

FUNCTIONAL AND RADIOLOGICAL OUTCOME OF KIENBOCK'S DISEASE TREATED WITH VASCULARIZED BONE GRAFTING FROM DISTAL RADIUS

Om Prakash Yadav¹, Pandiyan. L.², D. Thulasi Raman³, P. V. Raveendra Reddy⁴, Kiran Sasi Peringathara⁵

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Corresponding Author:

Dr. P.V.Raveendra Reddy

Email: raveendrareddyperam90@gmail.com

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¹Associate Professor, Department of Orthopaedics, Lord Budha Koshi Medical College and Hospital Saharsa Bihar, India.

²Assistant Professor, Department of Orthopaedics, Arunai Medical College and Hospital, Velu Nagar, Thenmathur, Tiruvanamalai, Tamil Nadu, India.

³Professor and HOD, Department of Orthopaedics, Meenakshi Medical College Hospital and Research Institute, Kanchipuram, India.

⁴Professor, Department of Orthopaedics, Dhanalakshmi Srinivasan Medical College and Hospital, Trichy Tamilnadu, India.

⁵MCh Hand Surgery, MS Ortho, D Ortho, DNB Ortho, Prime Healthcare, Dubai.

Abstract

Background: The purpose of our research is to study if Vascularized bone grafting from distal radius effectively relieves pain and restores wrist function and return to near normal activities in Kienbock's disease. **Materials and Methods:** A retrospective study was performed on patients who underwent distal radius vascularized bone grafting for Kienbock's disease in Paul Brand centre for Hand and leprosy Reconstructive Surgery from march 2023 to December 2024. Demographic data including history of trauma, ulnar variance, duration of symptoms, preoperative pain intensity with VAS scale and Preoperative Carpal Height ratio and Stage of disease are collected and follow-up period was studied. Donor Vessel of grafting recorded. Post-operative Plain radiographs were used to assess revascularization of the lunate with Carpal Height Ratio. Functional outcome was assessed with Modified Mayo Wrist Score and graded as excellent, good, satisfactory and poor and compared with similar studies by other authors. **Result:** The average postoperative pain intensity is 1 whereas preoperative pain intensity was 6 and there was statistically significant pain relief with P value 0.001. Average preoperative volar flexion and dorsiflexion are 47 and 52 whereas postoperative are 41 and 44 is not statistically significant. The average preoperative Carpal Height ratio was 0.45 while postoperative was 0.49. Improvement in Carpal Height Ratio was statistically significant with P value 0.001. **Conclusion:** In this study concluded that the Vascularized bone grafting from distal radius for Kienbock's disease provides good pain relief and prevents further collapse of lunate and in most of the patient restores preoperative employment status.

INTRODUCTION

Lunate is one of the carpal bones. Lunate is present in proximal carpal row. Lunate name was derived from Latin Luna which means moon Lunate is keystone in proximal carpal row. Lunate bone is uniquely positioned at the middle of the coronal and transverse Carpal arches. Stability of the proximal row is allowed by critical attachments of ligaments between the lunate, the scaphoid and the triquetrum. The lunate is the intercalated segment between the distal carpal row and the radius.^[1] Kienbock's disease is avascular necrosis of Lunate. Most commonly affects dominant hands of males in

20 to 40 years of age who are actively involved as labourers. Bilateral involvement is rare. Etiology is unclear and mostly multifactorial. Kienbock's disease was staged by Lichtman into four stages.^[2] Treatment of Kienbock's disease management depends on duration of symptoms, stage of the disease and Ulnar variance. Treatment options include immobilization, Joint-leveling procedures, selective intracarpal arthrodesis, revascularization procedures for Lunate and salvage procedures like proximal row carpectomy and wrist arthrodesis.^[3] Vascularized bone grafting is the one of the treatment options till the cartilage shell of the lunate is intact. Vascularized bone grafting is a management option

for Lichtman stage 1 to stage IIIB. Patients with vascularised bone grafting for Kienbock's Disease will have good relief from pain and return to near normal activities.

MATERIALS AND METHODS

Institutional Review Board and Ethics committee approval was sought for the study. A retrospective analysis was performed on the data collected from patients who underwent Vascularized bone grafting from distal Radius for Kienbock's Disease in the Paul Brand Centre for Hand and Leprosy reconstructive Surgery between March 2023 to December 2024.

Inclusion Criteria

1. Kienbock's disease patients treated with Vascularized bone graft from distal Radius whose preoperative X-ray and preoperative records were available.

Exclusion Criteria

Patients without preoperative radiographs and incomplete pre-operative data and patients with associated fractures of the other carpal bones. The data was collected from medical records, Radiographs and physiotherapy register and operation registry. The collected data included demographic data, pre-operative pain using VAS scale, Duration of pain, side of pain, history of trauma, Stage of disease, pre-operative range of movement, Ulnar Variance and pre-operative Youm's Carpal Height Ratio. Most of the Details of donor vessel of the vascularized bone graft and any associated procedures were collected from the operation registry. Data of any other subsequent procedure was also collected.

The following data was collected at final follow up

- Present Pain using VAS Scale
- Active range of Movement
- Youm Carpal Height Ratio
- Grip strength using Hand held Dynamometer
- Present employment status in comparison to pre-operative employment status
- Functional score using Modified Mayo Wrist Score.
- Closed tendon injuries
- Any other complications

At final follow-up informed consent is taken. Present pain is assessed with Visual analogue scale consisting from 0 to 10.

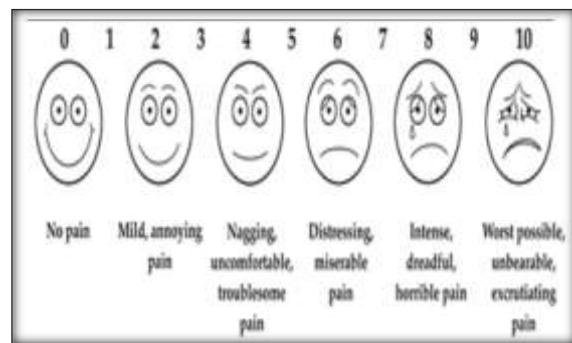


Figure-1: Visual analogue scale for Pain

Active Range of movement is assessed using Goniometer. Active volar flexion, Dorsiflexion, radial and ulnar deviation are recorded.



Figure 2: a) Assessment of active DorsiFlexion of wrist; b) Assessment of active wrist Volar flexion

Plain radiographs in both antero-posterior and lateral views of the involved wrist with hand. Youm's carpal height ratio is measured in antero-posterior view. Carpal height ratio is calculated as ratio of carpal length to third metacarpal length as described by Youm¹². Normal carpal height ratio is 0.54 ± 0.0312 . Ratio of Carpal height to the capitate length is the revised carpal height ratio. Revised carpal height ratio is used instead of carpal height ratio if entire length of third metacarpal is not present in the plain radiograph. The revised carpal height ratio is reliable, reproducible, constant in normal population, bilaterally consistent, decreased in carpal collapse.

Grip strength of the involved wrist and contralateral wrist are assessed with hand held dynamometer (Biometrics Limited, United Kingdom). Grip strength is assessed as percentage of grip strength of involved wrist with contralateral wrist. Present employment status of the participant is assessed and compared with pre-operative employment status.

Functional score is assessed with modified Mayo Wrist score. Modified Mayo wrist score consists of four components each carrying 25 points, total of 100 points. Modified Mayo Wrist score is composed of pain intensity, present employment status in relation to pre-operative employment, range of movement as

percentage of contralateral wrist or total range of movement of involved wrist in degrees and grip

strength of involved wrist as percentage of contralateral wrist. Final score is graded as follows

Table 4: Grading of Modified Mayo wrist score

Score of 90-100 Excellent
Score of 80-90 Good
Score of 60-80 Satisfactory
Score <60 Poor

Data collected from participants at final follow-up include post-operative complications like closed tendon injuries, infection and any other complications participants noticed.

RESULTS

Seventeen patients underwent Vascularized bone grafting of lunate from distal radius between March 2023 to December 2024. One patient was excluded due to unavailable preoperative radiographs. 13 out of 16 patients came for follow-up.

Age Distribution

Graph 1 shows that more than 75% of the patients were in 20-40 year age group, similar to the data in other studies. The mean age was 29 years and ranged from 15 to 44 years.

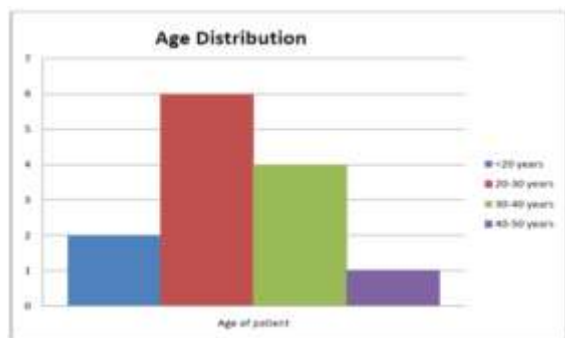


Figure 1: Age Distribution

Sex wise distribution

Our study has 10 female patients who underwent vascularized bone grafting of lunate from distal

radius while 3 are male patients. Reported incidence is more common in male patients. Reported incidence male: female is 2:1.

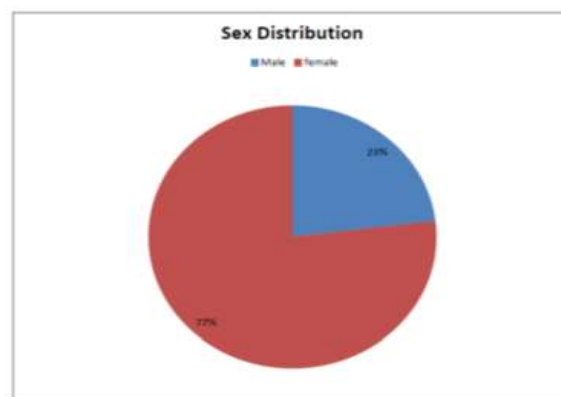


Figure 2: Sex Distribution

Incidence of Trauma

Table 1 Shows those 4 out of 13 (36%) patients are presented with history of trauma to the involved hand and 9 out of 13 (64%) patients are not presented with history of trauma. Reported literature is history of trauma is one of the etiologic factor which is either repetitive microtrauma or macrotrauma. In our study only 4 patients presents with macrotrauma. Repetitive microtrauma causes either compromise of lunate vascularity or fracture resulting progression of the disease.

Table 1: Incidence of Trauma

Particulars	Number of patients	Percentage
History of Trauma	4	36%
No History of Trauma	9	64%

Side of Hand

Table 2 shows that 5 out of 13(38%) are with right hand involvement while 8 out of 13 (72%) patients are with left hand involvement. Literature shows dominant hand is most commonly involved but in our series more patients showed involvement of non-dominant side.

Table 2: Side of Hand

Particulars	Number of patients	Percentage
Right Hand	5	38.46%
Left Hand	8	61.53%

Stages of Diseases

Figure 3 shows represents that one patient (8%) was stage I, 5 patients (38%) each with stage II and stage IIIA and 2 patients (15%) are with stage IIIB disease.

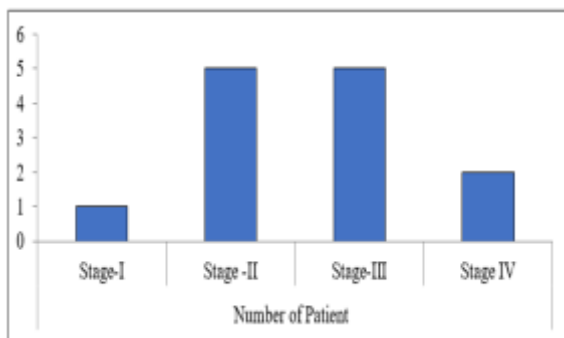


Figure 3: Stages of Diseases

Incidence of ulnar Variance

Figure 4 illustrate that Our study shows 8 out of 13 patients (62%) are with ulnar negative variance whereas 5 out of 13 Patients (38%) are with neutral or ulnar positive variance.

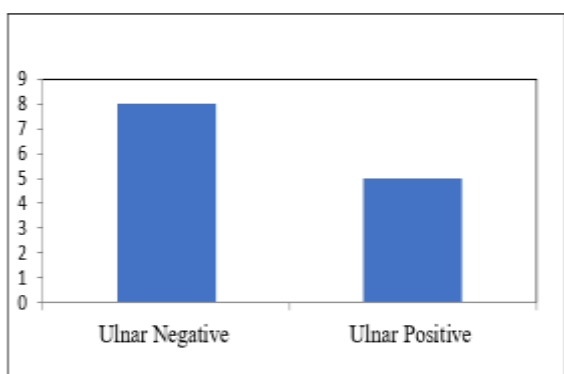


Figure 4: Incidence of ulnar variance

Pain Score

Figure 5 represents that the mean pain score of 6 preoperatively, range from 4 to 8 and postoperative mean score of 1 with range 0 to4. Statistically significant pain relief achieved with Vascularized bone grafting for lunate from distal radius (P value is 0.001). 8 out of 13 patients(62%) are completely relieved of pain at present. 12 out of 13 patients(92%) shows significant improvement in pain whereas 1 out of 13 patients(8%) shows only minimal improvement in pain. Our study results are correlated with 92% of patients showing significant improvement in pain.

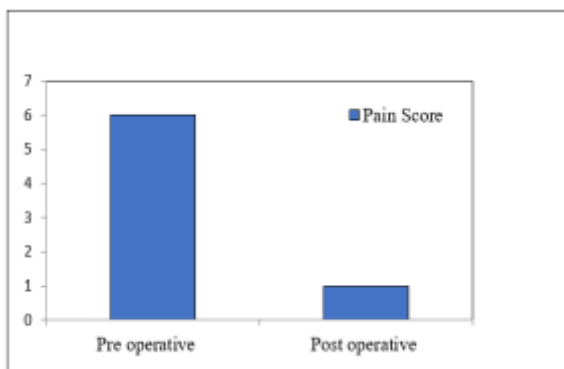


Figure 5: Pain Score

Duration of Symptoms

Duration of symptoms range from 9 months to 5 years with average duration is 2 years. One patient presents with duration of symptoms for 9 months, four patients presented with 1 year duration of symptoms, one patient presented with 14 months of symptoms and 18 months, two patients presented with 2 years of symptoms, one patient presents with 2 ½ years of symptoms and one patient each with 3 years, 4 years and 5 years.

Range of Movement

Fig. 6 Indicates that the mean preoperative volar flexion is 47 degrees range from 30 to 70 degrees while postop mean is 41 degrees range from 25 to 60 degrees with p value is 0.21. Pre-operative dorsiflexion mean is 52 degrees with range from 30 to 80 degrees while postoperative mean dorsiflexion is 44 degrees with range from 20 to 60 degrees with p Value is 0.181. There is decrease in both volar flexion and dorsiflexion postoperatively, but this is statistically not significant.

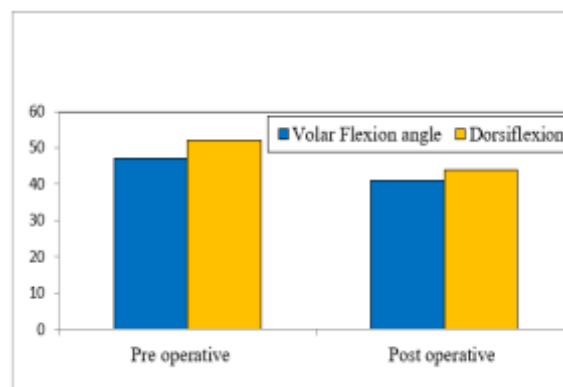


Figure 6: Range of Movement

Grip Strength

mean pre-operative grip strength of 45 percent ranged from 35 to 60 percent whereas mean postoperative grip strength of 79 percent with range from 57 to 100percent with P value is 0.001. Three patients achieved grip strength as equal to the contralateral hand. Right hand patients achieved better grip strength than left hand patients as right hand is dominant usually.

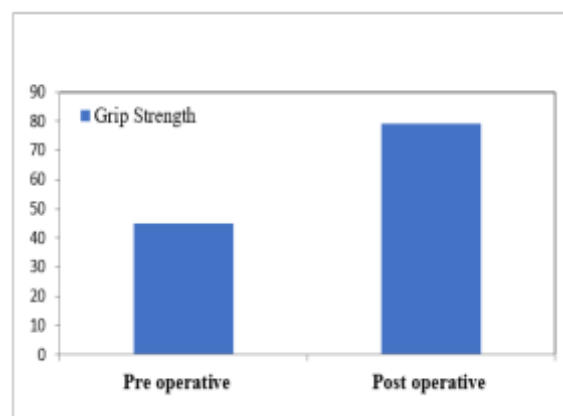


Figure 7: Grip Strength

Functional score

Functional score is assessed using Modified Mayo wrist score which consists of pain intensity,

present employment status, range of movement and grip strength.

Table 3: Modified Mayo wrist score

Score of 90-100	Excellent
Score of 80-90	Good
Score of 60-80	Satisfactory
Score <60	Poor

Graph 7 and Figure 45 shows 2 out of 13 patients(15%) achieved excellent function, 7 out of 13 patients (54%) achieved Good function, 3 out of 13 patients(23%) satisfactory function whereas 1 out of 13 patients(8%) achieved poor function. Our study shows more than 90% achieved satisfactory to excellent function. 12 out of 13 patients are satisfied with the procedure except 1 patient who had poor outcome. Our study results are similar to the satisfactory results of other studies.

Follow-up Period

Average follow-up period is seven years four months with range from 9 months to 15 years. One patient each is followed-up for fifteen years and twelve years , two patients are followed-up for ten years, three patients each are followed-up for nine and two years

and two patients are followed-up for 7 ½ years while one patient is followed-up for 9 months.

Carpal Height Ratio

preoperative carpal height ratio is 0.45 with range from 0.38 to 0.52 whereas average of postoperative Carpal height ratio is 0.49 with range from 0.40 to 0.57 with P value 0.001. Progression of carpal collapse was prevented in 12 out of 13 patients(92%) whereas carpal collapse was progressed in 1 out of 13 patients(8%). Statistically significant revascularization of Lunate bone present. Results of study are in correlation with seventy two percent of patients showed no further collapse on postsurgical radiographs³⁴. In One patient in our study who was not satisfied with the procedure progressed from stage I to Stage IIIA radiologically.

Table 4: Carpal Height Ratio

Particulars	Carpal Height Ratio	Significance
Pre operative	0.45	P<0.001
Post operative	0.49	

Adjuvant Procedure

9 out of 13 patients(69%) patients underwent Scapho-Capitate transfixation with K-wires as adjuvant procedure to temporarily unload lunate during initial revascularization phase whereas 4 out of 13 patients(31%) underwent scapho-lunate transfixation with K-wires. Subsequently 8 patients(62%) of patients underwent K-wire removal as Day care procedure and one patient had Extensor tendon reconstruction.

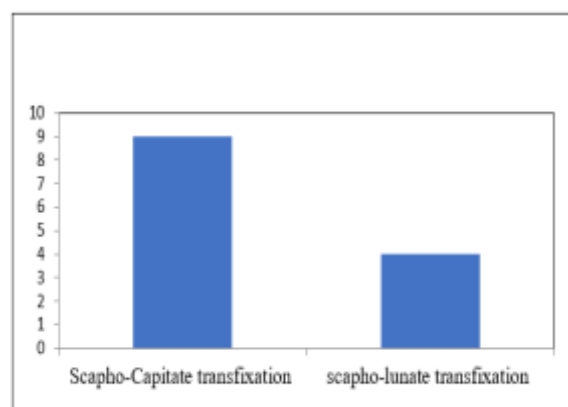


Figure 8: Adjuvant Procedure

Complications

One patient had attrition rupture of Index extensor tendons of operated hand. No patients had infection

or any other post-operative complications. Attrition rupture of these extensor tendons occurred about 3 years after vascularized bone grafting. No history of trauma precipitating extensor tendon rupture present. Patient had rupture of Extensor Digitorum Communis tendon of index finger and Extensor Indicis Proprius tendon. He presented with index finger drop of the involved right hand. He had undergone vascularized bone grafting of lunate from distal radius based on 2,3 Inter compartmental supra Retinacular artery. Finger Extensor or flexor closed tendon rupture is a common complication of kienbock's disease⁶⁵. No history of pain present before rupture in our series. Patient with extensor tendon closed injury had stage II kienbock's disease at the time of surgery. In other reported series patients who had closed tendon rupture had either stage IIIB or Stage IV. Closed tendon rupture usually associated with rupture of capsule of wrist either volar or dorsally. Normally rupture of closed tendon happens in non-operated patients. Closed tendon rupture can be either of extensor tendon or flexor tendon and occurs in activities requiring strenuous labour like farming; cleaning or construction activities⁶⁵. Closed tendon rupture occurs more commonly in elderly patients over 50 years of age⁶⁵. Patients with closed tendon. Friction is the main cause of rupture, mostly mechanical⁶⁵. Bony spur or fragment causes torn of

wrist joint capsule with extensor tendon rupture just immediately above the osseous lesion. Kienbock's disease normally have extensor tendon rupture of fourth compartment and radial side flexor tendon injury whereas ulnar sided extensor injury occurs in the distal radioulnar diseases. Other causes of closed tendon ruptures around wrist include Colles fracture, Distal radio-ulnar joint osteoarthritis⁶⁷ and hook of hamate non-union⁶⁸ and Rheumatoid arthritis



Figure 4: a) Antero-posterior and lateral radiograph showing Lichtman stage II disease; b) Postero-anterior showing stage II disease and lateral view showing bony spur of Lunate along with Kirschner wire protruding on the dorsal side at the time of closed rupture of extensor tendon; C) Postero-anterior radiograph showing revascularization of Lunate with Vascularized bone grafting;

Patient presented with sudden loss of index finger extension due to rupture of Extensor Digitorum Communis and Extensor Indicis Proprius. Patient underwent Extensor. Digiti Quinti Proprius transfer to EDC of index finger using Pulvertaft technique. Extensor digiti Quinti is also called as Extensor digitiminimi. Extensor digitiminimi originates from lateral epicondyle of the humerus and it crosses two joints. Extensor digitiminimi extends wrist joint and extends little finger. At 6 years follow up patient has 5 degrees of lag at meta carpo phalangeal joint of index finger with full finger closure. Patient attained about 83 percent grip strength in comparison to contra lateral wrist. Patient attained preoperative employment status.



Figure 5: a) Biometric hand held dynamometer assessing grip strength of involved hand; b) showing finger extension with lag of index finger at MCP joint; C) Showing complete closure of fingers and wrist joint

DISCUSSION

Re-establishing a new blood circulation within lunate is the intuitive solution for avascular necrosis of the lunate. Vascularized bone grafting has been used successfully in avascular necrosis of femoral head and Scaphoid proximal pole avascular fracture. Significant pain relief present in 92% of patients with 4+5 ECA vascularized bone graft.^[4] Improvement in pain is noticed in 16 of 21 patients without improvement in range of movement after surgery with replacement of lunate by vascularized pisiform transfer (Saffar's procedure) for late Kienbock's disease patients⁴⁰. Radial recession osteotomy is the joint-leveling procedure for kienbock's disease with ulnar minus wrist. Radial recession osteotomy provides pain relief in more than 90% of patients.^[5] Pain is improved in 20 out of 23 patients with Lunate reinforcement with vascularized Os Pisiform.^[6] Nine patients out of eleven patients had significant long term pain relief with implantation of second dorsal metacarpal artery and its venae comitantes into a hole which is made in lunate and packing of cancellous bone from dorsal distal radius.^[7] In our series Statistically significant pain relief achieved with Vascularized bone grafting for lunate from distal radius (P value is 0.001). 8 out of 13 patients(62%) are completely relieved of pain at present. 12 out of 13 patients(92%) shows significant improvement in pain whereas 1 out of 13 patients(8%) shows only minimal improvement in pain.

Range of movement was improved from 68% to 71% of the unaffected side with vascularized bone graft based on 4+5 ECA.^[4] Range of movement is significantly increased in comparison to Preoperative values but only 80% that of unaffected side 41. Range of movement was significantly improved after radial osteotomy and vascularized bone grafting in early stages¹⁷. In our series, range of movement is decreased in comparison to pre-operative range of movement. Wrist flexion extension arc pre-operatively is 99 degrees while postoperative is 85 degrees. Preoperative mean volar flexion was 47 degrees whereas postoperative was 41 degrees but decrease in volar flexion is 86 not statistically significant. Preoperative mean dorsiflexion was 52 degrees whereas postoperative was 44 degrees but decrease in dorsiflexion is not statistically significant.

Hori *et al*,^[8] found revascularization of the lunate in 9 patients with vascular pedicle from dorsal metacarpal implanted directly into the lunate⁷⁰.Lunate collapse is prevented by vascularised pisiform transfer in 16 of 22 patients in the long term follow-up⁴¹.Seventy-seven percent of patients showed no further collapse on postsurgical radiographs³⁴. In our series four donor vessels are used for vascularized bone grafting from distal radius. Our study shows further progression of carpal collapse is prevented in all except one patient, where stage I progressed to Stage IIIA.

Our study shows 92% of patients showed no further collapse on postsurgical radiographs. Carpus alignment was restored only partly and half of the patients develops osteoarthritis with Saffar's procedure. Changes in radiological parameters are not statistically significant in any procedure other than statistical significant worsening after radial osteotomy in the early stage of Kienbock's disease. Eighty five percent of patients showed satisfactory results based on the Lichtman outcome score. In our series 2 out of 13(15 percent) patients showed excellent results, 7(54 percent) patients showed good results, 3 (23 percent) patients showed fair results whereas 1 (8 percent) patient showed poor result based on modified mayo wrist score. In our study ninety two percent of patients showed satisfactory result.

Our clinical results in Stage IIIB after vascularized bone grafting are promising. Only two patients had stage IIIB disease. Both patients had good pain relief and minimal increase in carpal height ratio in postoperative radiographs. Stage IIIB results are in comparison with early stage kienbock's disease in pain relief and grip strength. Results are promising in stage IIIB patients treated with vascularized bone grafting in our series.

CONCLUSION

Distal radius vascularized bone grafting for kienbock's disease as an effective treatment method. The most commonly used 4+5 ECA vascularized radius graft requires less extensive dissection with preservation of the radiocarpal palmar stabilizing ligaments and technically easier than Zaidenberg's procedure which was used initially for

revascularization. Attractive procedure for either ulna neutral or positive ulna variant. Temporary unloading of the lunate with either scapho lunate or scapho-capitate transfixation procedure should be done along with vascularised bone grafting of lunate to facilitate revascularization of the Lunate. In long term follow-up there was only minimal improvement in radiological parameters like carpal height ratio. But satisfactory functional results were obtained in most of the patients. Vascularized bone grafting will continue to play a role in Kienbock's disease treatment.

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