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Bahaa A. Kornah

*Department of Orthopedics, Faculty of Medicine - Al Azhar University, Cairo Branch, Egypt*

Amro A. Fouaad

*Department of Orthopedics, Faculty of Medicine - Al Azhar University, Cairo Branch, Egypt*

Ahmed N. El-zebidy

*Department of Orthopedics, Faculty of Medicine - Al Azhar University, Cairo Branch, Egypt,*  
ahmedalzbedy36@gmail.com

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# Scapho-capitate Fusion in Grade (III C) Kienböck I Disease (Short Time Follow-up)

Bahaa Ali Kornah, Amro Ahmed Fouaad Attia, Ahmed Nasr Mohamed El-Zebidy\*

Department of Orthopedics, Faculty of Medicine - Al Azhar University, Cairo Branch, Egypt

## Abstract

**Background:** Kienböck's disease is a vascular-necrosis wrist condition in addition to osteo-necrosis, lunato-malacia or ischemic-necrotic of the lunate bone. According to Lichtman in 2010, determine the third stage C (III C) of Kienböck's disease which characterized by chronic-coronal-fracture of lunate bone.

**Aim:** To study scaphocapitate with lunate excision fusion for symptomatic III C Kienböck's disease with short-time follow-up.

**Patients and methods:** A retrospective study included 20 patients conducted in a 60 months duration, the period from January 2017 to January 2022 in orthopedic department of Al-Hussein Hospitals, Al-Azhar University with postoperative short-time 6 months follow-up.

**Results:** The findings revealed that; Mean flexion range of operated side was nonsignificant increased to  $47.6 \pm 7.9$  (25–40) and extension range  $58.5 \pm 10$  (55–69) ° postoperative Dash score postoperative, the lowest represent 25 while the highest represent 33 *P* value 0.05.

**Conclusion:** Scaphoapitate fusion with lunate excision has the potential to become a widely used surgical option for patients of advanced III C Kienböck's disease.

**Keywords:** Scaphocapitate fusion, Lunate excision, Kienböck's disease, Fouad's score

## 1. Introduction

Kienböck's disease is a condition characterized by a vascular necrosis of the lunate bone.<sup>1</sup> It is also known as osteonecrosis, lunatomalacia, and aseptic or ischemic necrosis of the lunate. Although the mechanisms by which this disorder develops are not fully understood, compromise of the bone vasculature is the most commonly proposed cause. Kienböck's disease is often progressive, resulting in joint destruction within 3–5 years if left untreated.<sup>2</sup>

Depending on Classification of Lichtman and colleagues<sup>3</sup> in 1977 modified Stähl's original radiologic classification system to help select the most appropriate treatment of each patient.<sup>4</sup> In 2010, Lichtman and colleagues<sup>5</sup> introduced a new stage III C, which corresponds to chronic coronal lunate fracture.

Repetitive manual labor was reported as a risk factor but currently is recognized as a factor aggravating symptoms of an already established disease. Usually one hand is affected; only 4% of cases of the disease are bilateral.<sup>6</sup> It is known that there is an association between Kienböck's disease and type 1 diabetes mellitus, systemic lupus erythematosus, and Legg-Calve-Perth's disease.<sup>7</sup>

Treatment of Kienböck's disease varies, starting from conservative modalities to surgical procedures, although none of the gold standard.<sup>7</sup> The algorithm of treatment depends on clinical and radiological symptoms. According to staging and ulna position, either positive or negative, there is different procedures for the management of Kienböck's disease starting from conservative treatment, drilling, distal-radius shortening, capitate shortening, partial wrist fusion or proximal raw carpectomy or ending with total wrist fusion.<sup>8</sup>

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\* Corresponding author. 6th of October Hospital for Health Insurance at Dokki, Egypt.  
E-mail address: [ahmedalzbedy36@gmail.com](mailto:ahmedalzbedy36@gmail.com) (A.N.M. El-Zebidy).

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This study aim to evaluate the clinical and radiologic outcomes of scapho-capitate fusion for the treatment of stage III C Kienböck's disease with postoperative follow-up.

## 2. Patients and Methods

Institutional ethics approval was obtained before the start of the study. A prospective and retrospective study included 20 patients conducted in a 60 months duration, the period from January 2017 to January 2022 in orthopedic department of Al-Hussein Hospitals, Al-Azhar University with postoperative short-time 6 months follow-up. Age 17–50 years-old, Both sexes, Kienbock's disease III C were included, tha 17 or more than 50 years-old, Patients complaining of wrist arthritis and Radiocarapal arthritis and intercarapal arthritis were excluded. All included patients were preoperative examined with: complaining of pain and limited range of motion was confirmed clinically examined the affected and contralateral wrists. Pain assessment by visual analog scale (VAS). Range of motion (ROM), Radiographic evaluation, Radiological staging, X. Ray, C.T scan and MRI scan. Intra-operative Surgical procedure: All patients was in supine position. The operation was done under general anesthesia or regional anesthesia, 15 regional and 5 general, Tourniquet was used 200 mmHg. Operative steps and Open dorsal approach for all patients. A radial and ulnar subcutaneous undermining was performed for partial wrist denervation. The extensor retinaculum was incised between the 3rd and 4th extensor compartment.

The denervation was completed by a resection of the terminal branch of the posterior interosseous nerve. After retracting the extensor tendons, an arthrotomy was performed by a T-shape opening of the articular capsule. A lunate excision was then performed. Followed by preparation of the articular surfaces between the scaphoid and the capitate using a bone drill.

Correction of scaphoid flexion was performed using a Kirschner (K-) wire inserted into the bone and allowing a 'joystick' effect. The scaphoid was fixed when the radio-scaphoid angle was less than 60. The arthrodesis between scaphoid and capitate was fixed using two K-wires in 10 cases and 9cases with two screws and one screw and one K wire in one case. Distal radius Cancellous bone autograft was added in 12 cases, In 8 cases, no bone graft was used; In all cases the triquetrum was left in place to avoid ulnar translation of the carpus.

Intra operative assessment under C. Arm to ROM, Anatomical closure was done to capsule then

compartments, extensor pollicis longus left free, subcutaneous closure, skin closure A hand forearm cast was held in place for a mean of 2.7 months (range 2–3 months). Less in Herbert screw than K wire. After Consolidation Rehabilitation started after cast removal. Kirschner wires were removed 2–3 months postoperatively.

### 2.1. Post-operative assessment

All the patients were examined at follow-up by a clinician independent from the case surgeon. Clinical evaluation analyzed pain level on a VAS, Joint mobility measured by a goniometer, Grip force was measured by the sphygmomanometer, Quick DASH and fouaad scores were also performed.

### 2.2. Clinical examination

Painless range of motion and good consolidation.

### 2.3. Radiological examination

X-ray.

### 2.4. Scoring system assessment

#### 2.4.1. - Dash score

The main part of the DASH is a 30-item disability/symptom scale concerning the patient's health status during the preceding week. The items ask about the degree of difficulty in performing different physical activities because of the arm, shoulder, or hand problem (21 items), the severity of each of the symptoms of pain, activity-related pain, tingling, weakness and stiffness (5 items), as well as the problem's impact on social activities, work, sleep, and self-image (4 items). Each item has five response options. The scores for all items are then used to calculate a scale score ranging from 0 (no disability) to 100 (most severe disability)

#### 2.4.2. Fouaad score

Although no scores were available pre-operatively. Fouaad score measuring different factors; pain, range of motion, re-turn to work, ROM flexion and extension, ROM radical and ulnar, and complications, each score ranged from 0 to 3 depends on degree of severity and difficulty. **Pain:** (0) no pain, (1) pain with extreme range of motion, (2) pain with range of motion and (3) pain at rest. **Re-turn to work:** (0) work normally.

(1) work with pain after heavy work, (2) tolerated pain and (3) cannot work totally. **Complication:**

(0) pin tract infection, (1) CRPs, (2) ulnar deviation and (3) progressive arthritis. **ROM flexion and extension:** (0) improved before surgery, (1) same as previous surgery, (2) limited that previous surgery 30 days and (3) stiff wrist. **ROM radial and Ulnar:** (0) improved before surgery, (1) same as previous surgery, (2) limited that previous surgery 10 days and (3) stiff wrist.

### 2.5. Statistical Analysis

Statistical analysis was performed using the GraphPad Prism™ software. Since the data were not normally distributed, the comparisons of paired data between the preoperative and postoperative assessments were made using the non-parametric Wilcoxon rank sum test with continuity correction. The statistical threshold of significance was set at  $p < 0.05$  (Figs. 1 and 2).

### 3. Results

This study included Twenty patients with Litchman stage III C Kienbock's disease, all patients applied scaphoapitate fusion with luante excision with different fixation techniques; wire and screw with  $p$  value 0.231 non significantly difference. The mean postoperative and preoperative; flexion-extension range of motion was  $105.5 \pm 22$  representing  $74.9 \pm 15$  of the side range. The mean flexion range of operated side was non-significantly increased to  $47.6 \pm 7.9$  (25–40); while extension range was significantly increased to  $58.5 \pm 10$  (55–69)°. Regarding radial-ulnar deviation, the

mean range was  $33.5 \pm 6.7$  (45–25)° representing  $76.5 \pm 16$  (100–50)% of the contralateral side. The mean ulnar deviation of operated side was significantly increased to  $22 \pm 3.5$  (15–25)°, while radial deviation was non-significantly increased to  $11.5 \pm 4.1$  (5–20)°. The mean grip strength of operated side was significantly increased to  $90 \pm 14.5$  (70–110) mmHg representing  $93.2 \pm 11$  (100–75)% of the operated side. Postoperative evaluation for the determination of infection, non-union, arthritis and carpal height ration. According to postoperative evaluation represent significantly differences with 0.05  $p$  value (Figs. 3–13, Tables 1–9).

### 4. Discussion

Kienböck disease refers to avascular necrosis of the lunate carpal bone, known as lunatomalacia. The prevalence for Kienböck disease was 0.27 % (138 of 51,071), including 0.10 % for incidental disease (51 of 51,071) and 0.17 % for symptomatic disease (87 of 51,071) in 2022 according to world health organization.<sup>8</sup>

Our study aimed to conducted in a 60 months duration, All consecutive patients in a AL-Hussien Hospital of Al-Azhar University who underwent scaphoapitate fusion between January 2017 to January 2022 for symptomatic III C Kienböck's disease with at least 12 months of follow-up were included in this study. This study was conducted on total of 20 patient grade III C Kienböck disease from the department of Orthopedic. In all cases, surgical management was performed due to persistent pain and impaired wrist function. Post-operative follow up were applied. Also, another cases also follow-up



Fig. 1. Open dorsal and Radial and ulnar subcutaneous wrist denervation.

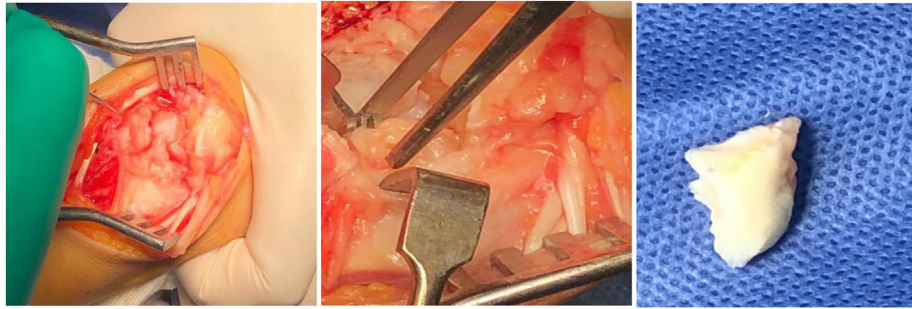


Fig. 2. Correction of IIIC kienbock disease wrist bone.

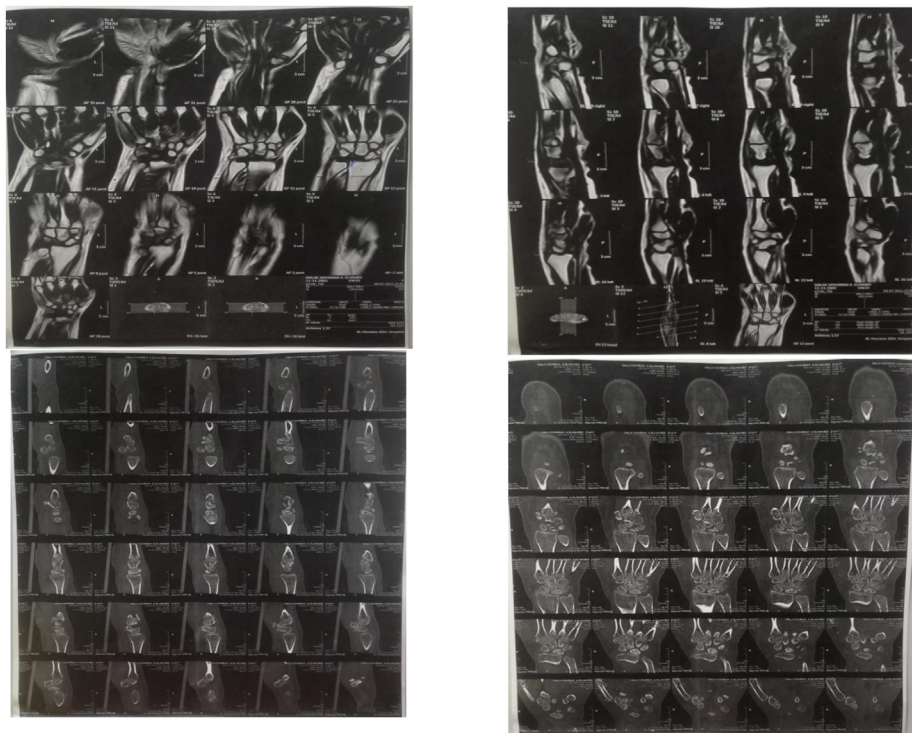


Fig. 3. Preoperative imaging Case 1.

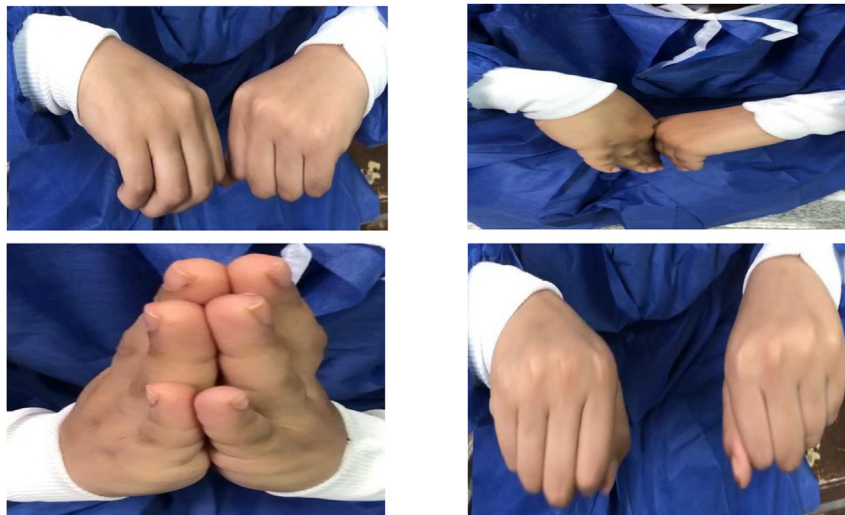


Fig. 4. Preoperative examination Case 1.

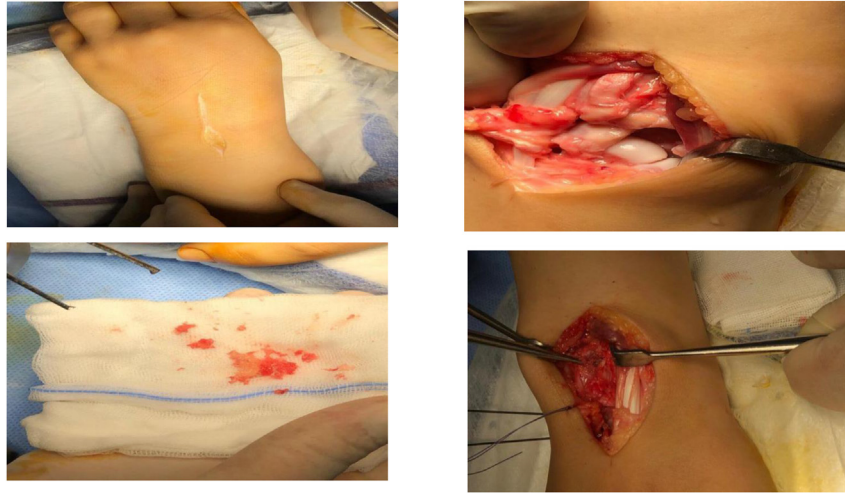


Fig. 5. Intraoperative opening dorsal of wrist Case 1.



Fig. 6. Post operative examination Case 1.

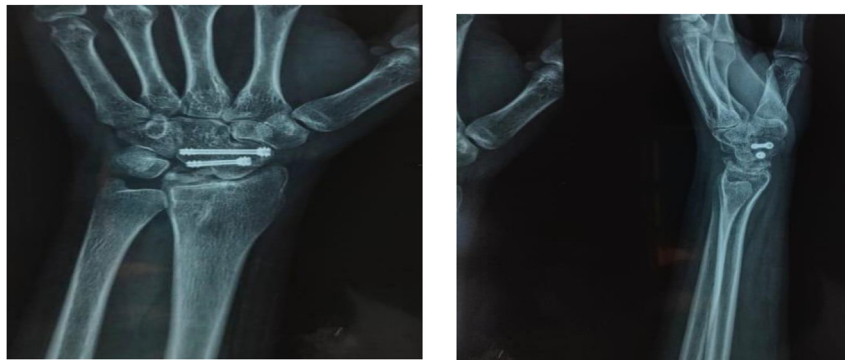
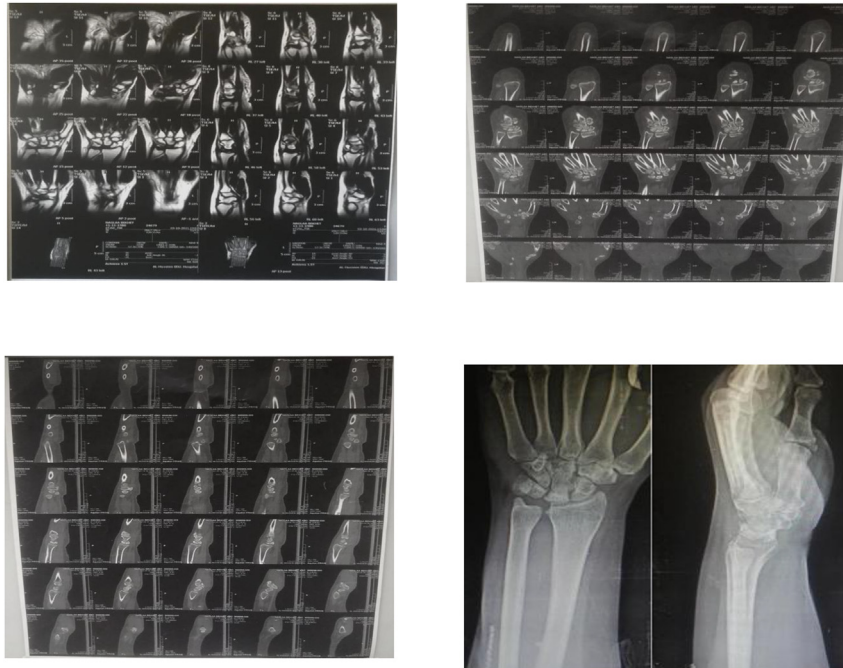
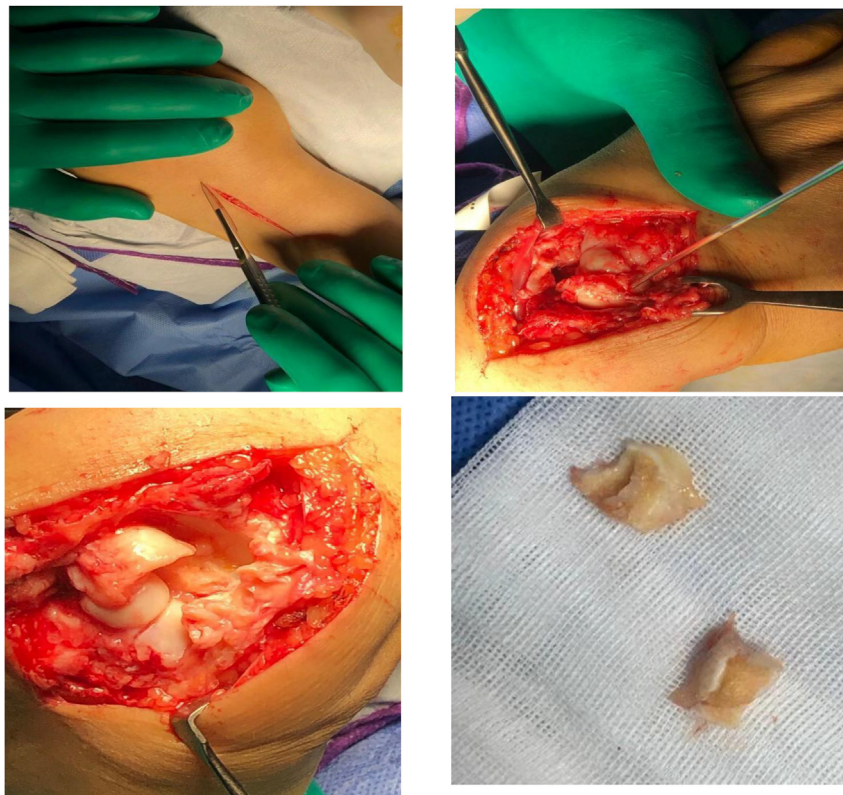


Fig. 7. Post operative follow up after 6 Months.



*Fig. 8. Preoperative imaging Case 2.*



*Fig. 9. Intra operative and open dorsal of the wrist Case 2.*



Fig. 10. Post operative imaging Case 2.



Fig. 11. Post operative examination Case 2.



Fig. 12. Post operative follow up after 6 Months.



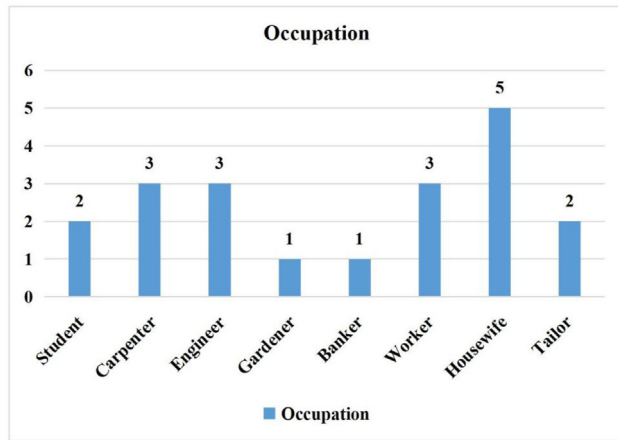


Fig. 13. Represents 20 patients with different occupation.

since 2020 till 2021 as a prospective, retrospective and randomized comparative study.

Many operative treatment methods have been suggested for the various stages of Kienböck's disease and they can be grouped into three categories: revascularization, decompression of the lunate and salvage procedures for pain relief. However, little is known about their effectiveness, mainly because Kienböck's disease is not very common and a long duration of follow-up is needed to evaluate the ultimate outcome.

This study included Twenty patients with Litchman stage III C Kienböck's disease with p value 0.231 non significantly difference.

According to previous study applied by Oh et al.,<sup>9</sup> demographic characteristics of this study including 88 male and 144 which were performed among large scale of patients the average age ranged from 18 to 55 years-old; all the included cases working hard and injured in both sides; the findings of our study in contrast with these study.

Table 1. Dash score grading system for wrist score.

Grading	Dash Score
Excellent	0–5
Good	6–15
Satisfactory	15–35
Poor	>35

Table 2. Fouaad Scoring and grading wrist system.

Score/Grading	Pain	Re-turn to work	Complication	ROM Flexion and extension	ROM Radical and Ulnar
0	no pain	work normally	pin tract infection	improved before surgery	improved before surgery
1	pain with extreme range of motion	work with pain after heavy work,	CRPs	same as previous surgery,	same as previous surgery,
2	pain with range of motion	tolerated pain and	ulnar deviation and	limited that previous surgery 30 days	limited that previous surgery 10 days
3	pain at rest	cannot work totally	progressive arthritis	stiff wrist	stiff wrist

Table 3. Demographic characteristics of included patients.

age	sex	side	P Value
26.3 ± 7.8	21.1 ± 3.8	12.2 ± 3.8	0.231 NS

Table 4. Represents Clinical examination of affected wrist.

Clinical Parameter	Preoperative	Postoperative	P value
Flexion	41.5 ± 8.1	47.6 ± 7.9 (25–40)	0.10562
Extension	51.1 ± 6.2	58.5 ± 10 (55–69)	0.10531
Radial Deviation	10.5 ± 2.8	23 ± 3.3 (19–28)	0.05
Ulnar Deviation	19 ± 3.9	2.3 ± 4.5 (2–27)	0.05
Grip	59.5 ± 3.3	90 ± 14.5 (45–80)	0.05

Table 5. Postoperative evaluation of affected wrist.

Clinical Parameter	Postoperative	P value
Infection	1.0 ± 1.2	0.05
Non-Union	1.0 ± 0.1	0.05
Arthritis	1.0 ± 0.1	0.05
Carpal Height Ratio	1.0 ± 0.1	0.05

Table 6. Evaluation of pain according fouaad scale.

Clinical Parameter	Mild	Moderate	Severe	P value
Pain	9.1 ± 2.9	4.2 ± 2.8	2.1 ± 1.5	0.0231
Clinical Parameter	Preoperative	Postoperative		P Value
Fouad Score	12.5 ± 8.18	4.2 ± 2.98		

Table 7. Evaluation of clinical parameter period of cast and smoking.

Clinical Parameter	1 M	2 M	Mild	3 M	P Value
Period of Cast	8.1 ± 2.5	7.3 ± 1.5	9.1 ± 2.9	2.1 ± 1.5	0.2371
Smoking	1.8 ± 1.1		12.5 ± 8.18	15.3 ± 2.1	0.05

Table 8. Postoperative and preoperative Scaphocapitate angle.

Clinical Parameter	Preoperative	postoperative	P Value
Scapholunate angle	39 ± 1.01	28.6 ± 2.89	0.05

Table 9. Represent postoperative fouaad score, dash score and return to work.

Clinical Parameter	Preoperative	Post operative	P Value
Dash Score	56.32 ± 6.43	21.32 ± 1.012	0.02
Return to Work	55.2 ± 31.91	2.1 ± 1.90	0.02

Another study Giacalone et al.,<sup>10</sup> performed on a small scale of patients injured with IIC kienbock disease; included 20 male and 10 female were occupied in moderate to severe hard working daily with average range from 25 to 55 years-old both sides were affected; there finding were in line with our findings.

In the current findings; The mean postoperative and preoperative; flexion-extension range of motion was  $105.5 \pm 22$  representing  $74.9 \pm 15$  of the side range. The mean flexion range of operated side was non-significantly increased to  $47.6 \pm 7.9$  (25–40); while extension range was significantly increased to  $58.5 \pm 10$  (55–69)°. Scaphotrapezio-Trapezoid fusion; gave good results have been described, although consolidation is sometimes difficult to obtain. Scaphocapitate arthrodesis for the treatment of advanced-stage Kienböck disease for the first time.

The postoperative and preoperative evaluation recorded a progressive range of motion with a decrease of flexion and extension which was statistically significant ( $p < 0.05$ ), this finding is similar to that reported by Harris et al.,<sup>11</sup> implicating the reduction in ulnar deviation, pointing towards the progressive nature of the disease and the inability of grip strength stabilisation to maintain the extension-flexion range of motion.

Our results observed that postoperative evaluation for the determination of infection, non-union, arthritis and carpal height ration. Among the included 20 patients; there is no infection, non-union, arthritis and carpal height represents normal. According to postoperative evaluation represent significantly differences with 0.05 p value.

In this study; postoperative evaluation for the determination of infection, non-union, arthritis and carpal height ration according to postoperative evaluation represent significantly differences with 0.05 p value.

As per a previous study; our findings in accordance with charre et al.,<sup>12</sup> which proved that there is no infection or arthritis performed. In line with our findings; latest study proved that the carpal height ratio were determined postoperative and preoperative to obtain the normality and disability of carpal height. In contrast with our result; Rhee et al.,<sup>13</sup> were mentioned that scaphoapitate fusion surgery were affect carpal height and increases the formation of arthritis.

In the current study postoperative and preoperative pain evaluated as mild, moderate and sever which is non statistically differences with P value 0.0231.

As regards pain; included 11 patients who had mild pain at rest, as compared to 7 patient in Van

Leeuwen et al.,<sup>14</sup> in series of 25 patients, and 2 patients in Guner et al.,<sup>15</sup> series of 30 patients. However, this mild pain was adequately controlled by conservative methods and did not affect the activities of daily living of our patients. On performing stressful activities (work), 6 of our patients had moderate pain that did not affect their work, while 2 more patients (11 %) had moderate pain that required modification of the level of their work, but still they kept their professions. This is compared to 3 patient who had pain on stressful activities in the series of 17 patients by Rhee et al.<sup>16</sup>

In the series by Hohendroff et al.,<sup>17</sup> 4 patients had pain on stressful activities, of which two patients had to change their profession, while two others continued their work at a reduced level of activity; in line with our results there is 3 patients had severe pain.

Our study found that postoperative and preoperative period of cast evaluated through 1 M, 2 M and 3 M which is statistically differences with p value 0.05.

Furthermore, none of the patients underwent additional surgery during the follow-up. The patient-rated outcome evaluation, including period of case demonstrated that postoperative and preoperative assessment were non significantly differences of patients with clinically significant improvement, and patients were used to or not used to smoking were showed an excellent outcome. This procedure has several advantages. Although in line with our findings Stewart et al.,<sup>18</sup> were proved.

The scaphoapitate angle were calculated to estimate the changes in each degree with p value 0.517 which is significantly differences.

First, it can preserve the scaphoapitate angle in both the radiocarpal and midcarpal joints. The limited wrist fusion with lunate excisions could provide the postoperative and preoperative wrist range of motion (flexion-extension) ranged from 50° to 60° in short-term follow-up. However, another study arthroscopic lunate excision could provide averaged 120° in the 2-year follow-up as mentioned by Rhee et al.<sup>19</sup>

Second, it needs only short-term postoperative therapy. Although limited wrist fusions require wrist immobilization for 6–12 weeks with short or long arm casts, arthroscopic lunate excision requires 3 weeks of immobilization with a short arm cast, which is similar to the postoperative and preoperative course of proximal row carpectomy in accordance with Cross and Matullo.<sup>20</sup>

As per our findings; return back to work considered as postoperative and preoperative evaluation to obtain month of recovery after surgical operation through months is statistically differences P value 0.02.

In another previous study Bellne're et al.,<sup>21</sup> return back to work have been studied and the authors concluded that return back to work increased more than 1 year due to the radio scaphoid mean pressure and decreased radio lunate mean pressure and had little effect on radio carpal mean pressure. However; another author Chantelot et al.<sup>22</sup> mentioned that after SC surgery were return back to work after 4 months in line with our findings.

In this study Dash score represents postoperative and preoperative changes after surgical operation, for the determination of disability among patients; the lowest represent 25 while the highest represent 33 with mean and standard deviation  $21.32 \pm 1.012$  which is statistically differences P value 0.05.

The average DASH score of our patients was ranged from 100 (23–33) which is comparable to that of the series of Chi et al.,<sup>23</sup> with an average DASH score of 20 (range 1–52).

In the current study; Fouad's score in this study were a patent scoring system for the determination of pain, range of motion, re-turn to work, ROM flexion and extension, ROM radial and ulnar, and complications. Although no scores were available pre-operatively. Fouaad score measuring different factors each score ranged from 0 to 3 depends on degree of severity and difficulty. Grading score system of fouad's excellent results were ranged from 4 patiens represents 17 and 3 patients represents 6 which is Very good with mean and standard deviation  $4.2 \pm 2.98$  which is statistically differences P value 0.05.

## 5. Conclusion

In conclusion, this study confirmed our hypothesis concerning the short-term results of scaphocapitate fusion with lunate excision for the treatment of advanced IIIC grade Kienböck's disease. Also; our study observed that fouad's score grading system were invented scoring system applied in this study for the determination of different factors with high specificity.

## Recommendation

Scaphocapitate fusion can reliably provide good outcomes and this is maintained in the mid to short-term follow-up. Fouad Score expected to be used in the future coming studies of IIIC grade and kienböck disease.

## Limitation

Short time follow-up of patients showed minimal functional outcomes both clinically and in patient-

reported outcome scores. Functional scoring was done only at the end of the follow-up period post-operative and preoperative.

## Conflict of interest

There is no any conflict of interest.

## References

- Kienböck R. On traumatic contact of the lunar bone and its consequences: degenerative forms and compression fractures. *Progress Pocket X-ray*. 1910;16:77–103.
- Stähl F. On lunatomalacia (Kienböck's disease): a clinical and roentgenological study, especially on the pathogenesis and the late results of immobilization treatment. *Acta Chir Scand*. 1947;95(suppl 126):1–133.
- Lichtman DM, Mack GR, MacDonald RL, Guhter SF, Wilson JN. Kienböck's disease: the role of silicone replacement arthroplasty. *J Bone Joint Surg Am*. 1977;59:899–908.
- Goeminne S, Degreef I, De Smet L. Reliability and reproducibility of Kienböck's disease staging. *J Hand Surg Eur*. 2010; 35, 555–55.
- Lichtman DM, Lesley NE, Simmons SP. The classification and treatment of Kienböck disease: the state of the art and a look at the future. *J Hand Surg Eur*. 2010;35:549–554.
- Tillberg B. Kienboeck's disease treated with osteotomy to lengthen ulna. *Acta Orthop Scand*. 1968;39:359–369.
- Culp RW, Bachoura A, Gelman SE, Jacoby SM. Proximal row carpectomy combined with wrist hemiarthroplasty. *J Wrist Surg*. 2012;1:39–46.
- Alsanawi H. Surgical interventions for Kienboeck's disease: an update. *J. Health Spec*. 2017;5:12.
- Oh WT, Kang HJ, Chun YM, Koh IH, An HM, Choi YR. Arthroscopic wafer procedure versus ulnar shortening osteotomy as a surgical treatment for idiopathic ulnar impaction syndrome. *Arthroscopy*. 2018;34:421–430.
- Giacalone F, di Summa PG, Fenoglio A. Resurfacing capitate pyrocarbon implant versus proximal row carpectomy alone: a comparative study to evaluate the role of capitate prosthetic resurfacing in advanced carpal collapse. *Plast Reconstr Surg*. 2017;140:962–970.
- Harris JD, Brand JC, Cote MP, Faucett SC, Dhawan A. Research pearls: the significance of statistics and perils of pooling. Part 1: clinical versus statistical significance. *Arthroscopy*. 2017;33:1102–1112.
- Charre A, Delclaux S, Apredoai C, Ayel JE, Rongieres M, Mansat P. Results of scaphocapitate arthrodesis with lunate excision in advanced Kienböck disease at 10.7-year mean follow-up. *J Hand Surg Eur*. 2018;43:362–368.
- Rhee PC, Lin IC, Moran SL, Bishop AT, Shin AY. Scaphocapitate arthrodesis for Kienböck disease. *J Hand Surg Am*. 2015; 40(4):745–751.
- van Leeuwen WF, Tarabochia MA, Schuurman AH, Chen N, Ring D. Risk factors of lunate collapse in kienböck disease. *J Hand Surg Am*. 2017;42(11):883–888.e1.
- Güner MD, Kamburoğlu HO, Bektaş U, Ay Ş. Osteoid osteoma of the lunatum mimicking Kienböck's disease. *Case Reports Plast Surg Hand Surg*. 2015;2(1):19–21.
- Rhee PC, Jones DB, Moran SL, Shin AY. The effect of lunate morphology in Kienböck disease. *J Hand Surg Am*. 2015;40(4): 738–744.
- Hohendorff B, Mühldorfer-Fodor M, Kalb K, van Schoonhoven J, Prommersberger KJ. STT arthrodesis versus proximal row carpectomy for Lichtman stage IIIB Kienböck's disease: first results of an ongoing observational study. *Arch Orthop Trauma Surg*. 2022;132(9):1327–1334.

18. Stewart DT, Froelich JM, Shin AY. Intercarpal arthrodeses. *J Hand Surg Am.* 2014;139(2):373–377.
19. Rhee PC, Lin IC, Moran SL, Bishop AT, Shin AY. Scaphocapitate arthrodesis for Kienböck disease. *J Hand Surg Am.* 2015;40(4):745–751.
20. Cross D, Matullo KS. Kienböck disease. *Orthop Clin North Am.* 2014;45(1):141–152.
21. Belleme`re P, Maes Clavier C, Loubersac T, Gaisne E, Kerjean Y, Collon S. Pyrocarbon interposition wrist arthroplasty in the treatment of failed wrist procedures. *J Wrist Surg.* 2012;1:31–38.
22. Chantelot C, Becquet E, Leconte F, Lahoude Chantelot S, Prodomme G, Fontaine C. Scaphocapitate arthrodesis for chronic scapholunate instability: a retrospective study of 13 cases. *Chir Main.* 2005;24:79–83.
23. Chim H, Moran S. Long term outcomes of proximal row carpectomy: a systematic review of the literature. *J Wrist Surg.* 2012;1:141 8.