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Original

Radial Shortening Osteotomy Using Volar Locking Plate for Kienböck's Disease

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SUMMARY

Purpose：The purpose of this study was to report the preliminary results for radial shortening osteotomy followed by volar locking plate fixation without post-operative immobilization for the treatment of Kienböck's disease.

Methods：Ten consecutive patients with Kienböck's disease of stages III were treated by radial shortening osteotomy at the metaphysis using a volar locking plate system. Radial shortening osteotomy was performed for patients with negative or neutral ulnar variance, and combined shortening of radius and ulna for those with positive ulnar variance. The active motion of the digits, wrist, and forearm was encouraged immediately after surgery, and no splints were used.

Results：The average follow-up was 26 months. In all the patients, the osteotomized bone united after an average of 11 weeks. Follow-up radiographs showed no further progression of the disease in carpal height, Ståhl's index, or Lichtman's stage classification. Moderate pain reported by all the patients preoperatively significantly improved by the final follow-up. Wrist extension, flexion, grip strength, and the Mayo wrist score were significantly improved compared with preoperative values.

Conclusions：Volar locking plate fixation without immobilization is a safe and effective procedure for radial shortening osteotomy of Kienböck's disease.

Key Words：Kienböck's disease, shortening osteotomy, radius, volar locking plate

INTRODUCTION

Kienböck's disease, or avascular necrosis of the lunate, causes major disability because of pain and loss of function in the wrists of young productive patients. Numerous treatments have been described. Radial shortening osteotomy for Kienböck's disease has been reported to be satisfactory[1~8]. However, conventional plate fixation after osteotomy generally requires immobilization of the wrist joint with a splint or a cast. Union of the osteotomy site sometimes may take 5 months or more[9,10]. In 2000, Orbay[11] introduced volar locking plate fixation for fresh distal radius fractures, and the good angular and length stabilities provided by this method made it possible to achieve the mobilization of the wrist immediately after surgery[12~14]. The clinical outcomes of this method have also been reported to be satisfactory[11,15~20].

We therefore anticipated that, with use of a volar locking plate, a radial osteotomy could be successfully performed at the metaphysis of the radius, where the

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Table 1 Patient data

Patient	Age (y)	Gender	R/L	Occupation	Follow-Up Period (mo)
1	51	F	R	Hairdresser	48
2	59	F	L *	Homemaker	40
3	23	M	R	Factory worker	12
4	28	M	L *	Communication lineman	42
5	54	M	R	Interior decorator	18
6	69	F	R	Homemaker	26
7	29	F	R	Homemaker	22
8	69	M	L *	Farmer	19
9	17	M	L *	Student	24
10	50	M	R	Mailman	12

* Non-dominant hand

Table 2 Radiographic results at preoperative and final examinations

Patient	Radius Shortening (mm)	Ulnar Variance (mm)		Carpal Height Ratio		Ståhl's index		Lichtman's Stage	
		Pre-op	Final	Pre-op	Final	Pre-op	Final	Pre-op	Final
1	2	0	1	0.49	0.50	0.39	0.35	ⅢB	ⅢB
2	2, 3 *	2	1	0.48	0.51	0.35	0.27	ⅢB	ⅢB
3	2	0	2	0.52	0.52	0.40	0.42	ⅢA	ⅢA
4	3	−2	1	0.56	0.61	0.37	0.38	ⅢA	ⅢA
5	2	1	3	0.56	0.58	0.35	0.32	ⅢB	ⅢB
6	2	1	2.5	0.52	0.51	0.24	0.25	ⅢB	ⅢB
7	4	−3	1.5	0.49	0.49	0.22	0.23	ⅢB	ⅢB
8	2	1	3	0.57	0.58	0.43	0.36	ⅢA	ⅢA
9	2	0.5	2.5	0.61	0.56	0.44	0.47	ⅢA	ⅢA
10	4	−4	−1	0.50	0.55	0.30	0.29	ⅢB	ⅢB

* : Ulnar shortening

bony union would be obtained in a shorter period than in cases of diaphysis osteotomy. In addition, post-operative wrist immobilization might not be necessary after volar locking plate fixation.

Since 2005, we have performed radial shortening osteotomy followed by volar locking plate fixation without post-operative immobilization. We herein report our preliminary results and demonstrate the validity of this method for treating Kienböck's disease.

METHODS

From 2005 to 2009, ten consecutive patients with Kienböck's disease of stages III[21] were treated by radial shortening osteotomy using a volar locking plate system (Table 1). There were six men and four women ranging in age from 17 to 69 years (average, 45 years). Based on the findings of preoperative radiographs, four patients were determined to have stage IIIA and six stage IIIB according to the staging system proposed by Lichtman and Degnan[21] (Table 2). The ulnar variances ranged from −3 to 2 mm (average, 0.1 mm). All patients presented with pain and loss of motion of the wrist joint, and grip weakness (Table 3).

Surgical Technique

The standard volar approach was used over the flexor carpi radialis tendon. The distal and radial borders of the pronator quadratus were lifted with an L-shaped incision, and the muscle was retracted ulnarly. The volar aspect of the distal radius was then identified. A DRV Locking Plate (Mizuho Ikakogyo Co, Ltd, Tokyo, Japan) was contoured to fit the volar aspect of

Table 3 Clinical results at preoperative and final examinations

Patient	Wrist Motion Ext/Flex (°)		Forearm Motion Supi/Pro (°)		Grip Strength : % of Normal Side		Pain *		Cooney Score	
	Pre-op	Final	Pre-op	Final	Pre-op	Final	Pre-op	Final	Pre-op	Final
1	65/45	64/60	90/70	90/78	59	100	++	−	65	100
2	50/40	75/55	92/85	94/80	27	83	++	+	50	80
3	62/46	70/58	90/72	90/78	73	98	++	−	60	80
4	40/60	80/80	85/80	90/80	18	58	++	−	50	85
5	50/40	66/60	80/80	90/86	82	78	++	−	60	90
6	60/40	70/66	90/80	90/80	59	92	++	−	55	85
7	60/50	72/62	95/80	95/80	45	56	++	+	50	65
8	40/25	50/47		90/87		83	++	−	55	80
9	60/20	70/80	90/85	92/80	71	72	++	+	55	85
10	40/40	68/70	90/80	90/70	49	87	++	−	50	90

* + : Mild pain, ++ : Moderate pain, +++ : Severe pain

the radius (Fig. 1)[13]. This plate was flat and wide distally, with a volar angulation of 19°. There were three small holes in the distal plate for temporary 1.0-mm K-wire fixation of the distal end of the radius and two lines of holes with threads for 2.0-mm locking pins or 2.7-mm locking screws. Under fluoroscopy, the DRV Locking Plate was temporarily fixed to the distal radius with two K-wires and was pre-drilled accurately for two holes in the distal row of the distal locking holes with a threaded drill guide. The two osteotomy lines were then marked between the proximal row of distal locking holes and the most distal 3.5-mm cortical screw hole. The plate was removed, and osteotomies were performed by making two transverse cuts with a thin oscillating saw to remove an appropriate segment of bone. The length of the removed segment depended on the ulnar variance (UV) measured on the preoperative radiograph. Patients with a negative UV (≤-2 mm) had a segment removed to correct UV to 0-2 mm, and patients with neutral UV (±2 mm) had a segment of 2 mm removed. Patients with positive UV (≥2 mm) recieved a combined shortening of the radius and the ulna. In these, the radius was shortened by 2 mm, and the distal third of the ulna was shortened to correct the UV to 0-2 mm. The osteotomy site of the radius was fixed with a DRV Locking Plate using four locking pins to fix the distal fragment, and locking screws or non-locking screws if needed (Fig. 2). In patients with positive UV, the osteotomy site of the ulna was finaly fixed with a six-hole or seven-hole dynamic compression plate.

Figure 1 The DRV Locking Plate System includes a large size (left) and a small size plate (right).

Post-operative Management

Full active motion of the digits, wrist, and forearm was encouraged immediately after surgery, and no splints were used. Functional use of the affected hand for light daily activities was encouraged, and lifting a weight less than 500 g was recommended until radio-

Figure 2 (A) Preoperative and (B) postoperative radiographs illustrating the case of # seven, a 29-year-old woman. Shortening osteotomy was performed at the metaphysis of the distal radius.

logical healing of the osteotomy.

Radiographic Examination and Clinical Evaluation

One of the authors carried out all of the radiographic measurements and the clinical evaluation both preoperatively and at the time of the final follow-up.

The radiographic parameters were measured using posteroanterior and lateral radiographs with neutral forearm rotation and with the wrist in a neutral position. Lichtman stage[21] the ulnar variance, the carpal height ratio[24] and Ståhl's index[25] were assessed both preoperatively and at the time of the final follow-up. The union time was determined trabecular bridging of the radius and ulnar osteotomies was observed radiographically. Postoperative radiographs were taken at every visit. These were scheduled every other week after the operation until the time of bony union.

Wrist and forearm ranges of motion (extension, flexion, radial deviation, ulnar deviation, supination, and pronation) were measured with a standard goniometer and compared with those of the contralateral side. Grip strength was measured with a dynamometer (Hand Dynamometer, MIS Co, Tokyo, Japan) and compared with that of the contralateral side. Residual pain in the wrist joint was graded as mild, moderate or severe, using evaluation criteria developed at the Mayo Clinic[22]. These criteria defined mild pain as that present only at the extremes of the active range of motion of the wrist joint, where the patient was neither physically nor psychologically disturbed by the pain. Moderate pain was defined as occurring during heavy manual labor and caused the patient to be disturbed physically or psychologically or both. Severe pain was defined as that occurring during activities of daily living and at rest. Patients were interviewed for functional assessment with respect to activity limitations and return to work. In the patients who were retired or unemployed, the return to work time was equated as the time taken to return to their pre-injury level of activity. At the time of the final follow-up, the clinical outcomes were graded using the Mayo wrist score[22]. In addition, the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire[23] was used to assess the ability of patients to perform various activities in daily living.

Statistical analysis

All data were presented as the average ± standard deviation. The radiographic parameters, the range of motion, and the grip strength at preoperative and final examinations were compared, and differences were analyzed with the use of the paired Student's t-test with a two-tailed distribution. The pain level and the Mayo wrist score at preoperative and final examination were compared with use of the Mann-Whitney U test. Differences were defined as significant if the p value was <0.05.

RESULTS

The average follow-up period of the ten patients was 26 months (range, 12-48 months). Three patients with negative UV had a 3 or 4 mm segment removed to correct the UV, and six patients with neutral UV had a 2 mm segment removed. One patient with positive UV was treated with a combined shortening of the radius (2 mm) and the ulna (3 mm) (Table 2).

Radiographic Examination

In all ten patients, healing of the radius and ulnar osteotomies was observed radiographically, and the average time for union was 11 weeks (range, 7-16 weeks). No progression of Lichtman stage was found in any patients (Table 2). The carpal height ratio was 0.53±0.04 at the preoperative examination and 0.54±0.04 at the final examination. The Ståhl's index was 0.35±0.07 preoperatively and 0.34±0.08 at the final examination. A statistical analysis of the carpal height ratio ($p=0.56$) and Ståhl's index ($p=0.45$) showed no significant differences between the preoperative and the final examination.

Clinical Evaluation

Preoperatively, the patients' wrist extension was 53±10°, flexion was 41±12°, forearm supination was 89±4°, and pronation was 79±5°. At the final examination, the wrist extension was 68±8°, flexion as 65±10°, forearm supination was 90±1°, and pronation was 81±5° (Table 3). Comparison of the preoperative and postoperative values showed that there were significant post-operative improvements in both wrist extension ($p=0.001$) and flexion ($p=0.001$). Preoperative grip strength compared with the normal side was 53±21%. At the final examination, the% grip strength was 81±15%, which was significantly improved compared with preoperative values ($p=0.005$). All of the patients had moderate pain preoperatively, which improved ($p=0.0002$) to no pain in seven patients and mild pain in two patients at the final examination. The Mayo wrist score was 55±6 preoperatively and 86±10 at the final examination, which was significant improvement ($p=0.0002$). The DASH score was 7.6±9.0 at the final examination.

At the final examination, none of the patients had any complications, such as infection, tendon problems, nerve injury, or implant failure.

DISCUSSION

Radial shortening osteotomy has long been the standard treatment for Kienböck's disease, and stable clinical outcomes are frequently achieved using this method[1~8]. The surgical approach, osteotomy site, and methods of fixation varied by investigators. The results of using the dorsal[2,3,7,26~28] or volar[1,4,10] approach, the targeting of the epiphysis[2], metaphysis[26,28,29] or distal diaphysis[1,3,4,7,10,27] of the radius to the osteotomy site, and the differences between using a K-wire[2], Rush-pin[26], T plate[28,29], or dynamic compression plate[1,3,4,7,10,27] for fixation of the radial osteotomy were described previously. Although the K-wire[2] and Rush-pin[26] fixation following osteotomy at the epiphysis or metaphysis of the radius were used previously, fixation of a dynamic compression plate following osteotomy at the distal diaphysis is now a common procedure. Some investigators[28,29] have reported conventional T plate fixation following osteotomy at the metaphysis of the radius, as a transitional procedure combining the old and new methods. Usually post-operative wrist immobilization was done, however, there have been few reports on the use of dynamic compression plates without subsequent immobilization[27,30]. The time to union of the osteotomy site has not been described in the majority of the previous reports. Some investigators have described that union occasionally took 5 months more[9,10]. Others have reported a complete non-union in case with dynamic compression plate fixation after osteotomy[4,27].

The biomechanical stability of volar locking plate fixation at the metaphyseal osteotomy of the distal radius has been described well[12~14,31]. The failure load of volar locking plate fixation of the cadaveric distal radius is 747-1667 N[12,13,31], which is tolerated in light activities of daily living. Moreover, a biomechanical comparison of dorsal T plates and volar locking plates in a model of 5000 cycles of axial loading showed that the volar locking plate maintained its initial stiffness better than the T plate[14].

For our patients, we elected to perform shortening osteotomy at the metaphysis of the radius followed by volar locking plate fixation without post-operative immobilization. One reason we used this method was that the metaphysis generally has more cancellous bone than the diaphysis. Eiken and Niechajev[26] have described union time after metaphyseal osteotomy with Rush-pin took 2.5 to 4 months. Of interest, the time to union of the osteotomy site was 7-16 weeks (average, 11 wk) in our series, which seemed shorter than that of previous reports. Another reason this method appears to be better than conventional procedures was the better stability of the volar locking plate. Our patients were able to use their affected hands for light activities related to daily living immediately after surgery. Consequently, there were no cases of non-union, and the clinical outcomes of our series were similar to or better than the previous reports[1~8)]. We think that there is no need of postoperative immobilization for radial shortening osteotomy of Kienböck's disease.

Based on the satisfactory clinical and radiographic outcomes reported herein, we conclude that volar locking plate fixation without immobilization is a safe and effective procedure for radial shortening osteotomy of Kienböck's disease.

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