full details of the patients at their final follow up are listed in Table 1.

**Table 1:** Patient details at their final follow up

| Patient | Litchman's Stage | Follow up in months | VAS | qDASH | X-ray at final follow up | Job     |
|---------|------------------|---------------------|-----|-------|--------------------------|---------|
| 1       | 3a               | 73                  | 4   | 31.8  | No further collapse      | Chef    |
| 2       | 3a               | 36                  | 3   | 25.5  | No further collapse      | Office  |
| 3       | 2                | 19                  | 1   | 20.5  | No further collapse      | Joiner  |
| 4       | 3a               | 13                  | 2   | 23.9  | No further collapse      | Office  |
| 5       | 3a               | 15                  | 2   | 24.7  | No further collapse      | Sales   |
| 6       | 3a               | 18                  | 3   | 26.2  | No further collapse      | Retired |
| 7       | 3a               | 12                  | 4   | 28.3  | No further collapse      | Sales   |
| 8       | 3a               | 17                  | 2   | 22.6  | No further collapse      | Office  |
| 9       | 2                | 55                  | 3   | 25.2  | No further collapse      | Farmer  |
| 10      | 3a               | 41                  | 2   | 21.3  | No further collapse      | Sales   |



**Figure 1a & 1b:** Pre-operative radiographs – Antero-posterior (1a) and Lateral (1b) of the wrist showing lunate sclerosis and collapse with neutral ulnar variance



**Figure 2a & 2b:** Post-operative radiographs - Antero-posterior (2a) and Lateral (2b) of the wrist showing no further collapse at latest follow up



**Figure 3:** Preoperative MRI scan T1 weighted images showing decreased signal intensity of lunate

There were no reported complications following the operation and none of them underwent further surgical intervention at their final follow up.

## DISCUSSION

Many studies have been conducted to determine a convincing management option for Kienbock's disease but none of them have proven its superiority over the other.

Conservative management in the form of wrist splints and/or cast immobilisation or no treatment in early stages of Kienbock's disease was proposed by Tajima *et al.* who conducted the study on 80 patients and found no difference in outcome for operative or conservative management [9]. Where as a case series by Kristensen *et al.* comparing immobilisation with no treatment proved to have progressive lunate collapse and wrist pain in his study of 49 patients [10]. Keith *et al.*, in his study of 33 patients, managed conservatively with a period of immobilisation, physiotherapy and analgesics, concluded that irrespective of the type of management, the disease will run its course with patients returning with decreased range of movements, pain and deterioration of grip strength [11].

Operative management was not found to be superior over conservative management in a retrospective study comparing both. In fact a quarter of patient who underwent operative management was noted to have reduced range of movement and change in social activities for a small gain in grip strength [12]. Therefore surgical management should be considered carefully for patients who are continuing to be symptomatic following a period of conservative management while bearing in mind the risks associated with it. Overall the surgical management of Kienbock's disease fall in to three categories, procedures to off load lunate, procedures to revascularise lunate and salvage procedures in advanced stages.

Joint levelling procedures such as radial shortening osteotomy has been suggested for patients with negative ulnar variance to off load lunate especially the early stages of Kienbock's disease where there is no carpal collapse or arthritic changes. In a study comparing with conservative management, radial shortening osteotomy was noted to provide significant pain relief and improve grip strength. However it did not reverse or prevent radiological progression in stage 3 disease but only delayed it [13]. In a long term follow up study Altay *et al.* showed comparable outcome for radial shortening osteotomy for both stage 3a and stage 3b disease [14]. Koh *et al.* found improvement in pain, range of movement and grip strength were maintained with radial shortening osteotomy at a minimum follow up of 10 years when they compared their results at 5 years [15]. Even though it does not cure the disease process, radial shortening osteotomy has been found to have subjective

improvement and high satisfactory rates in patients with negative ulnar variance [16].

Revascularisation procedures are aimed at addressing the primary pathology of avascular necrosis of the lunate. There are several options described which includes implantation of the dorsal metacarpal vascular pedicle or a vascularised bone graft. The bone graft is usually harvested with a pedicle from the inter-compartmental or compartmental artery from the dorsal aspect of the distal radius. Where as Arora *et al.* published a large series of 23 patients with stage 3 Kienbock's disease treated with free vascularised iliac bone graft. Over a mean follow up of 13 years they noticed disease progression only in 3 of their patients (13%) [17]. In a small series of 5 patients with stage 2 and 3 disease, Kirkeby *et al.* reported good long-term radiological and clinical outcome (mean 7.4 years) when treated with a pedicled vascularised bone graft from 4/5 distal radius extensor compartment. There were no reoperation and all the patients were fully satisfied [18]. There are a few short to midterm results following vascularised bone graft have been reported in the literature with good functional outcome [8, 19, 20].

In a systematic review by Tsantes *et al.*, total of 92 patients with Kienbock's disease treated with vascularised bone graft from different sources noted to have significant improvement in pain and grip strength where as the range of movement did not show a statistically significant improvement [21]. Nakagawa *et al.*, compared the results of vascularised bone graft for stage 2 and 3 Kienbock's disease from three different donor sites (4/5 extensor compartment artery, first and second suparetinacular intercompartmental artery of distal radius and second metacarpal neck graft) in 28 patients. They all had been shown to have a favourable and comparable functional outcome [22].

Vascularised bone graft procedure can also be used in conjunction with temporary or permanent lunate unloading procedure. The indications for such procedures were not clear and there were varied opinions on when to choose the temporary or permanent unloading procedure. These combined procedures were also shown to have improved grip strength and reduced pain in patients with stage 3 Kienbock's disease but at the expense of range of wrist movements [23].

The other options of surgical management described in early stages include core decompression of lunate and procedures to preserve carpal height like intercarpal fusion. In the later stages when there are advanced degenerative changes salvage procedures like proximal row carpectomy or wrist fusion could be considered.

In our study we also showed a good functional outcome with vascularised pedicle graft from 4/5<sup>th</sup> extensor compartment artery for Kienbock's disease stage 2 and 3a, which adds to the literature. There are certain limitations to our study. There were no MRI scans performed post-operatively to assess the vascularity of the lunate, as all our patients reported improvement in their symptoms, there were no clinical indications. We did not record range of movements and grip strength preoperatively therefore we could not compare the results. However none of the cohorts reported change of employment except for one who retired at the time of last follow up.

## CONCLUSION

Vascularised bone graft using the 4/5<sup>th</sup> extensor compartment artery is a viable treatment option for treatment of patients with early stages of Kienbock's disease. This study though with few limitations, garnered favourable outcome for the patients with reduction in pain, no further collapse of the lunate and good functional outcome scores.

## Conflict of Interest

None to declare

**Authors' Contribution**

**Mr. V Ramsingh** – Data collection and interpretation, drafting and critical revision of the article

**Mr. N Jayapal** – Data collection and interpretation, drafting the article

**Mr. A Morris** – Senior surgeon undertaken the surgical procedures, overseen article drafting

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