Limited Carpal Fusion in Kienböck's Disease: Early Results following Scaphocapitate Arthrodesis

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Abstract

Background Kienböck's disease leading to progressive carpal collapse alters the wrist biomechanics leading to early arthritis and degenerative changes. Out of multiple surgical procedures present, no gold standard has been described. Scaphocapitate arthrodesis (SCA) is limited carpal fusion which shifts the loading axis toward radio-scaphoid joint. This study presents the midterm clinical and radiological results of SCA in Kienböck's disease.

Materials and Methods The data were reviewed from January 2016 to December 2017. Lichtman's classification used to stage the disease. Clinical variables were noted for wrist range of motion, grip strength, visual analog scale (VAS) score, quick disabilities of the arm, shoulder, and hand (quickDASH), and patient-rated wrist evaluation (PRWE) scores. Radiographs were evaluated for union, ulnar variance, carpal height ratio, radioscapoid angle, and scapholunate angle.

Results A total of 11 patients of Stage IIIA and IIIB Kienböck's disease with mean age of 24 years were included in the study with a minimum of 18 months of clinical follow-up. The procedure resulted in decreased ranges of motion but improved grip strength (26.09 ± 4.76 from 19.54 ± 4.63 kgf) and reduced pain with VAS score decreased from 7.36 ± 0.8 to 2 ± 1 . Radiographic analysis showed union in all patients, reduced carpal height with a corrected radioscapoid angle (from 62.12 to 48.3 degrees), and scapholunate angle (from 34 to 26.27 degrees).

Discussion SCA has advantage of technical ease of orientation of the scaphoid and osteosynthesis of only one intercarpal joint with a large contact surface. Coupling the distal and proximal carpal rows results in significant loss of mean wrist range of motion but with improved grip strength, shifting the load away from the radiolunate joint. However, long-term studies are needed for clinical benefits and radiographic signs of radioscapoid arthritis for the treatment of advanced-stage Kienböck's disease.

Level of Evidence This is a Level IV, retrospective observational study.

Keywords

- lunate
- osteonecrosis
- avascular necrosis
- Kienböck's disease
- scaphocapitate arthrodesis

Aseptic osteonecrosis of lunate (Kienböck's disease), which leads to progressive lunate and other carpal collapse, was first described nearly a century ago.¹ Its exact etiology and natural history have not been delineated but numerous extrinsic and intrinsic factors have been described.² The

most common and accepted classification is by Lichtman et al.³ Multiple surgical procedures have been described for various stages but no gold standard for each stage of this disease exists.⁴ The procedures can be classified as either revascularization of lunate or joint levelling procedures in

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early stage, lunate excision and limited carpal fusion or proximal row carpectomy in middle stages and wrist arthrodesis or arthroplasty in advanced stages of the disease. Lunate excision and scaphocapitate arthrodesis (SCA) is a type of limited carpal fusion which was first described by Pisano et al.⁵ The proposed biomechanical basis of this procedure is that it reduces axial loading across radiolunate and lunocapitate joint while increasing load through radioscapoid joint.⁶ Scaphoid alignment and carpal height are also corrected or preserved simultaneously. Another theoretical advantage of this procedure is that it is technically easier than scaphoid trapezium trapezoid (STT) arthrodesis which is also another modality of treatment.

There are relatively few studies on the role of SCA in Kienböck's disease. We have described our clinical and radiological results on the role of SCA in stage IIIA/B of Kienböck's disease along with comprehensive review of literature on the management of this stage.

Materials and Methods

Prior approval from the institutional review board was obtained before the start of the study. In this retrospective study, from a national level teaching hospital, from January 2016 to December 2017, electronic medical records, files, and other relevant investigations were reviewed to identify all the patients with more than 18 years of age and with osteonecrosis of the carpal lunate. A total of 15 patients were thus identified and included in the study. Among them, 11 patients were found to be in stage IIIA or IIIB and were further analyzed. Bilateral affection, presence of radioscapoid arthritis, and any previous surgery on the same limb were excluded.

Preoperative work up and follow-up evaluation was done clinically by range of motion (ROM) at wrist, grip strength, visual analog scale (VAS) score (0–no pain to 10–severe pain), quick disabilities of the arm, shoulder, and hand (quickDASH score), and patient-related wrist evaluation (PRWE score).⁷ PRWE score takes into account pain and function at the wrist joint with lesser scores indicating better results. Ulnar variance, carpal height ratio, radioscapoid angle, and scapholunate angle were measured on routine PA and lateral radiographs of all the cases (►Fig. 1). Staging of the disease was done radiographically by 2 of the authors independently according to the Lichtman classification. In eight cases, the classification was agreed upon as being stage IIIB while in remaining three, there was disagreement between stage IIIA and IIIB. In all these 11 cases, SCA with or without lunate excision was done as per the standard operating procedure under regional anesthesia. In all the cases, the proper carpal alignment was ensured and scaphoid flexion, if any, was corrected. Cancellous bone graft from the distal radius through the same incision was used in all the cases.

Qualitative data were expressed as counts and percentages and quantitative data were expressed by mean $\pm$ standard deviation (SD) or range. Statistical analysis was performed with SPSS version 18. Results were analyzed using paired *t*-test, Chi-square test, as well as Wilcoxon's signed rank, and McNemar's tests depending upon the nature of variables with significance level set at 0.05.

Results

Of the 11 patients, 8 were females and 3 were males. The mean age at intervention was 24 years (range: 17–45 years). The dominant extremity was involved in majority of the cases ($n = 10$). All the patients were followed-up for a period of minimum 18 months (range: 18–26 months). All the females included in the study were housewives, while two males were manual laborers and one was a student.

The preoperative and postoperative clinical data are presented (►Table 1). A general reduction in ROM of the wrist joint was noted. But the greatest relief for the patients was noted in reduction in pain scores, as well as increase in grip strength. The reduction in ROM did not lead to affection of activities of daily living with most of the entries in quickDASH score being "mild difficulty."

Two wrists had positive ulnar variance and rest had negative or neutral variance. There was no change in variance postoperatively. The radioscapoid and scapholunate angles showed significant reduction compared with preoperative values (►Table 2). The carpal height ratio also showed reduction which was statistically significant. All the patients at final follow-up showed solid union at scaphoid and capitate (►Fig. 2).

Discussion

The exact etiology of Kienböck's disease or lunate avascular osteonecrosis hasn't been elucidated yet but it has been shown that progressive loading leads to increased collapse of the lunate.⁸ Negative ulnar variance has been postulated to be more predisposing to this disease.⁹ Nine patients (81.2%) in this study had a negative ulnar variance. The treatment depends on the staging of the disease and the aim is to provide acceptable wrist function with no pain by decompressing the forces across lunate. In the presence of negative ulnar variance, joint levelling procedures would alleviate the symptoms. But the transitional stage is stage 3 where lunate starts collapsing and capitate starts moving proximally along with rotational instability of scaphoid, hence many investigators recommend partial wrist arthrodesis or proximal row carpectomy instead of joint levelling procedures once lunate starts collapsing in view of concern for progression of carpal collapse and radiological degeneration which might lead to recurrence of symptoms.¹⁰ It has been shown that even if there is no radiological arthrosis, arthroscopically both radioscapoid and capitollunate joints have shown joint damage, hence joint levelling procedures, as well as proximal row carpectomy, was not thought to be suitable and limited intercarpal arthrodesis was advised.⁹ Furthermore, there have been no comparative studies, randomized or nonrandomized, which prove the superiority of any one procedure over the other. The outcomes of both joint levelling, as well as limited arthrodesis, in various studies are presented in ►Tables 3 and 4. Though the results shows decreased ROM in the limited arthrodesis group, there is no functional limitation by the procedure as evident by the PRWE and quickDASH scores.

Fig. 1 (A) Ulnar variance, showing positive ulnar variance. (B) Carpal height ratio, ratio between length of carpals to longitudinal length of 3rd metacarpal. (C) Radioscapoid angle, angle between longitudinal axis of radius and tangential line to scaphoid. (D) Scapholunate angle, angle between longitudinal axis of lunate and tangential line to scaphoid.

Limited arthrodesis of the carpals helps in preventing the rotatory instability of scaphoid, as well as maintaining the stability of wrist joint.³⁴ Various types of limited intercarpal arthrodesis like scaphoid–trapezium–trapezoid (STT) or cap-

itate-hamate arthrodesis (CHA) have been described. The nonunion rates are halved in comparison to other methods of limited intercarpal arthrodesis like STT arthrodesis or CHA.⁸ Regarding the reduction of compressive forces on lunate,

Table 1 Preoperative and postoperative clinical outcome measures

	Preoperative (degrees)	Postoperative (degrees)	p-Value
Flexion	51 ± 19.37 (15–80)	35 ± 9.34 (15–50)	<0.05
Extension	45 ± 13.86 (30–70)	36 ± 13.05 (20–60)	<0.05
Ulnar deviation	19 ± 5.04 (10–30)	15 ± 5.22 (10–25)	<0.05
Radial deviation	18 ± 3.43 (10–20)	12 ± 3.43 (10–20)	<0.05
VAS score	7.36 ± 0.8 (6–8)	2 ± 1 (1–4)	<0.05
QuickDASH	–	28.86 ± 4.58 (20.5–36.4)	
PRWE score	–	31.36 ± 7.65 (23–46)	
Grip strength (kgf)	19.54 ± 4.63 (14–26)	26.09 ± 4.76 (18–34)	<0.05

Abbreviations: PRWE, patient-rated wrist evaluation; DASH, disabilities of the arm, shoulder, and hand; VAS, visual analog scale.

Note: values are expressed as mean ± standard deviation (range).

Table 2 Preoperative and postoperative radiological outcome measures

	Preoperative	Postoperative	p-Value
Radioscaphoid angle	62.12 ± 9.6 (50–71)	48.3 ± 6.77 (40–60)	<0.05
Scapholunate angle	34 ± 7.8 (21–45)	26.27 ± 5.9 (16–35)	<0.05
Carpal height ratio	0.46 ± 0.01	0.45 ± 0.02	<0.05

Note: values are expressed as mean ± standard deviation (range).

Fig. 2 (A) Preoperative radiograph showing collapse of lunate with decreased radioscaphoid joint space but no arthritic changes. (B) At 8 months of follow-up, radiograph showing bony union at scaphocapitate joint.

SCA, and STT arthrodesis reduce it whereas CHA doesn't. SCA and STT arthrodesis shift the load bearing from radiolunate to radioscaphoid joint along with reduction of force transmission at lunocapitate joint.³⁵

The principle behind SCA in stage III is to arthrodesis scaphoid in a favorable position so as to take load off lunate and reduce the nociceptive stimuli arising out of it.⁸ SCA was done in all patients in this study with significant change in

Table 3 Review of limited arthrodesis done as procedure for treatment of stage-III Kienböck's disease

Study	Year	Procedure (number of cases)	Mean follow-up (mo)	Flexion–extension arc (pre-op) degrees	Flexion–extension arc (post-op) degrees	VAS score (post-op)	Grip strength ^a (pre-op) %	Grip strength ^a (post-op) %
Oishi et al ¹¹	2002	Capitohamate arthrodesis (45)	32	–	–	–	–	72
Minami et al ¹²	2003	Scaphotrapeziotrapezoid fusion (30)	84	88	77	–	50.70	76
Meier et al ¹³	2004	Scaphotrapeziotrapezoid fusion (59)	48	82.7	67	1.2	–	–
Waitayawinyu et al ¹⁴	2008	Capitate shortening osteotomy (14)	41	115	110	–	58	78
Gay et al ¹⁵	2009	Capitate shortening osteotomy (11)	67.4	89.09	85.72	1.7	47	72
Zakzouk et al ¹⁶	2012	Scaphocapitate arthrodesis (18)	28	68	69	–	57.17	71.57
Mir et al ¹⁷	2013	Lunate replacement with pedicled vascularized scaphoid graft and radioscaphoidal partial arthrodesis (13)	48	90	70	–	44	80
Fouly et al ¹⁸	2014	Capitate shortening osteotomy with capitometacarpal fusion (12)	20.7	90.5	108.2	–	75	81
Rhee et al ¹⁹	2015	Scaphocapitate arthrodesis (27)	60	91	66	–	50.60	64
Iorio et al ²⁰	2015	Scaphocapitate (10) or scaphotrapeziotrapezoid (2) fusion	13	–	53	2.8	–	–
Charre et al ²¹	2018	Scaphocapitate arthrodesis (18)	127	75	85	2.4	46.50	74
Özdemir et al ²²	2017	Lunate excision and scaphocapitate arthrodesis (9)	17.3	56.11	68.34	1.4	34	–
Tahta et al ²³	2018	Lunate excision and capitohamate fusion (7)	15.2	–	79.9	2	–	66.40
Barrera-Ochoa et al ²⁴	2018	Radial osteotomy and lunate fixation (11)	39	50.5	70.2	6.45	–	–

Abbreviations: post-op, postoperative; pre-op, preoperative; VAS, visual analog scale.

^aGrip strength of affected side represents as the percentage of contralateral side normal function.

Table 4 Review of joint levelling procedure done for treatment of stage-III Kienböck's disease

Study	Year	Procedure (number of cases)	Mean follow-up (mo)	Flexion-extension arc (pre-op) degrees	Flexion-extension arc (post-op) degrees	VAS score (post-op)	Grip strength ^a (pre-op) %	Grip strength ^a (post-op) %
Nakamura et al ²⁵	1991	Radial shortening osteotomy (27)	21	82	99	–	63	82
Salmon et al ²⁶	2000	Radial shortening osteotomy (15)	42	–	73% of contralateral side	–	–	75
Iwasaki et al ²⁷	2002	Radial shortening osteotomy (20)	29	93.4	116.2	–	52.3	82.6
Watanabe et al ²⁸	2008	Radial shortening osteotomy (13)	252	86	112	–	53	88
Wijffels et al ²⁹	2009	Radial shortening osteotomy (8)	99	82	130	–	58	83
Calfee et al ¹⁰	2010	Radial shortening osteotomy (31)	74	–	104	7.1	–	81
Rodrigues-Pinto et al ³⁰	2012	Radial shortening osteotomy (18)	123	77	101	0.6	–	73
Tatebe et al ³¹	2016	Radial shortening osteotomy (18)	138	63	99	–	59	89
Shin et al ³²	2017	Radial shortening osteotomy (14)	85	62.5	80.3	1.1	49.3	84.8
Luegmair et al ³³	2017	Radial shortening osteotomy (36)	145	88	111	3	51	82

Abbreviations: post-op, postoperative; pre-op, preoperative; VAS, visual analog scale.

^aGrip strength of affected side represents as the percentage of contralateral side normal function.

radioscaphoid, scapholunate angles, and carpal height ratio. Long-term studies have shown gradual arthrosis after SCA for which the patients included in this study are under follow-up.⁶ ROM is also reduced in all planes compared with preoperative values which is seconded in this study, but this reduction is less compared with STT arthrodesis.⁸ Literature shows increase in grip strength which has been noted in this study also.⁸ All the patients in this study had significant reduction in pain scores and patient satisfaction scores. Nonunion in various frequencies have been noted in literature after SCA.^{8,20} But this study has showed union in all patients which was achieved by the use of headless compression screws. In the long run, radioscaphoid arthritis has been noted in studies but due to short follow-up in this study, it couldn't be commented upon.³⁶ The other modalities of treatment in stage III disease are proximal row carpectomy, STT fusion, and capitohamate fusion.

Limitations

The limitations of this study are its retrospective nature and small sample size. Future multicentric prospective studies with longer follow-up with randomization, preferably between various methods of limited intercarpal arthrodesis and joint levelling procedures needs to be done to evaluate long-term outcomes.

Conclusion

To conclude, SCA using screws gives satisfactory clinical and radiological results in advanced stages of Kienböck's disease with high union rates and minimal complications in early follow-up period.

Ethical Approval

Ethical committee approval obtained.

Conflict of Interest

None declared.

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