

Kienböck's Diseases Treatment. A Novel Technique via Distal Capitate Shortening Accompanied by 3rd Metacarpal Base Fusion in Neutral Variance Ulna

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Received: 18 October 2020

Accepted: 29 December 2020

Abstract:

Background: Since there is not a definite cause for Kienböck's diseases despite appropriate knowledge of lunate bone blood supply, so there is a great debate about the ideal treatment protocol for treatment of Kienböck's diseases. **Objective:** The aim of this study is to assess outcome of combining distal capitate shortening and fusion to the base of the third metacarpal bone for treatment of Kienböck's disease (Lichtman stage II or stage IIIA) with neutral ulna variance. **Methods:** Twenty patients with 20 consecutive Kienböck's disease, their age mean was 26.1(SD 5.6) y. Patients were evaluated radiologically and clinically including pre- and post-operatively for pain, (ROM) and grip strength. Functional evaluation was carried out using (MMWS). **Results:** The final post-operative (MMWS) showed increasing from 17 (SD 2.5) to 88.5 (SD7.3). **Conclusion:** The technique of distal capitate shortening

with capito-metacarpal fusion yielded satisfactory results especially for treatment of stage II, than in stage IIIA.

Keywords: Kienböck disease, capito-metacarpal, fusion, capitate shortening, and third metacarpal

List of abbreviation:

1-SD = Standard of deviation.

2-ROM = Range of motion.

3-MMWS = Modified Mayo wrist score.

Introduction

Lunate morphology, local osseous anatomy and negative ulna variance increased the risk of Kienböck disease, however many studies failed to prove this relation. [1-4]

Although there is no general agreement regarding radiocarpal anatomy and the development of Kienböck's disease, it seems to be a relationship between unequal load distribution through the radiocarpal joint whereby the lunate loads an abnormal distribution of the force and the development of lunate osteonecrosis and collapse. [5] This may explain the beneficial effect of joint leveling and decompression procedures such as radial shortening; capitate shortening either isolated [6] or accompanied by capito-hamate fusion in management of early stages of the disease. [7]

Capitate shortening osteotomy accompanied with capito-hamate fusion technique was done [8]; however it was noted that a progressive carpal collapse occurred in 6 patients. They explained that scaphoid palmar flexion will lead to proximal migration of the distal carpal row, leading to a progressive carpal collapse. A reversed L-shape osteotomy was done to relieve the lunate facet of the capitate and to resist the

potential progression of carpal collapse, and concluded that isolated capitate shortening without capito-hamate fusion may be enough to achieve satisfactory results in the early stages of disease with normal ulnar variance. [9] All these procedures are accepted for management of Kienböck's disease associated with negative or positive ulnar variance, however in cases of neutral ulnar variance, these methods of treatment can modify the distal radio-ulnar joint biomechanics and lead to eventually chronic ulnar-sided wrist pain. [10]

Capitate shortening osteotomy accompanied by 3rd metacarpal base fusion arises as a solution and seems to be a logical procedure that reduces the load on the intermediate column preventing collapse, allowing revascularization and preventing proximal migration of the capitate due to progression of carpal collapse. [11]

The objective of this study is to evaluate the results of combining distal capitate shortening with capito- third metacarpal base fusion for treatment of Kienböck disease (Lichtman stage II "lunate sclerosis" or stage IIIA "lunate collapse" without scaphoid deformity) in neutral ulnar variance patients.

Patients and methods:

This is an interventional study done after approval of medical ethical committee of Benha faculty of medicine (RC 3.10.2020). Twenty patients, all of them were consecutive with Kienböck's disease Lichtman stage II in 12 patients and stage IIIA in 8 patients were operated on between December 2015 and May 2018 in hand surgery unit at Benha university hospitals in orthopedics and traumatology department. Patients were diagnosed by postero-anterior and lateral X-ray views of the wrist joint, and then MRI was done.

As regarded to gender; 14 (70%) patients were female wherever 6 (30%) patients were male. Patients' age (ranged 20-37y) with a mean 26.1 (SD 5.6) y. Dominant hand was affected in 16 patients (80%). Average duration of the symptoms was 24 months (range: 8-30m.). Sixteen patients were heavy manual labors, while 4 patients had an office based work. There were 6 patients who had a history of trauma on the affected wrist, while the other 14 had a repetitive minor trauma due to the nature of their work. Table [1]

Inclusion criteria:

1. Kienböck's disease stage II and IIIA with neutral ulna variance.

2. Age group between (18-60 years).
3. Unilateral Kienböck's disease.
4. Follow-up period should not be less than 12 months.

Exclusion criteria:

- 1- Skeletally immature patients.
- 2- Previous wrist surgery.
- 3- Previous wrist joint disease.

Surgical technique:

The operation was performed under regional or general anesthesia. Patient lies in supine position and this arm on a hand operating table. A pre-operative antibiotic was given at induction of anesthesia prior to tourniquet. A pneumatically measured tourniquet was used. Draping and sterilization were commenced. A 3cm midline longitudinal dorsal incision centered over the capito-metacarpal joint was made.

The tendons of the 4th. compartment was retracted to the ulnar side, and the capsule was incised longitudinally to expose the capito-metacarpal joint. The location of the capito-metacarpal joint confirmed by using fluoroscopy. With a fine oscillating saw, 1-1.5 mm wafer of bone and cartilage was resected from the distal end of the capitate and from the base of the 3rd metacarpal, creating a 2–3 mm defect. The saw cuts were completed by small osteotomies preventing an injury to the flexor tendons on

the palmar surface of the capito-metacarpal joint. The bone surfaces of the capitate and the 3rd metacarpal were compressed by reduction clamp forceps and fixed by a low profile mini-plate and screws. Wound was closed over the approximated capsule, 4th extensor compartment and the wrist was placed in a short arm volar splint.

Clinical evaluation:

Wrist range of motion (flexion, extension, and radial- ulnar deviation) was measured using a goniometer and compared to the pre-operative values and the normal contralateral side. Grip strength was measured using a Jamar Hand Dynamometer (expressed as percentage of healthy side strength). Pain scale was self-reported and graded according to the questionnaire provided by the MMWS. So, no pain was 25 points and severe pain was zero point. Functional evaluation was carried out using the (MMWS).^[11]

Radiographic evaluation:

The standard postero-anterior and the lateral radiograph views were evaluated both pre- and post-operatively for measurement of the ulnar variance, carpal height index "normal Youm index" is 0.54 (SD 0.03)^[12], lunate height index "method of Stahl" by dividing the length of lunate on postero-anterior view

by the antero-posterior diameter of lunate on lateral view, and the scapho-capitate angle "angle between the longitudinal axes of scaphoid and capitate on AP view".^[13]

Figure [1]

Post-operative regimen:

Active finger motion started immediately after surgery, and wrist joint motion was allowed 6 weeks after surgery. Active assisted and passive wrist joint motion was continued under supervision of a highly specialized physiotherapist until complete union was achieved. "Defined radiologically by obtaining solid fusion at least in two X-ray views each of them is perpendicular to the other". At final follow-up, patients "ROM", grip strength, pain and (MMWS) were recorded.

Statistical analysis:

Data were tested for normality using Shapiro Wilk test. Categorical data were presented as number and percentages while quantitative data were expressed as mean, standard deviation (SD), median and range. Paired "t" test and Wilcoxon signed test were used as tests of significance. The accepted level of significance in this work was stated at 0.05 (P <0.05) was considered significant.

Results

Results of operative treatment for Kienböck's disease by capitate shorting osteotomy combined with 3rd metacarpal base fusion were analyzed. All patients were followed-up with a mean 14.2 (SD 1.2) m. (range: 12-18ms). All of them achieved bony union at the fusion site within 8-14w. after surgery with a mean 10.1 (SD 1.4) w. Table [1] Median pain score was 15 points pre-operatively and 22.5 post-operatively with ($p < 0.001$).

Patients gradually returned to their original work at an average of 16 weeks (14-20w.). After one year follow-up, there were 16 patients who continue their original work, while 4 patients need to change their work. Average grip strength improved from 15.5 (SD 1.5) Kg to 22.5 (SD 2.5) Kg post-operatively ($p < 0.001$). Flexion and extension range of motion was changed from 15° to 22.5° post-operatively with a ($p < 0.001$). The final (MMWS) increased from 17 (SD 2.5) to 88.5 (SD 7.3) points. Table [2] Regarding the radiographic measures; carpal height index, showed a statistically significant

decrease from 0.51 (SD 0.005) to 0.4 (SD 0.02) ($p < 0.001$), the lunate height index showed non-significant decrease 0.5 (SD 0.03) to 0.47 (SD 0.02) ($p > 0.05$), and finally the scapho-capitate angle showed a statistically significant increase 45.4 (SD 4.3) degrees to 51 (SD 0.03) degrees ($p < 0.001$). Table [3] Pain score, ROM, grip strength and (MMWS) were positively correlated to the post-operative scapho-capitate angle. Table [4] Modified Mayo Wrist Score in patients with Lichtman stage II increased from 18.33 (SD 2.5) to 94.2 (SD 1.9) points ($p < 0.001$), while in stage IIIA patients score increased from 15 to 80 points. Finally, (MMWS) showed better results in Lichtman stage II than in stage IIIA ($p < 0.001$). Table [5] No surgery related major complications were recorded except superficial wound infection occurred in one patient (5%) that was treated by daily dressing and antibiotic. No cases of hardware failure or soft tissue impingement were recorded till the last follow-up. Also, there was no reported case with a progressive carpal collapse. Figure [2]

Table (1): Demographic data

Sex (20)	Male	16(30%)
	Female	14(70%)
Age		26.1 (SD 5.6) y. Range (20-37y.)
Side	Rt.(dominant hand)	16(80%)
	Lt.	4(20%)
Lichtman Stage	II	12(60%)
	IIIA	8(40%)
Fusion Time(weeks)		10.1 (SD 1.4) w. Range (8-14 w.)
Follow-up period(months)		14.2 (SD 1.2) m. Range (12-18m.)

Table (2): Clinical evaluation

Clinical evaluation	Pain		Grip strength		Range of motion		(M.M.R.S)	
	Pre.	Post.	Pre.	Post.	Pre.	Post	Pre.	Post.
	15(0-15) points	22.5 (20-25) points	15.5 Kg (SD 1.5)	22.5 Kg (SD 2.5)	15°	22.5° (20-25)	17 (SD 2.5)	88.5 (SD7.3)
P.value	z=4.8(<0.001*)		t=9.2(<0.001*)		z=4(<0.001*)		t=52.4(<0.001*)	

*significant result

Table (3): Radiographic evaluation

Radiographic evaluation	Carpal height index		Lunate height index		Scapho-capitate angle	
	Pre.	Post.	Pre.	Post.	Pre.	Post.
	0.51(SD 0.005)	0.4 (SD0.02)	0.5(SD 0.03)	0.47(SD 0.02)	45.4(SD 4.3)	51(SD 0.03)
P value	t=26.3(< 0.001*)		t=1.5 (>0.05)		t=36.7(< 0.001*)	

Table (4): Correlations between the post-operative scapho-capitate angle and clinical score parameters

	Pain		Grip of strength		ROM		MMRS	
	r	p	r	P	r	p	r	p
Scapho-capitate angle	0.681	0.001*	0.5	0.02*	0.609	0.004*	0.798	< 0.001*

*significant result

Table (5): Comparison of post-operative (MMWS) between stage II and IIIA Kienböck patients.

	Lichtman stage II		Lichtman stage IIIA	
	Pre.	Post.	Pre.	Post.
MMWS	18.33 (SD 2.5)	94.2(SD 1.9)#	15	80#
	t =73.2(< 0.001*)		-	

significant result. # t=25.2 (< 0.001)



Fig . 1 : (a) Carpal height ratio, (b): Lunate height index, (c) Scapho-capitate angle.



Fig. 2: (a): AP X-ray view shows sclerosis, (b) Lateral X-ray view, (c) MRI , (d) Final post-operative X-ray_Note complete fusion between the capitate and 3rd metacarpal base with decreasing lunate sclerosis, (e) Final lateral view showing complete fusion, (f) Final CT scan wrist showing solid fusion, (g) Full range extension of the Rt.wrist, (h) Full range flexion of the Rt.wrist

Discussion

The etiology of Kienböck's disease remains poorly understood, and thus is why there is still little evidence to support any particular form of operative treatment. ^[14]

The rationale for distal capitate shortening with fusion to the base of 3rd metacarpal is to decompress the lunate, preventing proximal migration of the capitate bone. Shortening will decompress the lunate, and the fusion of the capitate to the base of the third metacarpal will prevent proximal migration of the capitate and further carpal collapse. ^[11]

The vascular anatomy around the capitate bone is the theoretical basis for osteotomy technique. Studies reported that a branch of the anterior interosseous artery supplies blood to the proximal capitate, so it is recommended that osteotomy is performed 2 mm proximal to the distal capitate surface. ^[15]

In an anatomical study, significant load reduction on the lunate was evident in all specimens after capitate shortening in cases of neutral ulnar variance. The larger the angle between the capitate and scaphoid, the greater was the decrease in pressure. ^[16]

The 3rd metacarpal is the most fixed and the less mobile metacarpal one, affording more

stability in case its base is fused with the distal part of the capitate. The nearly rigid ligamentous connection of the capitate to the 3rd metacarpal base and lack of motion between these bones allows us to consider the distal row functionally as part of a fixed hand unit. ^[17]

Several studies combined revascularization with additional procedures to unload the lunate, such as capitate shortening radius osteotomy. ^[18-21]

Isolated capitate shortening osteotomy results were analyzed through several studies. A study was performed on 11 cases, all patients had a mild form of Kienböck's disease (stage I to IIIA) results were six good, two fair, and three poor results. ^[6] Other authors ^[22] did their study over 7 patients with stage II and IIIA, and patients returned to regular employment at a median of 6 months, with satisfactory range of motion, grip and pinch strengths. All were satisfied with the operation. Another study was performed on 10 patients 3 cases were stage II and 7 cases were III, achieved lunate revascularization which was detected by MRI in 6 patients. ^[23]

In a study that used the same technique of treatment for Kienböck's disease ^[11] as

described in our study and noticed complete pain relief in all patients (8 patients with stage II, and 4 patients with stage IIIA). They also noticed improvements in the ROM and grip strength up to 100% (range 80- 100%) of the healthy side; therefore, 5 of their patients had excellent results and 7 had good results according to the (MMWS), with no unsatisfactory or poor results. They noticed a significant increase in the scapho-capitate angle in all patients after surgery and reported that the distal capitate shortening with arthrodesis to the base of the third metacarpal not only prevented carpal collapse, but also improved the carpal height; and these findings were obtained all through this work. Another study [24] used also the same technique and reported obvious improvements in the mean of post-operative pain , grip strength, ROM and (MMWS) in patients with stage II disease, while in patients with stage IIIA, incomplete pain relief was documented in most of patients (6 patients), all of them received analgesics while the other (4 patients) needed another surgery. There was a radiological parameters difference between stage II and stage IIIA patients post-operatively clarifying the lower (MMWS) in their patients with stage IIIA disease. Also they stated that this technique is not

recommended for treating stage IIIA patients.

Herein this study, a significant improvement was found in the mean of post-operative pain, ROM, grip strength and (MMWS) in all patients with stage II, while in stage IIIA incomplete pain relief was reported. Also and it seems logically, we found that stage II post-operative clinical scores are superior to those in group IIIA, and these results were also reported in other studies [11-24].

Limitations of the study:

We acknowledge that our study limitations include paucity of researches that used the same surgical technique in this study, lack of a control group, relatively short follow-up period and small number of patients and accept that a greater number of patients with longer follow-up period are needed for more definite conclusions. Nevertheless our early results indicate that capitate shortening osteotomy combined with 3rd metacarpal base seems to be an effective treatment for Lichtman stage II than III-A patients.

Conclusion:

Distal capitate shortening with capito-metacarpal fusion can provide pain relieve, preserves an acceptable range of motion and improves grip strength in patients with stage II Kienböck disease.

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To cite this article: Mohamed E. Al-Ashhab, Hossam E Farag. Kienböck's Diseases Treatment. A Novel Technique via Distal Capitate Shortening Accompanied by 3rd Metacarpal Base Fusion in Neutral Variance Ulna. *BMFJ* 2021; 38 (orthopedic surgery): 22-33. DOI: 10.21608/bmfj.2021.46843.1329