Comparison of Clinical and Radiological Outcome of Radial Shortening and Capitate Shortening in the Early Stages of Kienböck Disease

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Research Article

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Abstract

Background: This study aims to compare the clinical and radiological outcomes of radial shortening osteotomy (RSO) and capitate shortening osteotomy (CSO) in the early stages of Kienböck disease.

Methods: Grip strength and wrist range of motion were assessed bilaterally. Also, the disease stage in pre-op and the final follow-up were determined. Quick-DASH, Patient-Rated Wrist Evaluation (PRWE), and Modified Mayo Wrist Score were used to assess patient comfort and function.

Results: 23 patients were followed up (13 patients with RSO and 10 patients with CSO) for mean 46 months. Affected wrist range of motion in flexion and extension and grip strength was significantly lower than the unaffected side. Pain score in the Mayo wrist questionnaire was significantly lower in the RSO group than CSO group. The failure rate was 1.16% and 2.59% per year for RSO and CSO, respectively. Radiologic stage worsened in two patients (one in each RSO and CSO groups) and it was improved in nine patients (six in RSO and three in CSO groups). Six patients (three in each RSO and CSO groups) underwent revision surgeries due to residual pain. As expected, wrist motion arc and grip strength were significantly more limited in these patients in comparison to others (p=0.031 and p=0.026, respectively).

Conclusion: We found no significant differences between the two groups in terms of clinical findings, patients' function and satisfaction, and success rate.

Level of evidence: III - Retrospective cohort study

Introduction

Pest first described lunate avascular necrosis (AVN) [1] and Kienböck described the radiological collapse of the lunate [2]. Since then, lunate AVN is called "Kienböck disease." In a retrospective review of wrist imaging of 51,071 patients in a single-center study, Kienböck disease prevalence was found 0.27% in the United States [3]. Various surgical techniques are described for the management of Kienböck disease, and radial shortening osteotomy (RSO) is the most popular surgery due to its less interference with wrist motion [4].

In this study, we aimed to compare the outcomes of Radial shortening osteotomy and capitate shortening osteotomy, in the early stages of Kienböck disease. Our main questions were failure rate, assessing radiological changes observed in post-op in comparison to pre-op, assign functional score on the basis of patient- and physician-rated questionnaires, and determining wrist range of motion and grip strength in each study group.

Materials And Methods

Participants

In a retrospective cohort study, we included all wrists with the diagnosis of Kienböck disease based on clinical and radiological findings at an academic medical center from September 2019 to May 2020. Informed consent was obtained from all individual participants included in the study.

We included patients diagnosed with Kienböck disease and a minimum follow-up of 6 months. We invited the patients for physical and radiographic examination. Anteroposterior and lateral views of the affected wrist were obtained, and the patients completed outcome questionnaires.

The related Ethical Committee has approved the study, but the code number is removed due to blinding issues. This study was performed in line with the principles of the Declaration of Helsinki, and the reporting of this study adheres to the STROBE guidelines.

Clinical examination

We assessed bilateral wrists' range of motion using a standard orthopedic goniometer. Grip strength was measured bilaterally using a grip meter (Jaymar Engineering, Los Angeles, CA, USA) while the patient was in a sitting position, 90 degrees elbow flexion, and neutral forearm rotation. We repeated every measurement three times, and the highest measurement was recorded in kilograms. Relative grip strength was measured in percentage compared to the unaffected side.

Questionnaires

To assess the functional outcome of the wrists at the latest follow-up, we used the validated versions of the Quick Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) [5] and Patient-Rated Wrist Evaluation (PRWE) [6], and Modified Mayo Wrist Score [7] questionnaires.

Radiologic staging

We determined the lunate osteonecrosis stage using Lichtman-Stahl classification on preoperative and the final radiographic wrist views [8].

Surgical techniques: Surgical techniques were based on the surgeons' preference.

Radial shortening osteotomy (RSO): We performed a longitudinal volar skin incision on the radial side of the flexor carpi radialis tendon. After releasing the tendon sheet, FCR was retracted to the ulnar side to protect the median nerve. Then, 3 millimeters osteotomy was done, fixed by a 3.5 mm six-hole stainless steel straight dynamic compression plate (Synthes com, Zuchwil, Switzerland). Patients had a long arm splint for two weeks, and strengthening and range of motion exercises were gradually initiated after six weeks [4].

Capitate shortening osteotomy (CSO): A 3-centimeter incision was made over the dorsal of the wrist at the level of the capitate. A 2-mm transverse osteotomy was made in the capitate with a small sagittal saw, and the bone segment was removed. The capitate was osteotomized at the level of the middle and distal thirds to avoid violating the radiocarpal ligament insertions. Distal and proximal fragments were re-approximated and fixed by one or two headless Herbert screws (Zimmer, Warsaw, IN, USA) under fluoroscopic imaging. Patients had a short arm splint for two weeks, and rehabilitation programs including muscle strengthening and motion improvement were initiated after four weeks.

Failure rate

Reoperation and Mayo wrist score below 65 (equal to the poor level in Mayo wrist score) at the follow-up visit was considered a failure [9].

Statistical analysis

All data were analyzed using SPSS statistical software. We used Chi-square to compare the categorical outcome data and Paired Independent Samples T-test to compare the continuous outcome data. We also assigned 95% confidence interval (95% CI) for failure rate of each procedure.

Results

In total, 23 patients (23 wrists) were included in this study. Of these, 17 patients underwent a single operation, and six patients underwent two or more procedures for the recalcitrant pain. In patients with a single procedure, ten patients underwent radial shortening osteotomy (RSO group) and seven patients underwent capitate shortening osteotomy (CSO group) **[Table 1]**.

Six (46.2%) patients in RSO and seven (70%) patients in CSO were classified as failure because of either reoperation or poor Mayo wrist score below 65. Failure rates were 0.46 (95% CI: 0.19-0.75) and 0.7 (95% CI: 0.37-0.93) for RSO and CSO, respectively. Because the mean follow-up intervals were different between the groups, we estimated the failure rates as 1.16% and 2.59% per year for RSO and CSO, respectively.

Radiologically, one patient in each group of RSO (out of ten) and CSO (out of seven) progressed to a higher stage in comparison to the pre-operation radiographs **[Table 1]**. In the RSO group, the stage was improved in 6 wrists while 3 had no changes. The stage was improved in 3 wrists in the CSO group while three remained unchanged **[Table 1]**.

Pain score in the Mayo wrist questionnaire (score 25 for the least pain and score 0 for the worst pain) was significantly lower in the RSO group (19 [SD 4.6]) in comparison to the CSO (13 [SD 7.0]) group (P=0.037) **[Table 1]**.

Clinically, we found a significantly lower range of motion in flexion and extension when comparing operated wrist with the other side in the RSO group (53 [SD 15] vs. 75 [SD 21] in extension, P=0.031; 53 [SD 17] vs. 75 [SD 14] in flexion, P=0.008) **[Table 1]**. Additionally, we calculated the arc of motion as the sum of wrist flexion and extension, and we found comparable results in both groups (106 in RSO and 107 in CSO, P=0.97).

The operated side's mean grip strength was significantly lower than the other side in both groups (22 [SD 7.2] vs. 32 [SD 9.8] kg; P<0.001). However, it was only statistically different in the RSO group (25 [SD 6.9] vs. 34 [SD 11] kg; P=0.005) **[Table 1].**

We also found six patients with more than one procedure for their Kienböck disease **[Table 2]**. Three patients were initially treated using RSO, of whom two underwent CSO and one underwent lunate excision and capitate lengthening. The other three patients were initially treated using the CSO, all of whom underwent Arthroscopic lunate decompression (ALD) for the second surgery. One patient underwent three procedures due to recalcitrant pain, including the CSO followed by the ALD and finally wrist arthrodesis.

We compared patients who underwent a single procedure (RSO or CSO) with patients who underwent one or more surgeries **[Table 3]**. We found a significantly limited range of motion in wrist flexion, extension, and the arc of motion between the two groups (P=0.05, P=0.016, and P=0.17, respectively). Moreover, the relative range of motion in wrist flexion and the arc of motion were significantly different (P=0.03 and P=0.05, respectively). Although we found statistically significant lower grip strength in the re-operation group compared to other groups (17 [SD 5.3] vs. 24 [SD 7] kg, P=0.035), relative grip strength was not significantly different between the groups (P=0.269). Demographic data and outcome questionnaires did not show a significant difference between primary and re-operation groups (P>0.05).

Discussion

We tried to evaluate all patients with Kienböck disease managed with any of the RSO and CSO procedures at least six months after their last operation (Mean follow-up of 46 months). Overall, 23 patients were included in our study, out of which 6 had more than one operation. Pain score in the Mayo wrist questionnaire was significantly lower in the RSO group than the CSO group. We found a significantly limited range of motion and grip strength compared to the contralateral side in the RSO group. Only wrist flexion was significantly limited compared to the other side in CSO group. Significantly limited wrist range of motion was observed in patients with re-operation for their Kienböck disease.

Failure rate

We evaluated the failure rate of the two standard procedures in Kienböck patients. As follow-up periods differed significantly, we calculated failure rates as 1.16% and 2.59%, for RSO and CSO, respectively. Gay et al. found an 18% (2 patients out of 11) failure rate due to persistent pain who required revision surgery in their series of patients after capitate shortening osteotomy (mean follow-up=67.4 months); both underwent revision surgery due to persistent pain [10].

Viljakka et al. reported a 25% (4 out of 16) failure rate after RSO in 25-year follow-up; one underwent silicone implant arthroplasty, one had wrist fusion, and the other two patients had disabling pain in the follow-up [11].

Stage

We found no reasonable correlation between the radiographic and clinical findings whereas some patients with improved radiologic stage showed limited wrist motion and grip strength. The radiological staging did not correlate with patients' satisfaction with the procedures. Two patients had worsened radiologic staging with Lichtman IIIA converted to IIIB, the same as Afshar et al.'s findings [12]. Just like Watanabe et al. implicated RSO as a protective measure to Lichtman stage IV in Kienböck patients in a 21-year follow-up [9], we found no patient in stage IV in neither groups. However, Luegmair et al. found 8 of 36 patients converted stage IIIA to IV Lichtman after RSO in a 12-year follow-up [13].

Functional questionnaires

DASH score seems to be conversely correlated with follow-up duration since we found a DASH score of 19 and 21, in RSO and CSO with 57 and 20 months follow-up. Afshar et al. found patients with RSO and CSO with 24.2 and 20 DASH scores in 3.2 and 3.1 years follow-up respectively[12]. Luegmair et al. reported a DASH score of 12 in a 12-year follow-up [13], and Viljakka et al. found a DASH score of 6 in patients with RSO in a 25-year follow-up [11].

The same trend was observed in Mayo wrist score. We found Mayo wrist score of 64.5 in our RSO group, while the RSO group in Luegmair et al. had a Mayo wrist score of 75 [13], and Ebrahimzadeh et al. reported a score of 77 in their cohort with a mean 7-year follow-up [4].

Range of motion

We found a significantly limited range of motion in wrist flexion and extension in the RSO group. Limited wrist range of motion was previously reported in several cohorts with mid-term follow-up for RSO [4, 12, 14] and CSO [10, 12, 15]. In a recent systematic review of 172 wrists with RSO procedure over ten years of follow-up, the mean wrist arc of motion was comparable to our results (107.4 [SD 10] vs. 106 degrees) [16]. In a long-term study, extension and flexion were 93% and 76% of the unaffected side [11]. Although wrist flexion was also limited in our study, only wrist extension was significantly lower in the involved side compared to the other side in CSO group.

Grip strength

Afshar et al. found grip strength 70.1% and 75.2% of the unaffected side in RSO and CSO groups [12]. Additionally, in RSO, grip strength in Rodrigues-Pinto et al. was 73% [14] and in Viljakka et al. was 95% of the contralateral side [11]. Singer et al. found 63% [15], and Gay et al. reported 72% of unaffected side grip strength in CSO [10]. Similar to these studies, we found grip strength was also diminished compared to the other side in RSO and CSO (75.3% and 71.69%, respectively). Although the literature shows that wrist motion and grip strength have improved after either of the procedures, all patients with Kienböck disease should be cautious about a diminished range of motion and grip strength. Neither of these procedures could take them back to unaffected side values.

Multiple operation results

Ultimately, three patients in each RSO and CSO group underwent re-operation due to residual pain and disability. However, residual pain in one patient with CSO and then ALD resulted in wrist arthrodesis. All these patients had worsened radiologic stage, and most of them are experiencing some degree of wrist pain and disability in daily activities. These patients were usually excluded in previous studies or reported as a failure. We assigned them into a separate group to further evaluate their condition after revision surgery. All but one had a poor result in Mayo score (<65 points). Additionally, all of them had a worse radiologic stage compared to before operation, and all but one was in stage IIIB Lichtman-Stahl. However, we found no statistically significant difference in radiologic stage in the re-operation group compared to patients in RSO and CSO groups.

Due to patients' limitations for the follow-up, we could not include all patients in the current study. Also, patients' pre-operative range of motion and grip strength were not complete for all patients to be used for comparison. Therefore, we used the contralateral side for the comparison. The low sample size is an inevitable issue due to the low prevalence and rarity of Kienböck disease while, at the same time, not all are candidates for surgery.

In conclusion, we evaluated three different Kienböck disease procedures with a mean 46 months follow-up. We found no significant difference in functional, satisfaction, or radiologic properties between RSO and CSO procedures. However, patients who underwent RSO had lower pain scores among others.

Declarations

Consent for publication: Not applicable

Competing interests: The authors declare that they have no competing interests.

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Trial registration: Not applicable because this study is not a clinical trial.

Ethics approval: This study was performed in line with the principles of the Declaration of Helsinki, and the reporting of this study adheres to the STROBE guidelines. Approval was granted by the Ethics Committee of Mashhad University of Medical Sciences B (No. IR.MUMS.MEDICAL.REC.1398.230).

Patient Consent: Written informed consent was obtained from all subjects before the study.

Statement of the location: Present study was performed in Imam Reza hospital, Mashhad University of Medical Sciences (MUMS).

Availability of data and material: Not applicable

Keywords: capitate shortening; Kienböck disease; osteotomy; radial shortening

Author Contributions: DN, AB, and ASA researched literature and conceived the study. AM and ARK were involved in protocol development, gaining ethical approval, patient recruitment and data analysis. ARK wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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Tables

Table 1. Demographic, radiologic, clinical, and outcome data of patients with Kienböck disease

	Background						Radiology (Lichtman-Stahl)		Physical examination				Outcome (Questionnaire)		
Pat.	Group	Sex	Age	Side	Heavy work	Follow-up	Stage-pre	Stage-post	Flexion	Extension	Motion Arc	Grip	Quick DASH	Mayo	PRWE
1	RSO	F	35	R	N	12	IIIA	II	40 (80)*	40 (80)	80 (80)	12 (48)	38.63	50	45
2	RSO	F	28	L	N	7	IIIB	IIIA	75 (100)	70 (100)	145 (100)	21 (81)	38.63	80	82
3	RSO	M	42	R	Y	56	IIIA	II	42 (70)	60 (75)	102 (73)	26 (67)	36.36	35	83
4	RSO	M	46	R	N	20	II	II	50 (67)	40 (57)	90 (62)	25 (71)	6.82	70	14
5	RSO	M	49	R	N	204	II	I	38 (51)	43 (61)	81 (56)	23 (61)	4.55	65	11
6	RSO	M	35	L	Y	80	IIIB	IIIA	75 (89)	70 (100)	145 (94)	23 (70)	0.0	75	11
7	RSO	M	31	L	N	11	IIIB	IIIA	40 (38)	40 (31)	80 (34)	37 (62)	40.91	40	12
8	RSO	M	31	R	Y	93	II	II	60 (80)	35 (50)	95 (66)	21 (81)	0.0	75	0
9	RSO	M	26	R	N	10	II	IIIA	75 (100)	70 (100)	145 (100)	30 (86)	4.55	90	0
10	RSO	M	36	L	N	77	IIIA	IIIA	35 (47)	62 (89)	97 (67)	32 (128)	20.45	65	21
Mean RSO		**-**	**35.9**	**-**	**-**	**57**	**-**	**-**	**53 (72.1)**	**53 (74.3)**	**106 (73.1)**	**25 (75.3)**	**19.1**	**64.5**	**27.9**
11	CSO	F	32	L	N	28	IIIA	II	84 (112)	88 (126)	172 (119)	23 (92)	11.36	90	27
12	CSO	M	23	R	Y	25	IIIA	II	35 (58)	40 (62)	75 (60)	19 (35)	43.18	15	87
13	CSO	M	46	R	N	29	II	II	50 (100)	80 (94)	130 (96)	39 (111)	9.09	95	15
14	CSO	F	38	R	N	6	II	IIIA	24 (32)	30 (43)	54 (37)	18 (67)	15.91	60	42
15	CSO	M	31	R	Y	12	IIIA	II	40 (44)	80 (89)	120 (67)	24 (62)	25.0	50	47
16	CSO	M	33	R	Y	22	IIIA	IIIA	45 (60)	43 (61)	88 (61)	17 (45)	31.82	60	36
17	CSO	F	31	L	N	24	IIIA	IIIA	48 (64)	60 (86)	108 (74)	20 (91)	11.36	70	22
Mean CSO		**-**	**33.4**	**-**	**-**	**20.9**	**-**	**-**	**46.6 (67.3)**	**60.1 (80)**	**106.7 (73.4)**	**22.9 (71.7)**	**21.1**	**62.9**	**39.4**
Mean		**-**	**35.1**	**-**	**-**	**42.1**	**-**	**-**	**50.3 (70.1)**	**55.9 (76.7)**	**106.3 (73.2)**	**24.1 (76.7)**	**19.9**	**63.8**	**32.6**
p-value		**0.59**	**0.4**	**1.0**	**-**	**0.15**	**-**	**-**	**0.56**	**0.47 (0.7)**	**0.44 (0.65)**	**0.97 (0.98)**	**0.80**	**0.88**	**0.43**

* Values in parentheses represent proportion of each variable in relation to the other side in percentages.

Abbreviations. CSO: Capitate shortening osteotomy, DASH: Disabilities of the Arm, Shoulder, and Hand, F: Female, L: Left, M: Male, MS: Multiple surgeries, N: No, PRWE: Patient-Rated Wrist Evaluation, R: Right, RSO: Radial shortening osteotomy, Y: Yes.

Table 2. Characteristics of patients with more than one procedure for their Kienböck disease

	Background					Radiology (Lichtman-Stahl)		Physical examination				Outcome (Questionnaire)		
Pat.	**Sex**	**Age**	**Side**	**Heavy work**	**Follow-up**	**Stage-pre**	**Stage-post**	**Flexion**	**Extension**	**Motion Arc**	**Grip**	**Quick DASH**	**Mayo**	**PRWE**
18	F	38	R	N	165	IIIA	IIIB	40 (53)[a]	50 (71)	90 (62)	21 (75)	11.36	65	19
19	F	24	R	N	17	IIIA	IIIB	31 (41)	34 (49)	65 (45)	18 (69)	36.36	45	87
20	F	40	L	N	34	IIIA	IIIB	0 (0)	0 (0)	0 (0)	12 (54)	56.82	45	111
21	F	50	L	N	39	II	IIIA	43 (57)	38 (54)	81 (56)	14 (64)	20.45	60	24
22	M	34	R	Y	79	II	IIIB	20 (27)	10 (14)	30 (21)	25 (71)	36.36	50	56
23	M	38	R	N	7	IIIA	IIIB	35 (64)	30 (75)	65 (68)	12 (40)	45.45	45	52
Mean		**37.3**	**-**	**-**	**56.8**	**-**	**-**	**33.8* (48.5)**	**32.4* (52.7)**	**66.2* (50.4)**	**17 (62.2)**	**34.5**	**51.7**	**58.2**

[a] Values in parentheses represent proportion of each variable in relation to the other side in percentages.

* Patient no. 20 with wrist arthrodesis was excluded.

Table 3. Comparison of patients' outcomes after primary procedures and re-operation

Group	**Background**					**Physical examination**				**Outcome (Questionnaire)**	
	Sex (male)	**Age**	**Side (right)**	**Heavy work**	**Follow-up**	**Flexion**	**Extension**	**Motion Arc**	**Grip**	**Quick DASH**	**M**
Primary	70.6%	35.1±7.4	64.7%	23.5%	42.1±49.9	50.3±17.3 (70.1±24.2)[a]	55.9±18.2 (76.7±24.7)	106.3±31.8 (73.2±22.7)	24.1±7.02 (73.8±23.5)	19.9±15.5	63
Re-operation	33.3%	37.3±8.5	66.7%	16.7%	56.8±58.5	33.8±9.0* (48.5±14.7)	32.4±14.6* (52.7±24.2)	66.2±22.9* (50.4±18.7)	17.0±5.3 (62.2±13.1)	34.5±16.5	51
p-value	**0.357**	**0.556**	**1.0**	**1.0**	**0.558**	**0.05 (0.03)**	**0.016 (0.07)**	**0.017 (0.05)**	**0.035 (0.269)**	**0.065**	**0.**

[a] Values in parentheses represent proportion of each variable in relation to the other side in percentages (i.e. relative flexion, etc.).

* Patient no. 24 with wrist arthrodesis was excluded.